Time Oil Bulk Terminal PPA

Supplemental Upland Remedial Investigation and Feasibility Study

Prepared for

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

Supplemental Upland Remedial Investigation and Feasibility Study

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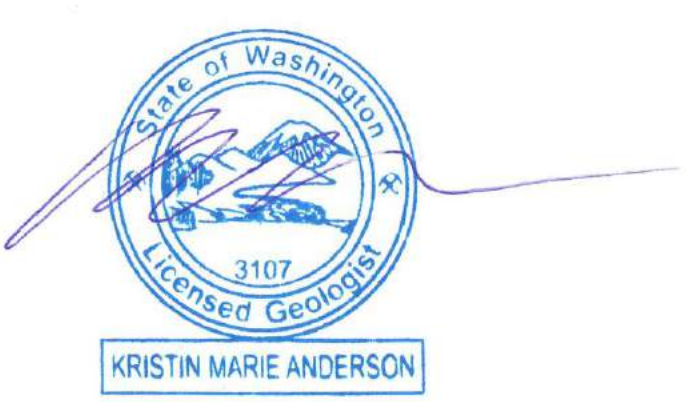

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List of Acronyms and Abbreviations

Acronym/ Abbreviation	Definition
ADEC	Alaska Department of Environmental Conservation
AO	Agreed Order
AOC	Area of concern
ARAR	Applicable or Relevant and Appropriate Requirement
ASKO Property	ASKO Hydraulic Property
AST	Aboveground storage tank
BDI Plus	Bio-Dechlor INOCULUM Plus
bgs	Below ground surface
BNSF	BNSF Railway Company
BTEX	Benzene, toluene, ethylbenzene, and xylenes
CAA	Cleanup action area

Acronym/ Abbreviation	Definition
Cantera	Cantera Development Group, LLC
CAP	Cleanup Action Plan
CCMP	Construction Compliance Monitoring Plan
CMP	Compliance Monitoring Plan
COI	Chemical of interest
COPC	Chemical of potential concern
cPAH	Carcinogenic polycyclic aromatic hydrocarbon
CPOC	Conditional point of compliance
CUL	Cleanup level
cVOC	Chlorinated volatile organic compound
CY	Cubic yards
DAHP	Washington State Department of Archaeology and Historic Preservation
DCA	Disproportionate cost analysis
DCE	Dichloroethene
DNR	Washington State Department of Natural Resources
DPE	Dual-phase extraction
DRO	Diesel-range organics
Ecology	Washington State Department of Ecology
EDR	Engineering Design Report
EPH	Extractable petroleum compounds
ERD	Enhanced reductive dechlorination
ERH	Electrical resistance heating
FBI	Freidman & Bruya, Inc.
FOE	Frequency of exceedance
FS	Feasibility Study
ft/ft	Feet per foot
GMP	Groundwater Monitoring Plan
GPR	Ground-penetrating radar
GRO	Gasoline-range organics
gZVI	Granular zero-valent iron
IC	Institutional control
IHS	Indicator hazardous substance
ISCO	In situ chemical oxidation

Acronym/ Abbreviation	Definition
ISS	In situ solidification and stabilization
Jobbers	Jobbers Petroleum Company
LCS	Laboratory control sample
LCSD	Laboratory control sample duplicate
LDA	Large-diameter auger
LNAPL	Light non-aqueous-phase liquid
LTCMP	Long-Term Compliance Monitoring Plan
m/day	Meters per day
MCL	Maximum contaminant level
µg/L	Micrograms per liter
mg/kg	Milligrams per kilogram
MNA	Monitored natural attenuation
MPE	Multi-phase extraction
MS	Matrix spike
MSD	Matrix spike duplicate
MTCA	Model Toxics Control Act
mZVI	Microscale zero-valent iron
NAVD 88	North American Vertical Datum of 1988
ng/kg	Nanograms per kilogram
ORO	Oil-range organics
PAH	Polycyclic aromatic hydrocarbon
PCE	Tetrachloroethene
PCSM	Preliminary Conceptual Site Model
PCUL	Preliminary cleanup level
penta	Pentachlorophenol
PID	Photoionization detector
PIHS	Preliminary indicator hazardous substance
POC	Point of compliance
PPCD	Prospective Purchaser Consent Decree
PRB	Permeable reactive barrier
Property	Former TOC Seattle Terminal facility
PSL	Preliminary screening level
RAO	Remedial Action Objective
Rattan	Rattan Furniture Manufacturing Company

Acronym/ Abbreviation	Definition
RCRA	Resource Conservation and Recovery Act
REL	Remediation level
RI	Remedial Investigation
RI Work Plan	Supplemental Upland Remedial Investigation Work Plan
ROW	Right of way
SCO	Sediment Cleanup Objective
SDG	Sample delivery group
SES	SoundEarth Strategies, Inc.
SF	Square feet
Site	Time Oil Bulk Terminal PPA Site
SMS	Sediment Management Standards
SREMP	Soil and Remedial Element Management Plan
SVE	Soil vapor extraction
SVOC	Semivolatile organic compound
TBT	Tributyltin
TCE	Trichloroethene
TEE	Terrestrial ecological evaluation
TOC	TOC Holdings Co. and any predecessor entity including Time Oil Company
TPH	Total petroleum hydrocarbons
Trustee	Chapter 7 Trustee of the Bankruptcy Estate of TOC Holdings Co.
UCS	Unconfined compressive strength
USACE	U.S. Army Corps of Engineers
USEPA	U.S. Environmental Protection Agency
UST	Underground storage tank
VCP	Voluntary Cleanup Program
VOC	Volatile organic compound
VPH	Volatile petroleum compounds
WAC	Washington Administrative Code
WBZ	Water-bearing zone
WDFW	Washington Department of Fish and Wildlife
WPTP	West Point Treatment Plant
WQC	Water quality criteria
ZVI	Zero-valent iron

1.0 Introduction

This Supplemental Upland Remedial Investigation (RI) and Feasibility Study (FS) was prepared at the request of Cantera Development Group, LLC (Cantera) for the Time Oil Bulk Terminal PPA Site (Site) located on W. Commodore Way in Seattle, Washington. The Site is the location of the former TOC Holdings Co. (TOC) Seattle Terminal facility (Property). The term TOC collectively refers to TOC Holdings Co. and any predecessor entity including Time Oil Company herein. The Property consists of four separate parcels (commonly identified as the Bulk Terminal Property, ASKO Hydraulic Property [ASKO Property], East Waterfront Property, and West Waterfront Property) to be acquired under the terms of an Asset Purchase Agreement (APA) and Prospective Purchaser Consent Decree (PPCD). The Site will be more specifically described and legally defined in the PPCD and that definition will govern. The general location of the Site is shown on Figure 1.1, and the Property and its surroundings are shown on Figure 1.2.

1.1 PROJECT BACKGROUND AND REGULATORY OVERVIEW

Three of the four upland parcels (all but the West Waterfront Property) were previously enrolled by TOC in the Washington State Department of Ecology (Ecology) 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 FS reports for each of these three parcels, which were submitted to Ecology in 2014 (SES 2014a, 2014b, 2014c, 2014d, 2014e, 2014f). SES completed investigation activities for TOC until mid-2016, when TOC filed for bankruptcy.

The former owner, TOC, filed a Chapter 7 liquidation bankruptcy, and the Property is currently for sale. The four upland parcels are currently managed by Edmund J. Wood, acting as Chapter 7 Trustee of the Bankruptcy Estate of TOC Holdings Co. (Trustee). Cantera is a prospective purchaser and is currently in a due diligence process to evaluate environmental contamination and other feasibility issues prior to purchase of the Property pursuant to an APA with the Trustee. Cantera's objective is to obtain a PPCD from Ecology; Cantera is not currently a potentially liable person for the Site. Cantera will be assigning its rights under the asset purchase agreement to TOC Seattle Terminal, LLC, at the time of closing.

As part of the due diligence process, Cantera enrolled the four upland parcels into the VCP in July 2018 (as a single VCP Site). Ecology accepted the VCP application on July 10, 2018, and identified the VCP Site name as Time Oil Bulk Terminal PPA[1] with VCP Project No. NW3201. The PPCD will address the specific work to be performed including remedial actions above the ordinary high-water mark and a cash out payment to Ecology for sediments below the ordinary high-water mark as specifically defined in the PPCD. The RI/FS is the technical basis for the remedial actions to be performed under the PPCD and was also included among other considerations in calculating

[1] The Time Oil Bulk Terminal PPA nomenclature has been changed by Ecology to Time Oil Bulk Terminal to be consistent with their database.

the sediment cash out payment defined in the PPCD. The PPCD will become effective at the time of closing of the purchase.

1.2 PURPOSE AND SCOPE OF SUPPLEMENTAL UPLAND REMEDIAL INVESTIGATION

The purpose of the RI is to collect, evaluate, and document the data necessary to adequately characterize the environmental conditions associated with the Property in support of the FS. As previously mentioned, SES prepared separate RI reports for the Bulk Terminal, ASKO, and East Waterfront Properties, which were submitted to Ecology in 2014 (SES 2014a, 2014b, 2014c).

A draft Supplemental Upland RI Work Plan (RI Work Plan) was submitted to Ecology by Cantera in October 2018. The RI Work Plan was finalized in March 2019 and approved by Ecology in correspondence dated April 8, 2019 (Floyd|Snider 2019). As part of development of the RI Work Plan, Floyd|Snider developed preliminary screening levels (PSLs) for the Site and reviewed all available and current (i.e., in situ) data relative to the PSLs to identify chemicals of potential concern (COPCs). Section 4.0 of the RI Work Plan provided rationale for derivation of PSLs and identification of COPCs for groundwater and soil at the Property on a parcel by parcel basis. Based on this evaluation, primary COPCs, which are chemicals that are likely to be remedial drivers, were identified for groundwater and soil for each parcel as follows:

Bulk Terminal Property	
Groundwater	Total petroleum hydrocarbons (TPH; gasoline-range organics [GRO], diesel-range organics [DRO], and oil-range organics [ORO]); benzene and ethylbenzene
Soil	TPH (GRO and DRO) and benzene
ASKO Property	
Groundwater	TPH (GRO, DRO, and ORO), benzene, and chlorinated volatile organic compounds (cVOCs; *cis*-1,2-dichloroethene (DCE), trichloroethene [TCE], and vinyl chloride)
Soil	TPH (GRO, DRO, and ORO), benzene, and cVOCs (*cis*-1,2-DCE and TCE)
East Waterfront Property	
Groundwater	TPH (GRO, DRO, and ORO), benzene, and ethylbenzene
Soil	TPH (GRO and DRO) and ethylbenzene

Data gaps were identified during a review of existing data and current conditions (including post-RI interim measures and data collection completed by SES) in consultation with Ecology and were presented in the RI Work Plan. Chemicals identified for further evaluation as part of the RI Work Plan included TPH, benzene, cVOCs, carcinogenic polycyclic aromatic hydrocarbons (cPAHs), metals, and pentachlorophenol (penta). The Supplemental Upland RI field investigation was completed to collect groundwater and soil data to fill the remaining data gaps to support preparation of this comprehensive Supplemental Upland RI/FS for the Site. Supplemental RI data

were collected by Floyd|Snider between March and August 2019, to meet the objectives of the RI Work Plan.

1.3 PURPOSE OF SUPPLEMENTAL UPLAND FEASIBILITY STUDY

The purpose of the FS is to evaluate and develop remedial action alternatives and select a Preferred Remedial Alternative for the Property, or for a portion of the Property, in accordance with Washington Administrative Code (WAC) 173-340-350 through 173-340-370. As previously mentioned, SES prepared separate FS reports for Bulk Terminal, ASKO, and East Waterfront Properties, which were submitted to Ecology in 2014 (2014d, 2014e, 2014f).

This FS was completed using updated data and current Site condition information and includes a review of additional remedial technologies, the completion of an updated disproportionate cost analysis (DCA), and selection of a preferred remedial alternative for the Site.

1.4 DOCUMENT ORGANIZATION

The RI sections of this document are organized as follows:

- **Section 2.0—Site Background and Setting.** Describes the Site and its setting, including features, adjacent properties, former and current operations, and geology and hydrogeology.
- **Section 3.0—Previous Site Characterization and Interim Actions.** Summarizes previous activities conducted on the Site by SES and others, including previous environmental investigations and interim cleanup actions.
- **Section 4.0—Preliminary Cleanup Level Development.** Provides the rationale for the development of preliminary cleanup levels (PCULs).
- **Section 5.0—Supplemental Upland Remedial Investigation Summary.** Provides a description of the identified data gaps and approach to sample collection to fill these data gaps, and a summary of sample results compared against PCULs.
- **Section 6.0—Development of Indicator Hazardous Substances and Proposed Cleanup Standards.** Identifies preliminary indicator hazardous substances (PIHSs) and proposed indicator hazardous substances (IHSs) in groundwater and soil, and selects cleanup standards for the proposed IHSs.
- **Section 7.0—Nature and Extent of Contamination.** Provides a summary of the nature and extent of the IHSs by medium and by parcel.
- **Section 8.0—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.

The FS sections of this document are organized as follows:

- **Section 9.0—Supplemental Feasibility Study.** Provides a summary of previous FSs for the Site, presents remedial action objectives, cleanup standards, and remediation levels for the Site.

- **Section 10.0—Supplemental Cleanup Action Alternative Screening.** Provides a summary of remedial technologies that were selected for further evaluation as part of the three separate FS reports for the Bulk Terminal, ASKO, and East Waterfront Properties (SES 2014d, 2014e, 2014f), along with a supplemental evaluation of retained remedial technologies with respect to their effectiveness for the IHSs.
- **Section 11.0—Identification of Sitewide Cleanup Action Alternatives**. Presents compiled cleanup action alternatives for groundwater and soil contamination at the Site and provides a description of the Sitewide alternatives.
- **Section 12.0—Remedial Alternatives Evaluation and Disproportionate Cost Analysis.** Evaluates the remedial alternatives proposed in Section 11.0 according to the Model Toxics Control Act (MTCA) requirements and evaluation criteria for a cleanup action. Summarizes the evaluation in a DCA and identifies a preferred cleanup remedy based on this analysis.
- **Section 13.0—Recommendations for the Preferred Remedial Alternative.** Provides detail regarding the preferred remedial alternative for the Site based on the results of the Section 12.0 evaluation.

The following section of this document contains references for both the RI and FS portions of this document:

- **Section 14.0—References.** Includes a list of references included in the Supplemental Upland RI/FS.

2.0 Site Background and Setting

The former TOC Seattle Terminal consists of four separate parcels (Bulk Terminal Property, ASKO Property, East Waterfront Property, and West Waterfront Property) located on W. Commodore Way in the Magnolia neighborhood of Seattle. The four parcels encompass a total of 10.42 acres, with 5.67 acres south of W. Commodore Way and 4.75 acres north of the roadway and along the Salmon Bay shoreline. 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. Property ownership extends from the four parcels to the middle of the adjacent W. Commodore Way. The general location of the Site is shown on Figure 1.1, and the Site and its surroundings are shown on Figure 1.2. The Site will be more specifically described and legally defined in the PPCD and that definition will govern.

2.1 SITE DESCRIPTION

Between 1941 and 2001, the former TOC Seattle Terminal 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 14 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 buildings are currently vacant, with the exception of Marine Service & Supply, Inc., a tenant that uses a building on the southern portion of the Property for sales and storage of marine supplies.

2.2 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 and ASKO Properties 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 4.10 acres. The Bulk Terminal Property is bounded to the east by 27th Avenue W 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 1.57 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 Company (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 3.17 acres. 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 1.58 acres and is adjacent to and west of the East Waterfront Property. The West Waterfront Property is bound to the west by Lockhaven Marina and Apartments and other residential properties beyond.

The former TOC Seattle Terminal and immediately surrounding area have mixed industrial zoning designations. The northern parcels (East Waterfront and West Waterfront Properties) are zoned by the City of Seattle as IG1 (focus on marine/rail industrial uses), and the majority of the southern parcels (Bulk Terminal and ASKO Properties) are zoned IG2 (broader range of industrial function, including commercial). The City of Seattle prohibits residential use in all industrial zones.

2.3 HISTORICAL AND CURRENT OWNERSHIP AND OPERATIONS

TOC was originally a Seattle-based oil distributor in the 1930s and became one of the largest petroleum products companies on the West Coast by the late 1960s. TOC began operations at the former 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 former TOC Seattle Terminal. Barrels were loaded onto ships at the Shipping Terminal Dock. The former 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 summary of the operational history at the former TOC Seattle Terminal properties is included in the following sections. Figures 2.1a and 2.1b show the former TOC Seattle Terminal features.

2.3.1 Bulk Terminal Property

The Bulk Terminal Property, which extends from W. Commodore Way to the BNSF parcel to the south, was originally two separate parcels owned by C.F. Anderson and H.D. Chaplin and was first developed for residential use in the early 1900s. In the 1920s and 1930s, the property was developed by Salmon Bay Manufacturing Company and Rattan Furniture Manufacturing Company (Rattan) for furniture manufacturing. In 1939, Jobbers Petroleum Company (Jobbers), a distributor of Hancock gasoline and other petroleum products, purchased the property. In March 1941, Jobbers opened the company's new plant on the Bulk Terminal Property. In support of their operations, Jobbers constructed a 500-foot pier to accommodate large oil tankers, a two-story office building, and storage tanks for 3 million gallons of gasoline (Calkins 1941).

From 1941 until 2001, TOC owned and operated the Bulk Terminal Property for the distribution of gasoline, diesel, kerosene, and mineral spirits to be transported by vessel, rail, or truck. In

support of petroleum bulk storage operations, TOC constructed several buildings on the western portion of the property. These included a 13,662-square-foot (SF) office building, a 7,200-SF warehouse building, two Foamite sheds and associated smaller Foamite houses containing hoses used for fire suppression, a boiler room, and a pump shed. The west side of the warehouse building extended onto the ASKO Property.

Between 1941 and 1944, 14 ASTs, and associated piping, were constructed in the Lower and Upper Tank Yards, within the central and eastern portion of the property. The storage capacity of the ASTs ranged between 219,450 to 966,000 gallons. Petroleum products were transported by drum and pipelines from the ASTs on the Bulk Terminal Property to barreling sheds. There, 5-gallon containers and 55-gallon drums were filled and then transported underneath W. Commodore Way to the East Waterfront Property using a barrel incline (former west and east barrel inclines) extending from a barreling shed to the East Waterfront Property. Two barreling sheds were located on the Bulk Terminal Property, one on the western portion of the property east of the ASKO Property and one on the southwestern portion of the property extending onto the ASKO Property. In 1941, two overhead fuel loading racks were constructed on the northern portion of the property adjacent to the Lower Tank Yard.

Fuel distribution lines were connected from the ASTs to a manifold system and then to overhead fuel loading racks. Fuel loading racks were also connected to the pipeline utilidor. Petroleum was then either transported from the Bulk Terminal Property through the pipeline utilidor that extended underground from the Lower Tank Yard to the Shipping Terminal Dock on the East Waterfront Property for loading onto vessels, or fuel would be pumped directly into tanker trucks through the overhead fuel loading racks. Four rail spurs entered onto the former 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.

A 10,000-gallon former penta mixing AST and associated piping was installed on the Bulk Terminal Property in 1967. According to TOC employees, as part of a military contract for a few months in 1967, wood preservatives were formulated near the west wall of the Lower Tank Yard. Penta crystals were mixed into heated diesel fuel in the former penta mixing AST located south of the pump shed. After mixing, wood preservative was then transferred via an underground pipeline to a barrel shed located on the ASKO Property. From there, 5-gallon containers and 55-gallon drums were loaded onto rail cars for shipment to Vietnam. A solvent known as “B-6,” and reported to possibly be a mineral spirit, was used in their formulation. However, based on the known petroleum products handled at the facility, it was reported that diesel or stove oil was likely used by TOC in formulating their wood preservative (SES 2014c).

As reported in a Phase I Environmental Site Assessment completed by Foster Wheeler (which included interviews conducted with former and current TOC 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 (Marine Service & Supply, Inc.), and warehouse space.

2.3.2 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. Other structures on the property included a 7,200-SF warehouse building constructed in 1947, a concrete platform constructed in 1948, and a 1,660-SF open-sided building constructed in 1952. 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 7,198-SF 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 ASKO Hydraulic Repair, later known as ASKO Industrial Repair, and began operating a hydraulic repair shop on the property that included oil and solvent storage and steam cleaning areas on the east side of the shop building. 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, Inc, a commercial fishing marine supply store, currently leases the 1947 warehouse building located on the southeast corner of the property for retail sales, storage, and equipment repair. The eastern portion of this warehouse building extends onto the Bulk Terminal Property.

2.3.3 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 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 East Waterfront Property in 1941. By the mid-1940s, all of the structures associated with Rattan had been removed. In 1943, the Shipping Terminal Dock

(located within the Washington State Department of Natural Resources [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 Bulk Terminal and ASKO Properties and 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 6,400-SF general storage warehouse building constructed on pilings with access to Salmon Bay, a 2,250-SF one-walled shed/canopy, a 1,518-SF garage, and a 226-SF laboratory building used for paint storage and quality testing of oil. 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, Inc. 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, Inc., operations. TOC reported that during a site visit with Icicle Seafood, Inc., several small areas of surface soil staining were observed attributed to the storage of "dismantled hydraulic equipment and auto maintenance activities." Presumably, Icicle Seafoods, Inc., used sandblast grit during their operations, because 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).

From 2005 until as recently as 2014, ASKO Selective Plating, a company that provides electroplating of parts and equipment for aerospace, marine, electronics and commercial industries, occupied a 1,920-SF storage warehouse building constructed in the 1970s. A second smaller, building presumed to be a storage shed is located to the east of the storage warehouse. The buildings on the parcel are currently vacant.

2.3.4 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 records of historical operations conducted on this portion of the former 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.

2.4 CURRENT PROPERTY FEATURES AND OPERATIONS

Three of the Property parcels, including the Bulk Terminal, East Waterfront, and West Waterfront Properties, are primarily unused. A portion of the ASKO Property and a portion of the Bulk Terminal Property are currently leased by Marine Service & Supply, Inc., a recreational watercraft storage and maintenance facility. The overwater portions of the West Waterfront Property are leased by Lockhaven Marina for houseboat moorage. The Bulk Terminal and ASKO Properties, and overwater structure areas of the East Waterfront Property, are fully fenced and accessed via locked gates. Current Site features are shown on Figure 2.2. The Property is serviced by public sewer (combined storm/sanitary), water, and electrical utilities, which enter the Property through various lateral lines branching off the main lines that run along W. Commodore Way.

On the eastern portion of the Bulk Terminal Property, in the vicinity of the former ASTs, the property is unpaved with a gravel ground surface. Structures on this portion of the property include three sheds that contain components of former groundwater and stormwater treatment systems and drums of waste byproducts from water treatment. A series of groundwater extraction wells and associated surface piping is located within a gravel-lined pit area. The northern and western portions of the property are paved with asphalt. In the vicinity of the former loading racks, ASTs used for water treatment are located within a concrete-bermed containment area. Surface piping from the ASTs and groundwater treatment piping/sheds is routed toward a King County Metro sanitary sewer discharge point. These groundwater extraction and treatment systems are currently inactive. Stormwater from the former AST area and paved areas of the Bulk Terminal Property is collected and managed by a stormwater treatment system, which remains operational. The stormwater treatment system is being monitored by the Trustee with permitted discharge to sanitary sewer (refer to Figure 2.2) under a King County discharge permit (permit 4427-01). Stormwater generated on other unpaved areas of the Bulk Terminal Property, such as the gravel pit and vegetated areas along the southern property line, infiltrates to the subsurface. Erosion has not been observed from unpaved areas of the Bulk Terminal Property due to the presence of stabilizing gravel surfacing; vegetation; an onsite stormwater treatment system; and, in the case of the gravel pit, topography that directs stormwater to the property interior.

The western portion of the Bulk Terminal Property is developed with the former TOC office building and paved parking areas surrounding the office building. The paved parking areas, as well as a loading dock area and series of buildings currently leased by Marine Service & Supply, Inc., extend from the Bulk Terminal Property onto the ASKO Property. The western portion of the ASKO Property is developed with a machine shop building that is currently vacant and paved parking areas surrounding the building. Roof drains from the former TOC office, current Marine Service & Supply, Inc., and former machine shop buildings and surface water runoff from paved areas are collected in on-property storm sewer catch basins. The remainder of the ASKO Property is unpaved and covered with grass. The larger unpaved grass area along W. Commodore Way (refer to Figure 2.2) is currently used for log storage by a tree service company. Stormwater generated on the unpaved areas of the property infiltrates to the subsurface. Erosion has not been observed from unpaved areas of the ASKO Property due to stabilizing vegetation.

The East Waterfront Property is largely unpaved aside from a former access driveway and an asphalt pad adjacent to the warehouse formerly used by ASKO Selective Plating. The ground surface at the East Waterfront Property consists of two gravel parking areas adjacent to the shed/garage and warehouse and is thickly vegetated along the waterfront and surrounding the parking areas. The West Waterfront Property contains a gravel driveway and parking area used by the residents of Lockhaven Marina and Apartments. The remaining ground surface on the West Waterfront Property is vegetated with managed landscape plants. The shoreline of the waterfront of Salmon Bay ranges in elevation from approximately 1 to 3 feet above the average water level of the bay, and the soil along the shoreline is stabilized by concrete and rock armoring to control erosion. The structures at the East Waterfront Property, including the former testing laboratory and shed/garage formerly used by TOC and the warehouse and storage shed formerly used by ASKO Selective Plating, are currently vacant. A single commercial-use pier originating at the East Waterfront Property that was formerly used by TOC is currently vacant and blocked from public access by a fence. Three smaller docks originating at the West Waterfront Property are used by residents of Lockhaven Marina and Apartments to access houseboats moored at the marina. Roof drains and stormwater collection structures have not been observed on either waterfront property, and stormwater generated on the waterfront properties is presumed to infiltrate to the subsurface. Erosion has not been observed on the waterfront properties due to the presence of gravel surfacing and stabilizing vegetation.

2.5 PHYSICAL SETTING, GEOLOGY, AND HYDROGEOLOGY

This section describes regional and Site-specific topography, geology, and hydrogeology. This information forms the basis of the conceptual hydrogeology model for the Site, which in turn provides information regarding how physical and chemical properties affect contamination transport from source areas to potential receptors.

2.5.1 Topography

The Site is generally situated on the southern shoreline of Salmon Bay, an embayment adjacent to the Hiram M. Chittenden Locks, which connect Lake Union to the Puget Sound. The local topography slopes gently to the north on the Bulk Terminal and ASKO Properties, then more steeply to the north toward Salmon Bay on the East Waterfront and West Waterfront Properties. A steep slope generally borders the Site to the south and is intersected by a BNSF rail line. The southern portion of the ASKO Property is terraced between the property and the rail line, and the southern portion of the Bulk Terminal Property is a cut slope. The Site is bordered to the west by the steep slopes of Kiwanis Memorial Preserve Park.

2.5.2 Regional Geology and Hydrogeology

The Site lies within the Puget Lowland region, which is a basin situated between the Cascade and Olympic mountain ranges. Shallow soils in the vicinity are characterized by interglacial and glacial deposits dating from the most recent Fraser glaciation. Deposits from older cycles of Quaternary glaciation and nonglaciation underlie the most recent deposits and are in turn underlain by tertiary bedrock, which is encountered between 300 and 400 feet below ground surface (bgs) in the vicinity

of the Site (Yount et al. 1985). Prior to the most recent Fraser glaciation, small rivers and shallow lakes deposited silt, clay and sand in the Puget Sound basin. The uppermost of these interglacial deposits are the Olympia beds and other preglacial deposits, which consist of oxidized layers of clay and silt thinly interbedded with sand. The uppermost preglacial deposits are characterized by interbedded silt/clay and sand with organic material, which are lavender to gray in color indicating cooling temperatures (Troost et al. 2005). Later during the Fraser glaciation, the glacier advancing from the north acted as an ice dam, which formed Lake Russell, a pro-glacial lake filling the Puget Sound basin. Lake deposits formed at the base of Lake Russell are the Lawton Clay, a massive clay layer without organic debris often greater than 30 meters thick (Mullineaux 1970, Troost et al. 2005). Overlying the Lawton Clay are the Esperance Sands, an advance outwash deposit of well-graded sand and gravel carried by rivers draining from the glacial front (Booth and Goldstein 1994). The Esperance Sands are overlain by Vashon Till, an unsorted mix of silt, clay, sand, and gravel deposited at the base of the glacier as it retreated north at the end of the Fraser glaciation.

The sandy water-bearing units within the glacial and nonglacial deposits overlying bedrock comprise the Puget Sound Aquifer System. In the vicinity of the Site, groundwater is present in sandy lenses within the Vashon Till, throughout the Esperance Sands, and in sandy interbeds within the preglacial deposits. The Esperance Sands are a major aquifer in the Seattle area, with measured hydraulic conductivities of greater than 10 meters per day (m/day), compared to conductivities generally measured at 0.1 m/day down to 0.0001 m/day in the overlying till and underlying preglacial units (Savage et al. 2000).

Regional groundwater in the area flows generally from topographic highs to topographic lows and discharges to adjacent water bodies. In the northward-sloping vicinity of the Site, groundwater flows north/northwest toward Salmon Bay.

2.5.3 Surface Water

The Property lies adjacent to Salmon Bay, a former tidal embayment that was dredged during construction of the Hiram M. Chittenden Locks connecting the inland water bodies of Lake Washington and Lake Union to the Puget Sound. Construction of the locks necessitated flooding Salmon Bay with water from a canal connecting to Lake Union to the east. The elevation of Lake Union was approximately 20 feet higher than Salmon Bay at the time of construction, and the current water level of the bay is, therefore, approximately 20 feet above the former water level of this historically marine embayment. The flooding of Salmon Bay with freshwater was completed in 1916.

Salmon Bay is connected via the locks to Shilshole Bay, a saltwater embayment of Puget Sound. The locks are required to be maintained at a water level of 20 to 22 feet above sea level to prevent saltwater intrusion into the freshwater lakes. Water levels are managed by the U.S. Army Corps of Engineers (USACE). Water is released via gates continually to maintain a water level of 20 feet during the wet season to reduce shoreline erosion from stormy winter weather. From mid-February through April, gates are closed in order to raise the water level to 22 feet above sea level by May 1. USACE manages water through the summer in order to maintain vessel traffic and flows for adult salmon in the fish ladder and juvenile salmon in the smolt slides. The

water level typically draws down slowly to 20 feet above sea level in late autumn at the beginning of the wet season (FBL 2014).

2.5.4 Geology and Hydrogeology

Soils at the Property generally consist of 2 to 5 feet of surficial fill underlain by interbedded interglacial deposits presumed to be the Olympia beds or transitional deposits between the Olympia beds and Lawton Clay. The overlying Lawton Clay, Esperance Sand, and Vashon Till units are exposed in the higher elevation bluffs to the west of the Site. Fill soils at the Site are composed of sand, silty sand, and gravel and are presumed to consist of engineered fill as well as reworked native soil. The interglacial beds are composed of low-permeability silt units interbedded with moist to wet sands and silty sands with moderate permeability.

Shallow native soils at the Property consist of soft silts, sands, and silty sands. Depths to groundwater are variable across the Property due to variability in topography described in Section 2.5.1. A discontinuous zone of shallow perched water is encountered in sandy and gravelly layers and within the shallow soft silt. The Perched Water-Bearing Zone (WBZ) is typically encountered at elevations between 50 and 46 feet North American Vertical Datum of 1988 (NAVD 88) and is present on the upslope southern portion of the ASKO Property.

Another WBZ, referred to as the Shallow WBZ, is encountered within silty sands. The Shallow WBZ is present at elevations as high as 42 feet NAVD 88 on the Bulk Terminal Property and slopes downward to the north and west. The Shallow WBZ is underlain by a continuous low-permeability layer of slightly moist to dry, stiff sandy silt approximately 5 feet thick that generally slopes to the north along with the Site topography. The thickness of the Shallow WBZ ranges from approximately 5 to 12 feet on the Bulk Terminal and ASKO Properties, then thins as it crosses W. Commodore Way and approaches the steep slope to the north; the thickness of this saturated zone is less than 1 foot along the north side of the ROW. Farther north, the Shallow WBZ slopes more gently on the East Waterfront and West Waterfront Properties to the approximate level of Salmon Bay (about 20 feet NAVD 88) and may experience additional recharge from infiltration through the unpaved areas of these properties. It is presumed that the Shallow WBZ discharges to Salmon Bay.

A third Sitewide WBZ, referred to as the Intermediate WBZ, is encountered in sand/silty sand deposits below the uppermost low-permeability silt layer. The elevation of the Intermediate WBZ is relatively flat relative to the ground surface and generally slopes to the north toward Salmon Bay, ranging in elevation from 20 feet NAVD 88 to 2 feet NAVD 88 across the Site. The Intermediate WBZ is underlain by a second low-permeability stiff silt layer estimated to be approximately 5 feet thick. This silt layer also slopes northward consistent with overall Site topography. The elevation of the Intermediate WBZ where it meets Salmon Bay is similar (within approximately 1 foot) to the water level in the bay, and it is presumed that the Intermediate WBZ discharges, at least in part, to Salmon Bay.

A fourth Sitewide WBZ, referred to as the Deep WBZ, has been documented at the boring for well 01MW65. The Deep WBZ is present within deeper sand/silty sand deposits at an elevation of 0 feet NAVD 88 at this location.

Downward vertical gradients have been measured consistently between the Perched and Shallow WBZs and between the Shallow and Intermediate WBZs. Vertical gradients are more strongly downward to the south on the Bulk Terminal and ASKO Properties and become weakly downward to flat to the north at the shoreline of Salmon Bay. Previous monitoring events conducted by SES also found downward vertical gradients between the Intermediate and Deep WBZs. Available groundwater quality data also suggest that downward flow of groundwater occurs from the Shallow WBZ to the Intermediate WBZ; however, this flow is limited by the presence of low-permeability silt layers between the two WBZs.

Lateral groundwater gradients have been documented most extensively in the Shallow WBZ. In this WBZ, although overall groundwater flow is to the northwest, secondary flow directions to the north/northeast and west 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 are present to the south of and within the W. Commodore Way.

2.5.4.1 Hydraulic Conductivity

Hydraulic conductivity was previously measured at selected wells by slug tests performed by SES. SES collected rising head measurements to calculate hydraulic conductivity according to the Bouwer Rice analysis method.

Hydraulic conductivity measurements ranged from 0.03 to 1.9 m/day at the Site and were generally consistent with regional measurements that estimate the area to have low-moderate to moderate perviousness. These conductivities varied by WBZ and position at the Site and are summarized below.

- The lowest hydraulic conductivities were measured in the light non-aqueous-phase liquid (LNAPL)-saturated area of the Shallow WBZ on the Bulk Terminal Property and in W. Commodore Way north of the Bulk Terminal Property, where significant thinning of the Shallow WBZ occurs. The hydraulic conductivity in the LNAPL-saturated area (01MW21) was 0.03 m/day, and the hydraulic conductivity in the ROW (01MW03) was 0.6 m/day.
- In the Shallow WBZ, hydraulic conductivities ranged from 1.0 to 1.5 m/day in the interior of the Bulk Terminal and ASKO Properties (01MW40, 01MW44, 01MW62). Shallow WBZ hydraulic conductivity on the West Waterfront Property (02MW14) was 1.8 m/day.
- Hydraulic conductivity was lower, at 0.9 m/day in the Intermediate WBZ at the ASKO Property (01MW57). Of the two wells screened in both the Shallow and Intermediate WBZs on the Bulk Terminal Property (01MW38 and 01MW59), hydraulic conductivity measurements were inconsistent at 1.6 and 0.8 m/day, respectively.
- The greatest hydraulic conductivity of 1.9 m/day was measured in the Deep WBZ (01MW65).

Hydraulic conductivity measurements were also analyzed in two laboratory samples collected from the Shallow WBZ by SES. Hydraulic conductivity in these samples ranged from 0.9 to 1.7 m/day.

2.5.4.2 Groundwater Seepage Velocity

Groundwater seepage velocity can be calculated using the measured values of horizontal gradient, hydraulic conductivity, and porosity according to the Darcy's law equation $v_s=(K*i)/\rho$ where: v_s equals seepage velocity, K equals hydraulic conductivity, i equals the horizontal gradient, and ρ equals porosity. Laboratory measurements of effective porosity of samples collected from the Shallow WBZ by SES ranged from 32.8 to 33.8. Using an average porosity of 33.3, the estimated seepage velocities in the Shallow WBZ are consistent across all parts of the Site, ranging from approximately 0.002 to 0.003 meters per day in the interior of the Bulk Terminal and ASKO Properties, W. Commodore Way, and waterfront properties.

2.5.5 Groundwater Potability

The low-moderate perviousness of the water-bearing soils in the vicinity of the Site suggests that shallow groundwater at the Site would not be a commercially viable source of groundwater withdrawal for use as drinking water. Site-specific testing to determine the potability of groundwater has not been completed.

Shallow groundwater at the Site discharges to the adjacent Salmon Bay. Although Salmon Bay has historically experienced saline intrusion, particularly during summer months, because of mixing with seawater that occurs at the Hiram M. Chittenden Locks (Floyd Snider McCarthy et al. 2003), the length of the Lake Washington Ship Canal from Lake Washington to the locks is considered to be usable as a drinking water source by the Washington State Surface Water Quality Standards (WAC 172-201A-200; Table 602). Therefore, for the purposes of evaluation of groundwater quality in this RI, potable groundwater standards will be used for assessment.

2.6 W. COMMODORE WAY NORTH TRUNK SEWER LINE

Between 1909 and 1913, the City of Seattle constructed the Interbay District of the North Trunk System beneath W. Commodore Way. The sewer line beneath W. Commodore Way was constructed as a 144-inch brick-lined pipe that ran approximately 40 feet below street grade. The sewer line in the vicinity of the Site was constructed as a "tunnel lining where excavation was by mining methods" (Municipality of Metropolitan Seattle 1976), which indicates that the pipe was tunneled between dug shafts, rather than constructed in an open trench. The tunnel portion of this sewer line was constructed with a brick crown within a timber set and lagging and traversed to the west under Fort Lawton. The North Trunk Sewer Line receives wastewater from additional sewer lines upslope to the south, including a line that runs from W. Government Way along the western boundary of the Property and a line that runs from 27th Avenue W. along the eastern boundary of the Property. The alignment of the sewer pipes in the vicinity of the Property is shown on Figures 2.1 and 2.2. Construction details of the North Trunk Sewer Line are shown on Figure 2.3.

Construction of the sewer system would have occurred in native soil deposits, because the shoreline configuration in this area did not change substantially until 1912 when 245,000 cubic yards (CY) of sediment were dredged for the construction of Hiram M. Chittenden Locks and the Lake Washington Ship Canal, which raised the water level in Salmon Bay to 20 feet above mean sea level and transformed the tidal bay to a freshwater reservoir (Williams 2017). The shoreline in the vicinity of the Site remains largely unchanged since before construction of the Hiram M. Chittenden Locks. More significant shoreline changes occurred on the northern shoreline of Salmon Bay adjacent to the Ballard neighborhood of Seattle, where prior saltwater wetland areas were filled during industrial development of the area.

Construction of the pipe primarily by tunneling is consistent with subsurface geology observations in the ROW; at multiple locations, borings were advanced through an undisturbed silty sand Shallow WBZ and underlying low permeability silt. Timber lagging believed to be top of the sewer pipe corridor was encountered during previous soil boring investigations by SES in W. Commodore Way at approximately 26 feet bgs. This finding is consistent with the probable trench support system built on top of the 12-foot-diameter pipe, which is expected to be approximately 28 feet bgs. The top of the sewer pipe lays below the elevation of the Intermediate WBZ in this area, where the potentiometric surface is approximately 22 to 24 feet bgs. There is, therefore, likely some groundwater seepage to the pipe (and possible seepage out of the pipe), given its age and brick construction. This is expected to be primarily in the Intermediate WBZ where saturated soils are in direct contact with the pipe; however, given the depth and size of the pipe, direct study of this interaction is difficult and hydrogeologic interpretations are inferred from surrounding soil boring and monitoring well data.

The sewer pipe continues to the west beyond the Property where it is tunneled under Fort Lawton and eventually connected to an outfall at the base of a bluff at West Point that discharges into Puget Sound. Sewage conveyed by the pipe has been treated at the West Point Treatment Plant (WPTP) prior to discharge since completion of the WPTP in 1966.

The W. Commodore Way North Trunk Sewer Line is currently owned and managed by King County. It was originally designed to convey raw sewage from Lake Union to Puget Sound. The sewer line currently receives inputs of treated and untreated waste waters that are regulated by King County Industrial Waste Program discharge limits for metals, volatiles, petroleum, and other organic compounds.

2.7 ECOLOGICAL SETTING

The Property includes two upland parcels that have been significantly graded and developed for commercial/industrial uses (the Bulk Terminal and ASKO Properties) and two parcels adjacent to Salmon Bay that have been more lightly developed and have more vegetation (East Waterfront and West Waterfront Properties).

On the upland parcels, the ground surface is composed primarily of pavement or crushed gravel, with minor vegetated areas. Vegetation on these parcels is unmaintained and composed primarily of turf grass and invasive and pioneering species including lichens/mosses, blackberries,

sedges, scotch broom, tansy ragwort, thistles, and poplar seedlings. On the waterfront parcels, the vegetated areas comprise larger portions of the land area. Vegetation on the East Waterfront Property is similar to the upland parcels and also unmaintained. Vegetation on the West Waterfront Property is maintained by Lockhaven Marina and includes grasses and ornamental landscape plants, blackberries, and some established trees.

Future development plans will include installation of buildings, impervious pavement, or landscaping with biological barriers to fully cover the ground surface of the two upland parcels. There are no current redevelopment plans for the East Waterfront and West Waterfront Properties; the waterfront parcels may be redeveloped in the future for commercial/industrial use consistent with zoning based on the specific needs of a future user.

The surrounding area is heavily developed with commercial/industrial buildings and paved surfaces. The largest vegetated area is the BNSF parcel to the south, which is lined by trees and other vegetation along both sides of the rail line.

The proximity of the Site to Salmon Bay, a freshwater embayment, attracts waterfowl, primarily mallard ducks and Canada geese. Geese have been observed to nest and feed along the shoreline on the East Waterfront and West Waterfront Properties. Other wildlife with a high likelihood to be present at the Site include birds that use trees or structures for nests and rodents.

2.7.1 Terrestrial Ecological Evaluation

In accordance with WAC 173-340-7493, a site-specific terrestrial ecological evaluation (TEE) is prepared in order to evaluate the contaminants present at the Property and develop site-specific CULs to protect ecological receptors. A site-specific TEE may either develop site-specific CULs based on toxicological data and site-specific conditions or adopt the ecological indicator soil concentrations provided in Table 749-2 as the most conservative criteria for data assessment.

In accordance with WAC 173-340-7490, a TEE was considered because of the presence of legacy contamination in soil above 15 feet bgs (refer to Section 3.4 for a detailed summary of historical analytical data), where it may be disturbed by excavation resulting in exposure to ecological receptors. A summary of the TEE process completed for the Property is provided below.

1. **Step 1: Evaluate whether the Property qualifies for an exemption.**

   None of the exemptions listed WAC 173-340-7491(1) apply to the Property.

2. **Step 2: Evaluate whether a Site-specific TEE is required.**

   Under WAC 173-340-7491(2)(a)(i), a site-specific TEE is triggered by the Property's location adjacent to land designated as blue heron nesting area by the Washington Department of Fish and Wildlife (WDFW), where management plans require that nesting trees be retained. The requirement for maintaining trees is for the presence of the nesting colony, not because of foraging or site-specific use other than nesting. The nesting colony is defined as the area inside the line created when the outermost nesting trees are connected. Portions of the ASKO and Bulk Terminal Properties

adjacent to the nesting colony lie within the 197-foot year-round buffer for the nesting area. The ground surface of the Property in the buffer area consists of asphalt pavement, buildings, crushed gravel surfacing, non-native plants such as blackberries (refer to Section 2.7) and limited areas of grass that are regularly mowed.

3. Step 3: Evaluate Site-specific TEE problem formulation.

Problem formulation consists of evaluating whether hazardous substances are present at the Property at concentrations greater than the applicable indicator concentrations for the Property's land use, determining whether exposure pathways are complete, determining whether terrestrial receptors of concern are present at the Property, and determining the potential toxicity of hazardous substances to terrestrial receptors.

A. Evaluate chemicals of ecological concern.

The land use was first determined in order to identify the applicable indicator concentrations of hazardous substances to compare to Property soil data. The Property is zoned industrial, which permits industrial and commercial use; residential use is prohibited. In accordance with WAC 173-340-7490(3)(b), any TEE conducted at an industrial site (i.e., either a simplified or a site-specific TEE) should consider terrestrial wildlife receptors and need not consider plants and soil biota. The Property does not fit the exemptions to industrial zoning listed in WAC 173-340-7490(3)(b) that would trigger evaluation of plants and soil biota; specifically, Endangered Species Act-listed species are not present at the Property, and although the Property lies adjacent to a designated nesting area where "vegetation (i.e. nesting trees) must be maintained to comply with local government land use regulations" (WAC 173-340-7493(2)(a)(i)), regulatory requirements for the buffer zone include review of building plans but do not contain prescriptive requirements for vegetation maintenance.

The known concentrations of hazardous substances based on prior investigations were compared to the indicator concentrations for terrestrial wildlife presented in Table 749-3. The hazardous substances that are listed in Table 749-3 are also present at the Property and would be carried forward as chemicals of ecological concern for further evaluation based on maximum concentrations that exceed the TEE wildlife indicator concentrations. These include arsenic, barium, cadmium, chromium, lead, selenium, chlorinated dibenzofurans, chlorinated dibenzo-p-dioxins, GRO, and DRO (summed with ORO).

B. Evaluate exposure pathways, terrestrial ecological receptors of concern, and toxicological assessment.

The remainder of WAC 173-340-7493(2) details procedures for determining whether further evaluation is needed based on complete exposure pathways, the presence of wildlife receptors, and toxicity of hazardous substances to the likely wildlife receptors. The criteria retained for subsequent steps of the TEE are the indicator concentrations for terrestrial wildlife protection, as discussed in step 3.A above.

4. **Step 4: Select appropriate TEE methods.**

   As stated in WAC 173-340-7493(3), "If it is determined that further evaluation is necessary, the soil concentrations listed in Table 749-3 may be used as cleanup levels." In accordance with WAC 173-340-7493(2)(a)(i), the ecological indicator soil concentrations for wildlife receptors listed in Table 749-3 for commercial or industrial zoned sites will be used as conservative criteria in the development of PCULs to assess ecological risk posed by contaminants at the Property.

2.8 CULTURAL RESOURCES

Archaeological evidence in the vicinity of the Property has established that Native Americans inhabited Puget Sound and the area around Salmon Bay between 5,000 and 2,500 years ago. The most well-known archaeological site in this area is the West Point Site Complex, located approximately 2 miles west of the Property at the WPTP. Several archaeological shell midden deposits and hundreds of artifacts were discovered during the expansion of the WPTP in 1992 (King County DMS 1995). Prior to construction of Hiram M. Chittenden Locks and dredging of the ship canal entrance, Salmon Bay was a tide flat and an important area for shellfish and salmon fishing for the Duwamish people. Permanent Duwamish settlements were located along the shorelines of Salmon Bay (DAHP 2019, The Burke Museum 2019). After European-American settlement in the 1850s, shoreline property became highly sought after and was developed for residential and commercial uses. Early industries such as lumber and shingle mills and boat builders were located along the waterfront areas of Salmon Bay in the early 1900s. In 1911, the U.S. Army Corps of Engineers began construction of the ship canal and locks, which opened in 1917, making Lake Washington navigable from the Puget Sound.

The Washington Information System for Architectural and Archaeological Records Data, managed by the Washington State Department of Archaeology and Historic Preservation (DAHP), was reviewed for the presence of historic and prehistoric cultural resources. While no historic or prehistoric cultural resources have been documented either on or adjacent to the Property, archaeological sites are present along the shoreline areas less than 0.5 miles (805 meters) from the Site in all directions (DAHP 2019). The Property is located within a high-risk area for encountering cultural resources as determined by DAHP's predictive model.

The shoreline areas also retain historic properties, such as overwater structures and historic buildings related to former commerce on the ship canal, including operating boat yards and former mill sites. Many of these structures remain in their original or closely related function. The pier structure and inner harbor area associated within the East Waterfront Property (Parcel ID 1125039120) is located within the boundary of the Hiram M. Chittenden Locks and Lake Washington Ship Canal Historic District (DAHP 2019). Given the Property's industrial waterfront history, it is possible that historic-period artifacts may be encountered on the Property during future remedial action.

3.0 Previous Characterization and Interim Actions

This section provides an overview of environmental investigations and interim actions that were previously completed at the Property and includes a summary of the historical groundwater and soil dataset that considers the previous interim cleanup actions to reflect the most current conditions. These investigations resulted in the collection of a significant amount of groundwater and soil data. The 2014 site-specific RIs previously completed comprehensive reviews of the historical groundwater and soil data collected between 1991 and 2005 and data collected during the RIs between 2006 and 2014 at the Bulk Terminal, ASKO, and East Waterfront Properties. Discussions of the pre-2014 data including data summary tables and figures resulting from these investigations are presented in the RI reports prepared by SES and submitted to Ecology in 2014 (SES 2014a, 2014b, and 2014c). Figures from the site-specific RIs showing previous sample locations are provided in Appendix A. The data presented in the RI reports do not necessarily represent current Site conditions, because several investigations and interim cleanup actions have been conducted that were not fully documented in the RI reports.

Additional investigations completed after the RIs 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 (SES 2016c, 2016d, 2016e). Data collected from each of these investigations are discussed in greater detail in their respective reports, which include data summary tables and figures. A brief summary is included in the following sections.

3.1 PREVIOUS INVESTIGATIONS

Numerous environmental investigations including collection of hundreds of samples were previously conducted between 1991 and 2016 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 monitoring wells that were installed, along with the wells' designated WBZ screened intervals, during previous investigations are shown on Figures 3.1a and 3.1b. The location of all soil borings are shown on Figure 3.2. Below is a summary of the environmental investigations that took place at each parcel.

3.1.1 Groundwater and Soil Investigations Prior to 2006

Between 1999 and 2002, Foster Wheeler conducted multiple field investigations on behalf of TOC to collect groundwater and soil data on the Bulk Terminal and ASKO Properties and within W. Commodore Way. These events included two focused subsurface investigations in November 2000 and July 2001 to characterize contamination around areas of high concern identified during the Phase I Environmental Site Assessments completed in 2000. The following is a summary of the data collected between 1999 and 2002 by Foster Wheeler:

- A total of 78 soil borings were advanced on the Bulk Terminal Property and W. Commodore Way. Soil samples were collected and submitted for analysis at 53 of

these locations. Samples were tested for one or more of the following: TPH; benzene, toluene, ethylbenzene, and xylenes (BTEX); penta; lead; and cPAHs.

- 27 of the borings on the Bulk Terminal Property and W. Commodore Way were converted into monitoring wells 01MW01 through 01MW06, 01MW08 through 01MW14, and 01MW16 through 01MW29.
- A total of 18 soil borings were advanced on the ASKO Property. Soil samples were collected and submitted for analysis at 13 locations. Samples were tested for one or more of the following: TPH, BTEX, penta, lead, and cPAHs.
- Two of the borings on the ASKO Property were converted into monitoring wells 01MW15 and 01MW17.

In June and September 1999, an investigation on the East Waterfront Property was conducted by IT Corporation to characterize groundwater and soil conditions around the former waste oil UST. A total of 14 soil borings were advanced and five of the locations were converted into monitoring wells 02MW01 through 02MW05. Soil samples were collected from 12 of the locations and analyzed for TPH, BTEX, and lead.

In 2001, Foster Wheeler advanced two more borings on the East Waterfront Property and converted them into monitoring wells 02MW06 and 02MW07. No soil analytical results were available for these borings.

Multiple groundwater monitoring events were conducted on the Bulk Terminal Property between 1999 and 2005. GRO, DRO, ORO, BTEX, penta, and lead were all detected in groundwater during these events.

3.1.2 Previous Remedial Investigation

SES completed the data collection for the RI at the Bulk Terminal, ASKO, and East Waterfront Properties between April 2006 and February 2013. Below are summaries of the RI data collected at each of the properties.

Bulk Terminal Property

The Bulk Terminal Property RI included a ground-penetrating radar (GPR) survey; monitoring well installation; soil, groundwater, and LNAPL characterization sampling; and aquifer testing. A total of 172 borings were advanced during the RI to characterize the extent of penta, dioxins/furans, GRO, DRO, ORO, and BTEX in soil. Of these soil boring locations, 34 were converted into monitoring wells. These monitoring wells were 01MW30 through 01MW43, 01MW47 through 01MW51, 01MW59, 01MW66 through 01MW69, 01MW72 through 01MW75, 01MW84, 01MW86 through 01MW88, 01MW90, and 01MW91. Seventeen groundwater monitoring events were completed quarterly or semiannually from 2006 to 2013. Groundwater samples were analyzed for GRO, DRO, ORO, BTEX, volatile organic compounds (VOCs), penta, metals, and natural attenuation parameters.

ASKO Property

The ASKO Property RI included monitoring well installation, groundwater and soil characterization sampling, and aquifer testing. A total of 79 borings were advanced during the RI to characterize the extent of GRO, DRO, ORO, BTEX, VOCs, metals, and cPAHs in soil. Of these soil boring locations, 45 were converted into monitoring wells. Additionally, two borings were converted into injection wells and one boring was converted into a soil vapor extraction (SVE) well. The monitoring wells included MW01 through MW06, 01MW44 through 01MW46, 01MW52 through 01MW65, 01MW70, 01MW71, 01MW76 through 01MW83, 01MW89, 01MW92 through 01MW98, 02MW13, and 02MW14. Twenty-four groundwater monitoring events were completed from 2006 to 2013. Groundwater samples were analyzed for GRO, DRO, ORO, BTEX, VOCs, metals, and natural attenuation parameters.

East Waterfront Property

The East Waterfront Property RI included a GPR survey; UST assessment survey; monitoring well installation; soil, groundwater, and LNAPL characterization sampling; and aquifer testing. A total of 18 borings were advanced during the RI to characterize the extent of GRO, DRO, ORO, BTEX, VOCs, and lead in soil. Six of these soil boring locations were converted into monitoring wells 02MW08 through 02MW13. Sixteen groundwater monitoring events were completed quarterly or semiannually from 2006 to 2013. Groundwater samples were analyzed for GRO, DRO, ORO, BTEX, VOCs, and lead.

3.1.3 Supplemental Groundwater and Soil Investigations

Additional investigations completed by SES after the submittal of the 2014 RI reports included subsurface investigations at the Bulk Terminal and East Waterfront Properties in 2014 and 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 (SES 2016c, 2016d, 2016e). The most recent groundwater sampling events prior to the Supplemental RI data collection were conducted by SES in May 2016. The results from these groundwater events are summarized in the groundwater monitoring reports prepared for TOC (SES 2016c, 2016d, 2016e).

The 2014 and 2015 investigations at the Bulk Terminal Property are summarized below:

- In 2014, 28 additional soil borings (B327 through B354) were advanced in the vicinity of the 2012 excavation to evaluate whether 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 cleanup level (CUL) of 2.5 milligrams per kilogram (mg/kg).
- In 2015, 24 additional soil samples from seven borings (B357 through B363) were collected to address a data gap identified in the Bulk Terminal Property RI (SES 2014a) 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 MTCA Method A CULs. 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.

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 Property RI report (SES 2014a) and in Section 3.3 of the East Waterfront Property RI report (SES 2014c), with few exceptions noted below.[2] A brief summary is included below. Refer to Figure 3.3 for the locations of the interim cleanup actions involving soil excavation on the Bulk Terminal Property and Figure 3.4 for the locations of the interim cleanup action soil excavations on the East Waterfront Property.

3.2.1 Bulk Terminal Property

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

- **1991:** Removal of two USTs (UST #1 and #2; one gasoline and one dual-compartment with gasoline and diesel) and two connected fuel dispensers (shown on Figure 3.3). The removal included excavation of 140 CY of associated TPH-contaminated soil. Eight soil samples were collected from the excavation sidewalls and base and analyzed for TPH, BTEX, and lead. A new 4,000 gallon dual-compartment tank (UST #3) and new fuel dispensers were installed during backfill of the excavation.
- **2002:** Removal of 13 CY of surface soil in response to an accidental release of hydraulic fluid from a truck. The specific area of this release and excavation is not known. Six soil samples were collected from the base of the excavation and analyzed for TPH, BTEX, and lead. The analytical results were less than PCULs established in the 2014 RI.
- **2002:** Former penta mixing AST excavation; included the removal of 70 CY of penta-contaminated soil. Monitoring well 01MW14 was decommissioned during the excavation. Nine confirmation samples were collected from the base of the excavation and analyzed for penta.
- **2006:** Removal of the 4,000-gallon dual-compartment UST (UST #3), associated fuel dispensers, and a 3,000-gallon vapor knockout additive tank (UST #4). Twelve soil samples were collected from the base and sidewalls of the two ASTs and fuel dispensers. The samples were analyzed for TPH, BTEX, VOCs, and lead.

[2] 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 Property. In addition, some details regarding a groundwater and LNAPL extraction system were available but did not include complete information regarding system construction or operation.

- **June 2010:** Removal of a 300-gallon storage tank east of the Headquarters Building. Three soil samples were collected from the sidewalls and base of the excavation and analyzed for TPH and BTEX.
- **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 CY of contaminated soil.
- **2012:** Penta and dioxin/furan final excavation; included the removal of 2,700 CY of contaminated soil. A summary of this excavation was included in the SES RI report (SES 2014c). All contaminated soil with penta concentrations greater than the direct contact CUL of 2.5 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 the 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: SES 2014c). Performance and confirmation soil samples were collected during the excavation. Four soil samples were analyzed for dioxins/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 2014c). 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 the interim cleanup action. As reported in the 2014 RI, these results confirmed that penta and associated dioxins/furans in soil have been removed from the Site down to direct contact CULs (SES 2014c). During the excavation, an additional 47 samples were collected and analyzed for TPH and BTEX. The 2012 excavation did not address the extent of petroleum contamination.
- **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).
- **Approximately 2012 through 2017:** Groundwater and 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. Based on information contained in a King County Industrial Waste Program Wastewater Discharge Permit Application from February 2017, it appears there were 30 pumps that were intermittently active with an average discharge rate from the groundwater treatment system of 17,000 gallons per day (with a maximum daily discharge of 86,000 gallons). It appears based on information provided in the application that the system operated continuously during the wet season (with higher daily discharge rates) and intermittently during the dry season (with lower daily discharge rates).

- **2014:** Removal of approximately 300-gallon heating oil UST (UST #5) east of the Headquarters Building. Five soil samples were collected from the base and sidewalls of the excavation and analyzed for TPH and BTEX.

3.2.2 East Waterfront Property

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

- **1991:** Removal of a 300-gallon waste oil UST; included the removal of 100 CY of contaminated soil. Field observations of stained soil, petroleum odor, and heavy sheen on the surface of the water table were noted during the excavation.
- **1992:** Additional excavation in the vicinity of the former waste oil UST; included excavation of 150 CY 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 CY of petroleum-contaminated soil. The gasoline UST was not observed during excavation activities.
- **2013:** TPH soil excavation; included the removal of 1,700 CY 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 SUMMARY OF HISTORICAL GROUNDWATER DATA

Groundwater monitoring was performed by SES quarterly or semiannually from 2006 to 2016. The historical groundwater dataset used for this Supplemental Upland RI/FS includes only the most recent data collected for each well and for each analyte, which is between 2013 and 2016 for most analytes. The historical groundwater dataset does not include the more recent groundwater data collected as part of the Supplemental Upland RI between March and August 2019, which is

discussed in Section 5.0. Data from decommissioned wells, injection wells, and SVE wells were not included.

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

3.3.1 Bulk Terminal Property

The historical groundwater dataset includes data from 56 monitoring wells in the Bulk Terminal Property monitoring well network. Fifty-four monitoring wells were designated as Shallow WBZ groundwater wells, and two were designated as 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.

SES measured the thickness of LNAPL during each groundwater monitoring event. The maximum observed LNAPL thickness was 6.05 feet at 01MW10 in April 2013. Monitoring wells 01MW05 and 01MW10 have historically contained the thickest measured LNAPL, and both contained over 5 feet of LNAPL during the 2016 groundwater monitoring event. Prior to the 2012 penta and dioxin/furan excavation, LNAPL was present continuously from W. Commodore Way to monitoring well 01MW72. The 2016 groundwater monitoring event conducted by SES measured two distinct areas of LNAPL: one area at the Bulk Terminal Property's north boundary and one area around monitoring wells 01MW72 and 01MW73. The distribution and thickness based on the 2016 groundwater monitoring event is shown on Figure 5.1 of the RI Work Plan (Floyd|Snider 2019). The current LNAPL extent was modified following the Supplemental Upland RI Groundwater investigation discussed further in Section 5.4.4. SES additionally collected characterization samples of the LNAPL product and found that it was composed of GRO and DRO, with no detectable penta.

The primary groundwater COPCs developed in the RI Work Plan that are present within the Bulk Terminal Property include GRO, DRO, ORO, benzene, and ethylbenzene. Monitoring wells with concentrations of primary COPCs greater than the PSLs developed in the RI Work Plan are located primarily in the vicinity of the northern LNAPL plume (Figures 5.2 and 5.3 of the RI Work Plan). Elevated concentrations of TPH and benzene near the northern LNAPL plume extend in the direction of groundwater flow to the northernmost monitoring well, 01MW84, which is located on W. Commodore Way near the southern boundary of the East Waterfront Property. Additionally, high concentrations of TPH are located in the vicinity of the southern LNAPL plume and in the vicinity of the former ASTs, but the plume does not extend offsite to the south.

The range of analytical results in shallow and Intermediate WBZs for primary COPCs detected within the Bulk Terminal Property are summarized below. The results of non-detects and field duplicates were not reported.

- GRO was detected in 17 of 47 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 Bulk Terminal Property in the vicinity of the former pump island and area of LNAPL in groundwater.
- DRO was detected in 43 of 47 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.
- 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.
- 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 Bulk Terminal Property in the vicinity of the former pump island, in 2016.
- Ethylbenzene was detected in 16 of 47 monitoring wells. Detected concentrations of ethylbenzene ranged from 1.1 to 820 µg/L. The maximum concentration was also detected in 01MW19 in the LNAPL area in 2016.

3.3.2 ASKO Property

The historical ASKO Property groundwater dataset includes data from 49 monitoring wells in the ASKO Property monitoring well network, including the Shallow WBZ well located on the West Waterfront Property. Eight monitoring wells were designated as Perched WBZ wells, 34 were designated as Shallow WBZ wells, six were designated as Intermediate WBZ wells, and one was designated as a Deep WBZ well. One shallow monitoring well, 01MW81, was never sampled by SES. 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.

The primary groundwater COPCs developed in the RI Work Plan that are present within the ASKO Property include GRO, DRO, ORO, benzene, and cVOCs (*cis*-1,2-DCE, TCE, and vinyl chloride).

Monitoring wells with elevated TPH concentrations are located in the vicinity of 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, shown on Figure 2.1b.

Monitoring wells with elevated benzene concentrations are located northeast of the former oil and solvent storage area, and in the vicinity of the former barreling sheds #2 and #3, shown on Figure 2.1b.

High concentrations of cVOCs were detected in the vicinity of the former rail spurs on the BNSF parcel and historical operations on the west/central portion of the ASKO Property. Vinyl chloride and *cis*-1,2-DCE were detected in monitoring wells 01MW85 and 01MW53 outside of the ASKO Property on W. Commodore Way. There were no other offsite detections of cVOCs to the north of the ASKO Property on W. Commodore Way or the wells located along the southern boundary of the East Waterfront and West Waterfront Properties (Figure 5.6 of the RI Work Plan).

The range of historical analytical results for primary COPCs detected within the ASKO Property are summarized in the following sections by WBZ. The results of non-detects and field duplicates were not reported.

3.3.2.1 Perched Water-Bearing Zone

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

- GRO was detected in six of eight 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 parcel.
- DRO was detected in all eight 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 parcel.
- ORO was detected in seven of eight 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.
- *cis*-1,2-DCE was detected in seven of eight 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 parcel.
- TCE was detected in six of eight monitoring wells. Detected concentrations 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 parcel.
- Vinyl chloride was detected in five of eight monitoring wells. Detected concentrations 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.

3.3.2.2 Shallow Water-Bearing Zone

The ASKO Property monitoring well network has 34 Shallow WBZ wells. The results of the primary COPCs are summarized below:

- GRO was detected in 7 of 33 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.
- DRO was detected in 26 of 33 monitoring wells. Detected concentrations ranged from 53 to 1,300 µg/L. The maximum concentration was detected in 2016 in three Shallow WBZ wells (01MW07, 01MW45, and 01MW56), which all are located on the northeast corner of the ASKO Property.
- ORO was detected in 4 of 33 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.
- Benzene was detected in 10 of 33 monitoring wells. Detected concentrations 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.
- *cis*-1,2-DCE was detected in 15 of 33 monitoring wells. Detected concentrations ranged from 0.2 to 440 µg/L. The maximum concentration was detected in 2016 in monitoring well 01MW63 near former barreling shed #3.
- TCE was detected in 13 of 33 monitoring wells. Detected concentrations ranged from 0.2 to 7,700 µg/L. The maximum concentration was also detected in 2016 in monitoring well 01MW63.
- Vinyl chloride was detected in 16 of 33 monitoring wells. Detected concentrations of ranged from 0.2 to 81 µg/L. The maximum concentration was also detected in 2016 in monitoring well 01MW63.

3.3.2.3 Intermediate and Deep Water-Bearing Zones

There are six intermediate and one Deep WBZ wells within the ASKO Property. Refer to Figure 3.1b for locations. DRO, *cis*-1,2-DCE, and TCE were each detected at low concentrations in one of the six Intermediate WBZ wells (DRO in 01MW77, *cis*-1,2-DCE in 01MW76, and TCE in 01MW78). There were no detections within the Deep WBZ well.

3.3.3 East Waterfront Property

The groundwater dataset includes data from 15 monitoring wells in the East Waterfront Property 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. 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 East Waterfront Property (02MW05), and the remaining wells are Shallow WBZ wells. The general groundwater flow direction is north/northwest toward Salmon Bay.

Primary groundwater COPCs developed in the RI Work Plan that are present within the East Waterfront Property include GRO, DRO, ORO, benzene, and ethylbenzene. High concentrations of TPH, benzene, and ethylbenzene 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 of the RI Work Plan). There were no detections of COPCs in the one upland Intermediate WBZ well.

The COPC analytical results 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 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.
- DRO was detected in 8 of 13 monitoring wells. Detected concentrations ranged from 86 to 1,400 µg/L. The maximum concentration was detected in 2016 in monitoring well 02MW04, which is located in the vicinity of the former utilidor and former barrel incline.
- 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.
- Benzene was detected in 3 of 13 monitoring wells. Detected concentrations ranged from 1.3 to 200 µg/L. The maximum concentration 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.
- Ethylbenzene was detected in 3 of 13 monitoring wells. Detected concentrations ranged from 3.2 to 590 µg/L. The maximum concentration 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.

Results from the shoreline wells (02MW02 and 02MW07) were all 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.

3.3.4 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 Property TCE plume and was included in the summary of the ASKO Property Shallow WBZ wells in Section 3.3.2.2. All results for this well have been non-detect since the monitoring event conducted in May 2016.

3.4 SUMMARY OF HISTORICAL SOIL DATA

The historical soil dataset used for this RI 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, 2015b, 2016a). The dataset does not include samples that were removed during the multiple interim actions at the Site discussed in Section 3.2. The primary COPCs in soil for each property were identified as described in Section 4.2 of the RI Work Plan (Floyd|Snider 2019) and summarized in Section 1.2.

The soil data for the primary COPCs for the Bulk Terminal, ASKO, and East Waterfront Properties are summarized in the following sections. For a comprehensive evaluation of historical soil data, including summary tables and figures, refer to the reports noted above (SES 2014a, 2014b, 2014c, 2015a, 2015b, 2016a).

3.4.1 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 2014c), and soil data collected during the 2014 and 2015 additional investigations. The soil dataset also includes soil data from confirmation samples collected from the excavations in 1991, 2002, 2006, 2011, 2012, and 2014 but excludes data that were removed as part of these excavations.

Based on the results of the RI and supplemental subsurface investigations, the primary soil COPCs for the Bulk Terminal Property are GRO, DRO, and benzene. Penta was also identified as a chemical of interest within the Bulk Terminal Property. The soil data for these chemicals are summarized below:

- GRO was detected in 156 of 355 samples. Detected concentrations ranged from 3 to 760,000 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 150 of 358 samples. Detected concentrations ranged from 10 to 34,000 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 98 of 357 samples. Detected concentrations ranged from 0.00080 to 5,600 mg/kg. The maximum concentration was from a sample collected from boring 01SB09 in 1999, which was located in the former pump island area.
- Penta was detected in 30 of 166 samples. Detected concentrations ranged from 0.05 to 0.33 mg/kg. The maximum concentration was from two samples collected from borings B339 and B341 in 2014, which were both located in the former diesel and gasoline UST area.

3.4.2 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 2014a). The primary

soil COPCs for the ASKO Property are GRO, DRO, ORO, benzene, and cVOCs (*cis*-1,2-DCE and TCE). The soil data for these COPCs are summarized below:

- GRO was detected in 54 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 42 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 23 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 195 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-DCE was detected in 65 of 208 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.
- TCE was detected in 106 of 220 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.

Penta was detected at two locations within the ASKO Property and two locations on the BNSF parcel. The detected locations on the ASKO Property were collocated with other primary COPCs; therefore, penta is not considered a primary COPC for the ASKO Property.

3.4.3 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 2014b); 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 GRO, DRO, and ethylbenzene. The soil data for these COPCs are summarized below:

- GRO was detected in 46 of 170 samples. Detected concentrations ranged from 2.4 to 420 mg/kg. The maximum concentration was from a sample collected from boring B314 in 2013, which was located in the southeastern portion of the property adjacent to the former utilidor.

- DRO was detected in 27 of 171 samples. Detected concentrations ranged from 10 to 2,800 mg/kg. The maximum concentration was from a sample collected from boring B271 in 2013, which was located in the northeastern portion of the property.
- Ethylbenzene was detected in 28 of 171 samples. Detected concentrations ranged from 0.025 to 3.0 mg/kg. The maximum concentration was from a sample collected from boring B314 in 2013, which was located in the southeastern portion of the property adjacent to the former utilidor.

3.5 SOIL VAPOR

Soil vapor was retained in the 2014 RIs for the Bulk Terminal, ASKO, and East Waterfront Properties 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 Properties are summarized in the following sections. Soil vapor data are not available for the East Waterfront Property.

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).

3.5.1 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 (refer to Section 3.5.2). To support the ASKO Property study, an indoor air sample was collected from the former TOC office building located on the Bulk Terminal Property. TCE was detected in the indoor air sample from the former TOC office building at a concentration of 0.23 micrograms per cubic meter, less than the MTCA Method B CUL.

3.5.2 ASKO Property

The ASKO Property 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 Industrial Repair; 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 Property).

Sample collection included one soil gas, three indoor air, and three outdoor air samples. The soil gas sample was collected from the east side of the now former machine shop, which was still in

use by ASKO Industrial Repair during the assessment. Indoor air samples were collected from all of the buildings mentioned above except the 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).

3.6 PILOT TESTING

Pilot testing to determine the effectiveness of in situ remediation techniques has been completed at the Bulk Terminal and ASKO Properties. The following is a summary of the previous pilot tests at each of the properties. For a comprehensive description of the means, methods, and results of these tests, refer to the 2014 RIs (SES 2014a, 2014b, 2014c).

3.6.1 Bulk Terminal Property

In 2002, Foster Wheeler completed a dual-phase extraction (DPE) pilot test at the Bulk Terminal Property. Monitoring wells 01MW18 through 01MW20 were installed to complete the testing. Two DPE step tests were conducted for 15 hours and 47 hours with an average liquid flow rate of 40 gallons per minute. The vacuum radius of influence observed was 50 feet, and the groundwater extraction radius of depression was approximately 45 feet. An estimated 19 pounds of TPH was extracted during the two step tests.

3.6.2 ASKO Property

On February 23 and 24, 2010, SES conducted an SVE pilot test at the ASKO Property. The pilot test was performed on wells 01WSVE01, 01MW44, and 01MW63. An SVE blower was used to apply vacuum to the test wells, and the range of influence was observed at wells 01MW15, 01MW54, 01MW55, and 01MW65. During the pilot tests, SES observed a non-uniform gradient when measuring vacuum across the selected well network, indicating subsurface heterogeneities. Recovered vapor samples were collected at the three test wells and submitted for analysis of cVOCs. Laboratory results showed that a high concentration of TCE in soil vapor had been recovered from the wells during the pilot test; therefore, a high concentration of cVOCs could be removed using this technology.

In February 2011, SES collected a saturated soil sample and submitted to two laboratories to test the chemical oxidant demand of the soil. The two chemical products tested were permanganate and an activated sodium persulfate. Based on the laboratory results, both products were considered viable injection technologies. The results of the testing are further described in the RI (SES 2014a).

4.0 Preliminary Cleanup Level Development

This section provides a summary of the approach to identify the PCULs for groundwater and soil through evaluation of applicable local, state, and federal laws (Applicable or Relevant and Appropriate Requirements [ARARs]; WAC 173-340-710). The primary cleanup regulations (chemical-specific ARARs) that apply to this Site are MTCA and its implementing regulations (WAC 173-340); Water Quality Standards for Surface Waters of the State of Washington (WAC 173-201A), federal surface water quality criteria (WQC) under the Clean Water Act Section 304(a), and federal WQC for Washington under the National Toxics Rule (40 CFR 131.45) for protection of the adjacent groundwater receiving waterbody, Salmon Bay; Sediment Management Standards (WAC 173-204) for protection of sediment quality in Salmon Bay; and maximum contaminant levels from the Washington State Board of Health (WAC 246-290-310) and the federal Safe Drinking Water Act (40 CFR 141) for protection of drinking water.

Based on the ARARs, PCULs have been developed that are protective of both human health and ecological receptors. These PCULs are based on the PSLs presented in the RI Work Plan and are derived for those groundwater and soil COPCs identified in the RI Work Plan based on the PSL screening. Additionally, PCULs were developed for chemicals that were analyzed in the RI (described further in Section 5.0) that were identified as data gaps, in consultation with Ecology. These chemicals were originally established on a parcel-by-parcel basis in the RI Work Plan but are evaluated on a Sitewide basis in this Supplemental Upland RI/FS. In this RI/FS, these chemicals are collectively termed “chemicals of interest (COIs)” for simplicity.

The following sections identify potentially applicable exposure pathways and corresponding regulatory criteria considered in the development of PCULs for each of the impacted media. Importantly, at this Site, Ecology has directed that there should be a single CUL per analyte per medium, even if the pathway is incomplete in portions of the Site. Furthermore, because the East Waterfront Property portion of the Site abuts Salmon Bay, groundwater discharge to surface water becomes a critical pathway for the entire Site—even for properties that do not abut the waterway, because the properties are collectively considered all one Site. This greatly affects the derivation of PCULs described in the following sections and, ultimately, the cleanup standards for the Site.

4.1 GROUNDWATER

Table 4.1 presents the PCULs for groundwater for each of the potentially complete exposure pathways. These values are applied in the screening of IHSs, described in Section 6.0. The exposure pathways considered potentially complete in developing PCULs for groundwater and the applicable ARARs are presented below.

- **Protection of Drinking Water Quality.** Groundwater at the Site is considered potable; therefore, ARARs protective of drinking water quality apply Sitewide. These include maximum contaminant levels (MCLs) from the National Primary Drinking Water Regulations and MTCA Method B CULs. MCLs are selected as the PCULs (adjusted to

a cancer risk no greater than 1 in 100,000). If MCLs are not available, MTCA Method B CULs are selected as the PCUL.

- **Protection of Surface Water Quality.** Groundwater 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. The following ARARs apply, the most stringent of which was selected as the PCUL protective of surface water:
  - **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 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 criteria as target sediment concentrations. Target sediment concentrations were identified based on the Sediment Management Standards (SMS) Sediment Cleanup Objectives (SCOs) for freshwater. The lower of the sediment criteria for protection of human health direct contact (including beach play, clamming, and net fishing pathways), bioaccumulation, and benthic species was selected as the target concentration.
- **Protection of Indoor Air Quality.** Volatile contaminants in shallow groundwater Sitewide have the potential to volatilize, rise through the soil column, and discharge to ambient air. PCULs 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 2009).

4.2 SOIL

Table 4.2 presents the PCULs for soil for each of the potentially complete exposure pathways. These values are applied in the screening of IHSs described in Section 6.0. The exposure pathways considered potentially complete in developing PCULs for soil and the applicable ARARs are presented below.

- **Protection of Human Health Direct Contact.** The Site is in an area zoned for commercial/industrial use. Therefore, the PCULs 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 (i.e., lead, mercury, and TPH).
- **Protection of Terrestrial Ecological Receptors.** The terrestrial ecological evaluation PCUL is the Ecological Indicator Concentration protective of wildlife in the site-specific TEE under commercial/industrial land use (MTCA Table 749-3) in accordance with WAC 173-340-7493(2)(a)(i).
- **Protection of Groundwater Quality.** PCULs that are protective of contaminants leaching from soil to groundwater were based on the MTCA Method A values for groundwater protection presented in Table 740-1 (for TPH) or calculated using the fixed parameter three-phase partitioning model, MTCA Equation 747-1. PCULs were developed to protect drinking water, discharge to surface water, discharge to sediments, and volatilization to indoor air. The basis of the groundwater PCULs used in the calculation is described in Section 4.1.

  Soil-to-groundwater equilibrium calculations performed using the three-phase model can be modified to incorporate Site-specific contaminant leaching and transport variables if available, in accordance with WAC 173-340-708(10)(b)(i). Therefore, the fraction of organic carbon in soil (used to calculate the partition coefficient K_d in the three-phase model) was modified from the MTCA default value of 0.001 to a Site-specific average value of 0.009 by applying the average value for total organic carbon collected at the Site. The source of the organic carbon data is further described in Section 10.3.
- **Protection of Air.** As stated in Ecology's *Guidance for Evaluating Soil Vapor Intrusion in Washington State: Investigation and Remedial Action* (Ecology 2009), "Consistent with WAC 173-340-740(3)(b)(iii)(C)(III), at sites where soil cleanup levels are being established that will be protective of groundwater as a drinking water resource, these levels are likely to be low enough to be protective of indoor air via the [vapor intrusion] pathway." Because CULs are being established that will be protective of discharge to surface water and sediment as well, a pathway more conservative than protection of drinking water, a separate soil PCUL for volatilization to soil vapor has not been established.
- **Protection of Sediment Quality.** The PSLs in the RI Work Plan included protection of bank erosion and applied SMS SCO criteria. In this document, conservative soil PCULs protective of groundwater discharge to sediments are included. These conservative

PCULs are less than freshwater SMS SCO criteria, with the exception of DRO; therefore, separate PCULs for soil erosion protective of sediment have not been established.

Pursuant to MTCA, the RI has documented all potential transport pathways, and field observations indicate the soil erosion to sediment pathway is not currently active at the Property. However, if the erosion to sediment pathway were to become active in any area of the Property, further evaluation would be necessary to ensure adequate protection of sediment quality.

5.0 Supplemental Upland Remedial Investigation Summary

The Supplemental Upland RI was completed by Floyd|Snider in accordance with the Ecology-approved RI Work Plan and additional Ecology-requested data collection approved via email on July 10, 2019. The scope of the supplemental RI groundwater and soil data collection was determined by comparing the existing RI data against the PSLs to identify data gaps where the extent of the COPCs exceeding the PSLs were not fully delineated. The following data gaps were identified in the RI Work Plan:

- Groundwater flow directions and gradients in the Perched, Shallow, and Intermediate WBZs after shutoff of the groundwater pump and treat system in 2017.
- Current comprehensive data for all COPCs in groundwater.
- Downgradient extent of TPH in Shallow WBZ on the northeast corner of the Bulk Terminal Property.
- Downgradient extent of TPH in Shallow and Intermediate WBZs in W. Commodore Way adjacent to the Bulk Terminal Property.
- Downgradient extent of cVOCs in Intermediate WBZ on the ASKO Property.
- Downgradient extent of cVOCs in Shallow WBZ in W. Commodore Way adjacent to the ASKO Property.
- Potential presence of metals in soil on the East Waterfront Property near historical sandblast grit areas.
- Potential presence of metals and TPH in shoreline groundwater on the East Waterfront Property.

The following RI field activities were completed to fill the above data gaps:

- Comprehensive water level measurements to evaluate groundwater flow patterns under static conditions given that a groundwater pump and treat system was operational through June 2017. Water level measurements were collected in March, April/May, and July 2019.
- Installation of 14 monitoring wells, including 1 Shallow WBZ well on the Bulk Terminal Property (01MW105); 3 Shallow WBZ wells in W. Commodore Way north of the Bulk Terminal Property (01MW101, 01MW102, and 01MW103); 1 Intermediate WBZ well in W. Commodore Way north of the Bulk Terminal Property (01MW104); 1 Intermediate WBZ well on the ASKO Property (01MW108); two Shallow WBZ wells in W. Commodore Way north of the ASKO Property (01MW106 and 01MW107); 4 Shallow WBZ wells along the shoreline of the East Waterfront Property (02MW17 through 02MW20); and 2 Intermediate WBZ wells along the shoreline of the East Waterfront Property (02MW21 and 02MW22).
- Collection of soil samples, including three surface soil samples to evaluate metals on the western portion of the East Waterfront Property (SS-01 through SS-03) and

three shallow soil samples from two locations to evaluate potential petroleum and metals contamination on the eastern portion of the East Waterfront Property (at 02MW20 and 02MW22).

- Installation of 1 additional Shallow WBZ well on the Bulk Terminal Property (01MW110) and 1 Shallow WBZ well (01MW109) and 1 Intermediate WBZ well (01MW111) to sufficiently delineate groundwater contamination to the northeast of the Bulk Terminal Property.
- Sample collection and analysis of Shallow, Intermediate, and Deep WBZ groundwater from a subset of new and existing monitoring wells to evaluate groundwater quality and to delineate the nature and extent of contamination.

These supplemental RI field activities were completed by Floyd|Snider between March and August 2019. Minor deviations to the RI Work Plan are described in Section 5.3 and were discussed with Ecology during the implementation of the supplemental RI field program. The additional wells were installed after communication with Ecology in July 2019. Supplemental Upland RI locations are shown on Figure 5.1.

5.1 SOIL BORING AND MONITORING WELL INSTALLATION

Monitoring well borings were installed by Holocene Drilling Inc. using roto-sonic drilling methodology between April 22 and July 18, 2019. Soil samples were collected continuously by advancing 4-inch-diameter inner drill rods and transferring the recovered soils to sample liner bags at 5-foot intervals. Soils were logged and screened for field indications of contamination (i.e., odor, sheen, elevated VOC concentrations measured by photoionization detector [PID]) by the field geologist. Copies of soil boring/monitoring well completion logs, which include field screening information, are included in Appendix B.

During drilling, petroleum odor and elevated PID concentrations were encountered in saturated zone soils at well 01MW105 on the Bulk Terminal Property and in moist vadose zone soils at 02MW20 and 02MW22 on the East Waterfront Property. Other field observations of contamination were not observed during the installation of monitoring wells. In accordance with the RI Work Plan, samples were collected for laboratory analysis of petroleum compounds from the two locations with potentially contaminated vadose zone soils, and one additional sample to delineate the vertical extent of this contamination was collected at 02MW22 where the highest PID reading was recorded.

Monitoring well locations 02MW18 and 02MW19 were designated as surface soil sampling locations SS-02 and SS-03, respectively. Soil samples for metals analysis were collected from these locations at the surficial soil interval of the sonic cores and designated SS-02 and SS-03. Due to its location near the southern property line, surface soil sample SS-01 was collected using a hand trowel.

After soil logging and sampling were completed, the proper screened interval for the monitoring well was determined by the field geologist. Screened intervals in Shallow WBZ wells were set to

span the water table above the uppermost low-permeability silt layer. Screened intervals in intermediate wells were set within the saturated zone between the uppermost and second low-permeability silt layers. Wells were generally constructed with 10-foot screens in accordance with the RI Work Plan; however, a subset of wells were constructed with either 5-foot or 15-foot screens as necessary to sample from the targeted WBZ intervals. Details regarding deviations from the sampling plan are discussed in further detail in Section 5.3.

After completion of the well construction, traffic-rated flush-mount road boxes were installed for well protection. Monitoring wells were subsequently developed by pumping and periodically surging with a centrifugal pump until the purge water was visually clear.

5.2 GROUNDWATER SAMPLE COLLECTION

Groundwater samples were collected between April 30 and August 29, 2019. New wells were allowed to equilibrate for a minimum of 7 days after development before sampling. Groundwater samples were collected from the monitoring well network specified in the RI Work Plan using low-flow methodology, except for the deviations described in Section 5.3. Wells were purged until water quality parameters met the criteria for stabilization presented in the RI Work Plan before sampling.

5.3 DEVIATIONS

The Supplemental Upland RI sampling was performed in general accordance with the RI Work Plan. Minor deviations, which were discussed with Ecology for concurrence during the field sampling effort, are described in this section:

- At Shallow WBZ well 01MW102 in W. Commodore Way, thin lenses of saturated soil were present between approximately 10 and 20 feet. This well was screened with a 15-foot screen, between 7 and 22 feet, rather than a 10-foot screen, in order to span the full saturated interval as well as the potential water table at 10 feet.
- At Intermediate WBZ wells 01MW108 on the ASKO Property and 01MW104 and 01MW111 in W. Commodore Way, the intermediate saturated zone was approximately 5 feet thick and was encountered between moist to dry, stiff silt units. These wells were constructed with 5-foot screens rather than 10-foot screens in order to target the saturated interval without introducing excessive fine-grained material from under- and overlying silts.
- At the proposed 01MW104 location in W. Commodore Way, brick fragments were encountered in soil at approximately 28 feet bgs. This boring location was abandoned due to concern that the bricks were sewer pipe construction debris, suggesting very close proximity to the pipe. The 01MW104 boring, which was proposed to be adjacent to Shallow WBZ well 01MW101, was relocated approximately 70 feet to the west and adjacent to Shallow WBZ well 01MW102 and completed as an Intermediate WBZ well.
- Shallow WBZ wells 01MW103 and 01MW109 in W. Commodore Way, which were screened in sand above the uppermost low-permeability silt layer, were dry at the

time of groundwater sampling, and samples were not collected from these wells. Other wells along the north side of the ROW (01MW88, 01MW101, 01MW102) had 1 foot of water or less in the well casing and were purged dry in some cases despite using the slowest purge rate possible with a peristaltic pump. Because of the very thin saturated zone and low productivity, full stabilization of water quality parameters could not be achieved prior to sampling these wells.

- At East Waterfront Property Shallow WBZ well 02MW09, two lengths of high-density polyethylene sample tubing were found to be wedged inside the ¾-inch-diameter well casing. Field personnel attempted to grasp the tubing with pliers to remove it; however, the tubing stretched and tore before the friction from the well casing could be overcome. This well remains obstructed and a sample was not collected. SES had also noted an obstruction in this well since their October 2013 monitoring event; this well was last sampled in 2009.
- While collecting groundwater samples in the travel lanes in W. Commodore Way, the well identified on existing maps as Intermediate WBZ well 01MW51 was found to have a total depth consistent with Shallow WBZ well 01MW49; likewise, the well identified on maps as 01MW49 was found to have a total depth consistent with 01MW51. This error was traced to the initial well survey and is believed to stem from miscommunication between prior field staff and surveying crews. A sample was collected from the location identified in the RI Work Plan as 01MW51 and hereafter correctly identified as 01MW49. A sample was not collected from 01MW51 (previously identified as 01MW49) because this Intermediate WBZ well lies immediately upgradient of Intermediate WBZ well 01MW104 and adjacent to Intermediate WBZ well 01MW48 and does not provide useful data regarding potential migration of contaminants from the Bulk Terminal Property in the Intermediate WBZ.
- Inadequate sample volume was inadvertently collected from the Perched WBZ well 01MW97. Because the laboratory noted potential interference in GRO analyses caused by high TCE concentrations in other Perched WBZ wells, the available sample volume was analyzed for DRO only, rather than GRO and DRO, in order to obtain a better quality petroleum chromatogram. This sample was also analyzed for cVOCs in accordance with the RI Work Plan.
- Additional Shallow WBZ wells 01MW109 and 01MW110 and Intermediate WBZ well 01MW111, which were not specified in the RI Work Plan, were installed in order to delineate potential TPH impacts on the northeast corner of the Bulk Terminal Property at 01MW105.
- Intermediate WBZ well 01MW111 in W. Commodore Way had highly turbid water at the time of installation and was purged dry repeatedly during development. When this well was subsequently sampled, the purge water remained highly turbid. This well was purged until a decrease in turbidity was observed, and a sample was collected prior to the water quality parameters fully stabilizing.

- East Waterfront Property wells 02MW07, 02MW18, 02MW19 and 02MW20 were resampled for total and dissolved metals during the July 2019 monitoring event in order to compare results to the PCULs based on dissolved metals criteria. Bulk Terminal Property well 01MW105 was also resampled for TPH and BTEX during this event in order to compare results from the same period at this well and the new wells installed in July 2019.
- Due to the high turbidity observed at 01MW111, this well was redeveloped in August 2019 and resampled along with adjacent wells 01MW105 and 01MW110. The resulting purge water during the August 2019 sampling event had acceptable turbidity for sample collection using low-flow methodology.

5.4 HYDROGEOLOGY

Observations regarding hydrogeology during the Supplemental Upland RI are described in the following sections.

5.4.1 Groundwater Elevations

Groundwater elevations were collected during two Sitewide monitoring events and a supplemental monitoring event. In March of 2019, water levels were collected from targeted Shallow WBZ wells in order to confirm groundwater flow directions in advance of well installation for the Supplemental Upland RI. Water level elevations were also collected from wells screened in all WBZs, including newly installed wells, during the Sitewide RI sampling event completed in April/May 2019 and selected water levels were collected during additional supplemental groundwater sampling in July 2019. Groundwater elevation measurements are summarized in Table 5.1.

A map of groundwater elevation contours and flow in the Shallow WBZ during the March 2019 measurement event is presented in Figure 5.2. Perched and Shallow WBZ elevation contours from the April/May RI sampling event are presented in Figures 5.3 and 5.4. Elevation contours in the Intermediate WBZ from water level measurements collected during additional sampling in July 2019 are presented in Figure 5.5. There are not sufficient Site wells to produce accurate groundwater elevation contours for the Deep WBZ. The occurrence of groundwater in relation to lithology is presented in cross-section A-A' for the Bulk Terminal and East Waterfront Properties in Figure 5.6 and cross-section B-B' for the ASKO and East Waterfront Properties in Figure 5.7. The occurrence of groundwater in relation to lithology along the property line between the ASKO Property and BNSF parcel is presented in cross-section C-C' on Figure 5.8. Refer to Figure 5.1 for the cross-section locations.

Groundwater elevations in the Perched WBZ ranged from approximately 50 feet to 38 feet NAVD 88 on the ASKO Property and were generally highest to the south on the BNSF parcel (Figure 5.3). A saturated zone possibly representing the Perched WBZ was also observed at approximately 8 feet bgs (37 feet NAVD 88) at on-property well 01MW108 at the time of drilling but was not observed across W. Commodore Way at 01MW106 or 01MW107.

Groundwater elevations were most varied in the Shallow WBZ, with a maximum elevation of 43 feet NAVD 88, measured in the interior of the Bulk Terminal Property during the April/May sampling (Figure 5.4). This unpaved area where stormwater can freely infiltrate is likely a groundwater recharge area where localized mounding can occur. Groundwater elevations were lower to the north and west of the Bulk Terminal Property and dropped steeply in W. Commodore Way to the north, from approximately 35 feet NAVD 88 near the north property line to 25 feet NAVD 88 along the north side of the ROW. The Shallow WBZ is often less than 1 foot thick and was absent at 01MW103 and 01MW109, the easternmost wells along the north side of the ROW, during Supplemental Upland RI sampling.

On the ASKO Property, groundwater elevations in the Shallow WBZ ranged from approximately 23 to 30 feet NAVD 88. The highest elevations were observed to the southeast, and elevations were lower to the north and west. Groundwater elevations did not drop as steeply in W. Commodore Way north of the ASKO Property, with elevations of about 23 feet NAVD 88 observed on the north property line and 19 feet NAVD 88 observed on the north side of the ROW.

On the East Waterfront Property, Shallow WBZ elevations ranged from approximately 19 to 25 feet NAVD 88. In wells along the shoreline, the elevation of the Shallow WBZ was roughly equivalent to the water level of Salmon Bay.

Water level elevations in the Intermediate WBZ ranged from approximately 18 to 24 feet NAVD 88 during the July 2019 monitoring event (Figure 5.5). Elevations were relatively flat, ranging between approximately 19 and 21 feet, on the ASKO Property and in W. Commodore Way. A localized high point of the potentiometric surface has consistently been observed at Intermediate WBZ well 02MW05 on the East Waterfront Property; water levels at this well are typically 2 to 4 feet higher than in wells farther upland to the south. Potentiometric surface elevations decreased most steeply to the north-northwest of 02MW05 in the direction of Salmon Bay. At the waterfront along Salmon Bay, the elevations of the shallow and Intermediate WBZs were near the water level elevation of the bay, suggesting that both zones discharge to this water body.

A limited number of measurement points are available in the Intermediate WBZ in the vicinity of the W. Commodore Way sewer pipe. Groundwater elevations at two wells located to the south of the presumed pipe alignment (01MW48 and 01MW51) and one well located to the north of the pipe (01MW104) were measured during the July 2019 monitoring event. The potentiometric surface elevations south of the presumed pipe alignment were approximately 2 feet higher than the elevations north of the pipe; however, the elevations at all locations were above the approximate top of the sewer pipe. This indicates that the minor elevation differences may be due to an increase in permeability in the limited backfill materials that were likely placed along with the timber lagging surrounding the pipe rather than a hydraulic connection with the pipe itself.[3]

[3] Additional discussion and interpretation of the sewer pipe hydrogeology and regulatory context as it pertains to selection of the final remedy for the Site will be presented by Ecology in the Cleanup Action Plan (CAP) for the Site.

5.4.2 Flow Direction and Gradients

Overall groundwater flow in the shallow and Intermediate WBZs is to the northwest, in topographic highs to the south toward Salmon Bay. While few data points are available for the Perched WBZ, lower elevations observed moving north on the ASKO Property also suggest an overall north/northwestward flow.

In the Perched WBZ, which is present on the ASKO Property, the primary groundwater flow direction appeared to be toward the northwest, with a secondary flow direction to the northeast. Horizontal gradients in this WBZ ranged from 0.067 to 0.11 feet per foot (ft/ft) during the April/May 2019 monitoring event. Perched WBZ contours for the April/May 2019 monitoring event are presented in Figure 5.3.

On the Bulk Terminal Property, the potentiometric surface on the Shallow WBZ was found to slope downward to the northwest consistent with previous data; however, secondary flow directions were observed to the west, north, and northeast from the mounded area in the central portion of the property. On the ASKO Property, the potentiometric surface slopes primarily to the west in the southern portion of the property then gradually trends northwest in the northern portion of the property. On the East Waterfront Property, the overall flow of the Shallow WBZ is to the northwest with secondary flow directions to the north and west. Shallow WBZ contours for the March 2019 monitoring event are presented in Figure 5.2, and contours for the April/May 2019 monitoring event are presented in Figure 5.4.

Horizontal gradients in the Shallow WBZ vary significantly across the Site. The steepest gradients are present across W. Commodore Way, ranging from 0.11 to 0.35 ft/ft. In the interior of the Bulk Terminal and ASKO Properties, horizontal gradients range from approximately 0.043 to 0.079 ft/ft. The flattest shallow WBZ horizontal gradients are observed at the East Waterfront Property, ranging from approximately 0.028 to 0.065 ft/ft.

Groundwater elevation data for the Intermediate WBZ are available primarily from the ASKO and East Waterfront Properties. These data suggest groundwater in the Intermediate WBZ flows generally from higher elevations to the south, to the west and to the north toward Salmon Bay. Horizontal gradients in this WBZ ranged from 0.027 to 0.044 ft/ft. Intermediate WBZ contours for the July 2019 monitoring event are presented in Figure 5.5.

Vertical gradients were consistently downward between the Perched and Shallow WBZs and between the Shallow and Intermediate WBZs. Vertical gradients were most strongly downward between the Perched and Shallow WBZs with weaker vertical gradients between successively deeper WBZs. Vertical gradients at collocated Perched and Shallow WBZ wells and Shallow and Intermediate WBZ wells are presented in Table 5.2.

5.4.3 Monitoring Well Water-Bearing Zone Designations

During installation of soil borings for the Supplemental Upland RI, the Shallow WBZ was observed to be underlain by a stiff, dry, low-permeability silt that separated the water bearing sands and

silty sands of the Shallow and Intermediate WBZs. The existing well logs were reevaluated after completing the RI field work to determine whether the Shallow WBZ wells were screened above this silt layer to target only the Shallow WBZ for sampling. This evaluation found eight wells that were screened through the silt layer and into the Intermediate WBZ. These wells were re-designated as Shallow and Intermediate WBZ wells and were not used for the purposes of creating Shallow or Intermediate WBZ groundwater elevation contours. Monitoring well construction details and revised WBZ designations are presented in Table 5.1.

5.4.4 LNAPL Occurrence

LNAPL thickness measurements were collected from wells that were observed to have LNAPL in April/May 2019. LNAPL thickness measurements and the current extents of LNAPL areas are shown on Figure 5.9.

In the northern portion of the Bulk Terminal Property and extending into W. Commodore Way, eight wells had measurable LNAPL ranging in thickness from 0.05 feet to 5.23 feet. The thickest LNAPL layer was observed at 01MW10 in W. Commodore Way and at 01MW05 to the north of the former TOC office building, which is generally consistent with LNAPL measurements collected by SES in 2016. LNAPL attenuates rapidly to the north in the presumed downgradient direction; wells to the north of both 01MW10 and 01MW05 did not have measurable LNAPL.

A second, smaller area of LNAPL was present near the center of the Bulk Terminal Property in the former AST area; it is assumed that these two areas of LNAPL were contiguous prior to the interim action excavation that was completed between the areas in 2012. Measurable LNAPL was observed at 01MW72 and 01MW73, with thicknesses of 2.80 and 4.39 feet, respectively, in these two wells. Similar to the northern portion of the property, LNAPL also attenuates rapidly in this area, and wells surrounding 01MW72 and 01MW73 did not have measurable LNAPL.

5.5 GROUNDWATER SAMPLE ANALYSES AND RESULTS SUMMARY

Groundwater samples were collected from the Sitewide well network for targeted analysis to fulfill data gaps identified in the RI Work Plan. Samples were collected for analysis of metals; GRO, Total DRO and ORO, and BTEX compounds; extractable petroleum compounds (EPH) and volatile petroleum compounds (VPH); cVOCs; and semivolatile organic compounds (SVOCs). Analytical results are discussed in the following sections. Monitoring well locations are shown on Figure 5.1. Laboratory reports for groundwater sampling are presented in Appendix C.

5.5.1 Metals

The Resource Conservation and Recovery Act (RCRA) list of eight metals were analyzed in samples collected from the wells located along the shoreline of the East Waterfront Property, including 02MW07, 02MW17, 02MW18, 02MW19 and 02MW20. Additionally, arsenic was sampled in the Perched WBZ well MW03 on the ASKO Property. Samples for total metals analysis were collected from all wells during the April/May 2019 monitoring event. A subset of

the shoreline wells (02MW07, 02MW18, 02MW19 and 02MW20) were resampled for both total and dissolved metals in July 2019. Analytical results for metals are presented in Table 5.3.

- Arsenic was detected in all 10 of the samples analyzed; detections of arsenic exceeded the PCUL of 5.0 µg/L at three of the locations and in five of the samples analyzed, including total arsenic at MW03 and both total and dissolved arsenic at 02MW19 and 02MW20. The greatest detected concentration of arsenic was 66 µg/L total arsenic in the sample collected from MW03.
- Barium was detected in all 9 of the samples analyzed; detected barium concentrations did not exceed the PCUL of 1,000 µg/L in any samples.
- Chromium was detected in 3 of the 9 samples analyzed; total chromium concentrations slightly exceeded the PCUL of 0.20 µg/L in samples collected from 02MW07, 02MW18 and 02MW19 during the April/May 2019 monitoring event, but total and dissolved chromium were not detected in any samples collected in July 2019 after a longer period of equilibration with the surrounding formation. The greatest detected concentration of chromium was 2.4 µg/L total chromium in the sample collected from 02MW19.
- Lead was detected in 2 of 9 samples analyzed; total lead exceeded the PCUL of 0.50 µg/L in samples collected from 02MW07 and 02MW18 during the April/May 2019 monitoring event, but total and dissolved lead were not detected in any samples collected in July 2019 after a longer period of equilibration with the surrounding formation. The greatest detected lead concentration was 6.0 µg/L total lead in the sample collected from 02MW07.
- Cadmium, mercury, selenium, and silver were not detected in any samples.

5.5.2 TPH and BTEX

TPH and BTEX compounds were analyzed in samples from wells located on the Bulk Terminal, ASKO, and East Waterfront Properties (46 GRO samples, 86 Total DRO and ORO samples, and 55 BTEX samples). GRO, Total DRO and ORO, and benzene results are discussed below, for consistency with the COIs presented in Section 4.0. Samples were collected for analysis during the April/May 2019 monitoring event, and additional samples from 01MW110 and 01MW111 were collected after those wells were installed in July 2019. 01MW105 was also resampled in July 2019. Samples collected for TPH analysis in July 2019 were reanalyzed with silica gel cleanup after the laboratory noted potential interference from polar organic compounds in these samples, and samples collected in August 2019 were also analyzed with silica gel cleanup. Analytical results for all TPH and BTEX analyses are presented in Table 5.4.

5.5.2.1 Bulk Terminal Property

- GRO was detected in 9 of the 25 groundwater samples analyzed; 7 of the detected concentrations exceeded the PCUL of 800 µg/L. The greatest detected GRO concentration was 10,000 µg/L in the sample collected from 01MW19.

- Total DRO and ORO was detected in 40 of 46 groundwater samples analyzed; 23 of the detected concentrations exceeded the PCUL of 500 µg/L. The greatest detected Total DRO and ORO concentration was 11,000 µg/L in the sample collected from 01MW15. Total DRO and ORO exceeded the PCUL in the sample collected from 01MW105 during the April/May 2019 monitoring event but did not exceed the PCUL when it was resampled in July and August 2019. The Total DRO and ORO concentration exceeded the PCUL in the sample collected from 01MW111 during the July 2019 monitoring event but was less than the PCUL in the sample collected in August 2019 after redeveloping the well and allowing a longer period of equilibration with the surrounding formation.
- Benzene was detected in 12 of the 29 samples analyzed; all 12 of the detected concentrations exceeded the PCUL of 0.44 µg/L. The greatest detected benzene concentration was 2,600 µg/L in the sample collected from 01MW19.

5.5.2.2 ASKO Property

- GRO was detected in 9 of the 12 samples analyzed; three of the detected concentrations exceeded the PCUL of 500 µg/L. The greatest detected GRO concentration was 2,100 µg/L in the sample collected from 01MW63.
- Total DRO and ORO was detected in 26 of the 28 samples analyzed; 11 of the detected concentrations exceeded the PCUL of 500 µg/L. The greatest detected Total DRO and ORO concentration was 5,900 µg/L in the sample collected from 01MW92.
- Benzene was detected in 13 of the 19 samples analyzed; 11 of the detected concentrations exceeded the PCUL of 0.44 µg/L. The greatest detected benzene concentration was 16 µg/L in the sample collected from 01MW80.

5.5.2.3 East Waterfront Property

- GRO was detected in 1 of the 9 samples analyzed. The sample collected from 02MW02 was not analyzed by the NWTPH-Gx Method but was instead analyzed by the EPH/VPH method. The equivalent GRO concentration (calculated by summing the detected VPH fractions concentrations [Ecology 1997]) detected in this sample was 8,500 µg/L, which exceeds the PCUL of 800 µg/L.
- Total DRO and ORO was detected in all 12 samples analyzed; the greatest detected concentration of 670 µg/L in the sample collected from 02MW07 slightly exceeded the PCUL of 500 µg/L.
- Benzene was detected in 1 of the 7 samples analyzed. The detected benzene concentration of 3.7 µg/L in the sample collected from 01MW04 exceeded the PCUL of 0.44 µg/L.

5.5.3 EPH/VPH

EPH and VPH were analyzed in four samples collected from wells on the Bulk Terminal Property (01MW19, 01MW47, 01MW69, and 01MW90); two wells on the ASKO Property (01MW71 and MW03); and one East Waterfront Property well (02MW04). Analytical results for EPH and VPH fractions and other target compounds associated with petroleum alkanes are presented in Table 5.5.

Most of the EPH and VPH compounds were detected in samples collected from Bulk Terminal Property wells 01MW19, 01MW47 and 01MW69; EPH and VPH were largely not detected in the sample collected from 01MW90, which is located on the southern portion of the Bulk Terminal Property. In the sample collected from 01MW71, the EPH results were all non-detect, and only one of the VPH compounds (C5-C6 aliphatics) was detected. In the samples from MW03 on the ASKO Property and 02MW04 on the East Waterfront Property, VPH was detected and EPH was largely not detected, with the exception of C12-C16 aromatics at MW02 and C10-C12 aromatics at 02MW04, both of which overlap with analytes detected by the VPH method.

5.5.4 cVOCs

cVOCs, including tetrachloroethene (PCE), TCE, *cis*-1,2-DCE, *trans*-1,2-DCE, 1,1-DCE, 1,2-dichloroethane, and vinyl chloride, were analyzed in 42 samples collected from wells on the ASKO Property and adjacent BNSF parcel, and Bulk Terminal well 01MW19 near the ASKO Property line. Analytical results for cVOCs are presented in Table 5.6.

- PCE was detected in 1 of 42 samples analyzed; the detected PCE concentration of 3.1 µg/L from 01MW55 exceeded the PCUL of 2.4 µg/L.
- TCE was detected in 22 of 42 samples analyzed; all detected TCE concentrations exceeded the PCUL of 0.50 µg/L. The greatest detected TCE concentration was 5,900 µg/L in the sample collected from 01MW63 on the ASKO Property.
- *cis*-1,2-DCE was detected in 23 of 42 samples analyzed; 14 of the detected concentrations exceeded the PCUL of 16 µg/L. The greatest detected *cis*-1,2-DCE concentration was 570 µg/L in the sample collected from 01MW92 on the BNSF parcel.
- *trans*-1,2-DCE was detected in 7 of 42 samples analyzed; none of the *trans*-1,2-DCE concentrations exceeded the PCUL of 100 µg/L.
- 1,1-DCE was detected in 8 of 42 samples analyzed; the detected concentration of 13 µg/L in the sample collected from 01MW71 on the ASKO Property exceeded the PCUL of 7.0 µg/L.
- 1,2-Dichloroethane was detected in 4 of 42 samples analyzed; none of the detected 1,2-dichloroethane concentrations exceeded the PCUL of 4.8 µg/L.
- Vinyl chloride was detected 22 of 42 samples analyzed; all detected vinyl chloride concentrations exceeded the PCUL of 0.20 µg/L. The greatest detected vinyl chloride concentration was 39 µg/L in the sample collected from 01MW63 on the ASKO Property.

5.5.5 SVOCs

SVOCs, including cPAHs and penta, were analyzed in selected samples collected from the Bulk Terminal, ASKO, and East Waterfront Properties and W. Commodore Way. cPAHs were analyzed in samples collected from nine wells (01MW84, 01MW88, 01MW101, 01MW102, 02MW07, 02MW17, 02MW18, 02MW19, and 02MW20). cPAHs were additionally analyzed as target compounds from samples collected from seven wells analyzed for EPH/VPH (01MW19, 01MW47, 01MW69, 0MW71, 01MW90, 02MW04, and MW03) as described in Section 5.5.3. Penta was analyzed in samples from eight wells (01MW01, 01MW27, 01MW48, 01MW66, 01MW67, 01MW69, 01MW101, and 01MW104). Analytical results for SVOCs are presented in Table 5.7.

- cPAHs were not detected in any of the 16 samples analyzed.
- Penta was detected in 2 of 8 samples analyzed; both detected penta concentrations exceeded the PCUL of 0.20 µg/L. The greatest detected penta concentration was 3.6 µg/L in the sample collected from 01MW66.

5.6 SOIL SAMPLE ANALYSES AND RESULTS SUMMARY

Six soil samples were collected from five locations (SS-01, SS-02, SS-03, 02MW20, and 02MW22) on the East Waterfront Property. Samples were analyzed for metals, TPH, EPH, VPH, VOCs, and/or polycyclic aromatic hydrocarbons (PAHs). Analytical results are presented in Table 5.8. Laboratory reports for soil sampling are presented in Appendix C.

5.6.1 Metals

Four of the six soil samples were analyzed for the RCRA list of eight metals. In addition to the three proposed soil sample locations specified in the RI Work Plan (SS-01, SS-02 and SS-03), a shallow soil sample from 02MW22 was also analyzed for metals. Analytical results for metals are summarized below.

- Arsenic was detected in all 4 samples analyzed; 2 detected arsenic concentrations exceeded the PCUL of 7.3 mg/kg. The greatest detected arsenic concentration was 30 mg/kg in the surface sample collected at SS-02.
- Barium was detected in all 4 samples analyzed; all detected barium concentrations exceeded the PCUL of 4.1 mg/kg. The greatest detected barium concentration was 84 mg/kg in the sample collected from 1.5 to 2 feet bgs at 02MW22.
- Cadmium was detected in 2 of 4 samples analyzed; both detected cadmium concentrations exceeded the PCUL of 0.77 mg/kg. The greatest detected cadmium concentration was 46 mg/kg in the surface sample collected at SS-02.
- Chromium was detected in all 4 samples analyzed; the detected chromium concentrations did not exceed the PCUL of 48 mg/kg.

- Lead was detected in all 4 samples analyzed; 2 of the detected lead concentrations exceeded the PCUL of 24 mg/kg. The greatest detected lead concentration was 100 mg/kg in the surface sample collected from SS-03.
- Silver was detected in 2 of 4 samples analyzed; both detected silver concentrations exceeded the PCUL of 0.10 mg/kg. The greatest detected silver concentration was 2.4 mg/kg in the surface sample collected at SS-02.
- Mercury and selenium were not detected in any soil samples.

5.6.2 TPH and BTEX

In accordance with the RI Work Plan, soil samples were also collected at sample locations 02MW20 and 02MW22, where field indications of contamination (petroleum odor and elevated PID readings) were encountered in unsaturated soils. At these two locations, soil samples were collected from 1.5 to 2 feet bgs. At location 02MW22, a deeper sample without field indications of contamination was collected from 3.5 to 4 feet bgs to delineate the depth of soil contamination. The samples collected from 02MW20 from 1.5 to 2 feet bgs and 02MW22 from 3.5 to 4 feet bgs were analyzed for TPH and BTEX. The sample collected from 02MW22 from 1.5 to 2 feet bgs was analyzed for TPH, EPH/VPH, BTEX, selected SVOCs, and as noted above, metals. Soil analytical results for TPH, BTEX, and EPH/VPH are presented in Table 5.8. GRO, Total DRO and ORO, and benzene results are discussed below, for consistency with the COIs presented in Section 4.0. EPH/VPH data are also briefly summarized below.

- GRO was detected in the samples collected from 1.5 to 2 feet bgs at both 02MW20 and 02MW22; both detected concentrations exceeded the PCUL of 30 mg/kg. The greatest detected GRO concentration was 440 mg/kg at 02MW20. GRO was not detected in the 3.5 to 4 foot bgs sample collected at 02MW22.
- Total DRO and ORO was detected at 3,400 mg/kg in the sample collected from 1.5 to 2 feet bgs at 02MW20, exceeding the PCUL of 2,000 mg/kg. Total DRO and ORO was not detected in either sample collected at 02MW22.
- Benzene was not detected in any soil samples.
- The detected petroleum fractions in the sample collected from 1.5 to 2 feet bgs at 02MW22 were primarily VPH, and EPH fractions were not detected except where they overlapped with petroleum fractions also detected by VPH (C10-C12 aliphatics, C8-C10 aromatics).

5.7 DATA VALIDATION

A Compliance Screening (Stages 1 & 2A) data quality review was performed on metals, TPH, BTEX, VOC, and PAH data resulting from laboratory analysis consistent with the RI Work Plan requirements. The analytical data were validated in accordance with the *National Functional Guidelines for Inorganic Superfund Methods Data Review* (USEPA 2017a) and *National Functional Guidelines for Organic Superfund Methods Data Review* (USEPA 2017b).

A total of nine soil samples were submitted in one sample delivery group (SDG) to Freidman & Bruya, Inc. (FBI) of Seattle, Washington, for chemical analysis by USEPA 6020B, NWTPH-Gx, NWTPH-Dx, USEPA 8021B, USEPA 8206C, and USEPA 8270D-SIM. A total of 109 groundwater samples were submitted in 12 SDGs to FBI for chemical analysis by NWTPH-Gx, NWTPH-Dx, USEPA 8021B, USEPA 8270D-SIM, USEPA 6020B, USEPA 1631E, and USEPA 8260C. EPH/VPH analysis by NWEPH and NWVPH was subcontracted to Fremont Analytical by FBI.

For all SDGs, the laboratory quality assurance and quality control requirements including surrogate, matrix spike (MS), matrix spike duplicate (MSD), laboratory control sample (LCS), and laboratory control sample duplicate (LCSD) recoveries and MS/MSD, LCS/LCSD, and sample/sample duplicate relative percent differences all met USEPA requirements, with some results requiring qualifications based on USEPA guidelines.

Based on the data quality review, the data are determined to be of acceptable quality for use as qualified.

5.8 SUMMARY

The purpose of the Supplemental Upland RI was to fill remaining data gaps as summarized in the RI Work Plan in order to support selection of a final remedy for the Property. This data collection was completed in accordance with the RI Work Plan, with a total of six soil samples and 106 groundwater samples collected for analysis of chemicals of interest to sufficiently delineate the extent of groundwater and soil contamination at the Site.

The groundwater data were generally consistent with prior data collected at the Property and served to sufficiently fulfill data gaps and delineate the extents of contaminants in groundwater. Samples collected during the Supplemental Upland RI fulfilled data gaps in groundwater necessary to select a final remedy for the Property.

Well installation and sampling during the Supplemental Upland RI also found that the Shallow WBZ thins drastically as it approaches the sloped areas on the north side of W. Commodore Way (refer to Figure 5.6). The Shallow WBZ is absent to the northeast of the Bulk Terminal Property at 01MW103 and 01MW109, where the Intermediate WBZ was also observed to be slower to recharge than in other areas of the Property.

Soil sampling conducted during the Supplemental Upland RI sufficiently fulfilled the remaining data gap regarding the potential presence of metals related to sandblast grit on the East Waterfront Property and served to further delineate known areas of residual TPH contamination in soil on this property in order to select a final remedy for the Property.

These Supplemental Upland RI data are combined with the existing data to determine the IHSs present at the Property and proposed cleanup standards (refer to Section 6.0), and the nature and extent of IHSs exceeding those cleanup standards (refer to Section 7.0) in order to determine remedial alternatives for the Property.

6.0 Development of Indicator Hazardous Substances and Proposed Cleanup Standards

This section identifies the proposed IHSs in groundwater and soil at the Property from among the COIs for each medium. IHSs are selected in accordance with WAC 173-340-703, which allows elimination of individual hazardous substances that contribute a small percentage of the overall threat to human health and the environment in order to focus remedial actions. IHSs are determined by screening Site data against the PCULs developed for each medium, described in Section 4.0. When data screening is complete, additional evaluation is conducted to identify the proposed IHSs by considering factors presented in WAC 173-340-703(2), as detailed below. Once IHSs are identified, cleanup standards are proposed for each of the IHSs. Cleanup standards are defined as a CUL combined with a point of compliance (POC) where the CUL applies. As mentioned in Section 4.0, Ecology has requested a single CUL per analyte per medium for the Site, regardless of whether a pathway is considered complete in all areas of the Site.

6.1 CHEMICALS OF INTEREST

As described in Section 4.0, COIs are chemicals for which PCULs have been derived and are the focus of IHS screening below. PCULs are derived for those groundwater and soil COPCs identified in the RI Work Plan based on the preliminary data screening. Additionally, PCULs were developed for chemicals that were analyzed in the Supplemental Upland RI (described further in Section 5.0) that were identified as data gaps, in consultation with Ecology. In this RI/FS, these chemicals are collectively termed COIs for simplicity.

6.2 INDICATOR HAZARDOUS SUBSTANCES

MTCA allows the selection of IHSs at Sites that are contaminated with a large number of chemicals of concern. Per WAC 173-340-703, chemicals that contribute a small percentage of the overall threat to human health and the environment may be screened out from consideration.

IHSs were developed for groundwater and soil in a stepwise approach. First, COIs were retained as PIHSs if they meet the following initial selection criteria:

- Greater than 10 percent of results exceed the PCUL and/or
- The maximum result exceeds the PCUL by 2 times or greater

After the PIHSs were identified for groundwater and soil, further evaluation was conducted to identify the proposed IHSs by considering factors presented in WAC 173-340-703(2):

- Whether the PIHS was identified as an IHS in other media at the Site
- The spatial footprint of exceedances and collocation with other IHSs
- Mobility
- Toxicological characteristics

A summary of the groundwater and soil IHS selection process and outcomes is presented in the following sections.

6.2.1 Groundwater

This section describes the selection process for IHSs in groundwater from among the COIs identified in the RI Work Plan by screening groundwater data against the PCULs. Table 6.1 presents Sitewide frequency of exceedance (FOE) information. For each COI, Table 6.1 presents the PCUL; information about the number of groundwater results; whether detected results exceed the PCUL; and the maximum exceedance factor for each COI. The most recent groundwater results have been included for each location, which is reflective of current Site conditions, particularly given the extent of soil interim actions performed at the Site. The COIs that meet the PIHS initial selection criteria for groundwater presented above are listed in Table 6.1. Additionally, Appendix D presents the data for all COIs with PCUL exceedances in summary tables.

PIHS screening for metals was performed using metals results representing both the dissolved and total fraction of Site groundwater samples. To assess compliance with a groundwater CUL, it is appropriate for the fraction measured to match the fraction regulated. The basis of the PCUL for cadmium, chromium, lead, and mercury are surface water standards specific to the dissolved fraction, which are protective of chronic effects caused by dissolved metal concentrations in the water column. Therefore, the evaluation to identify metals that are retained as PIHSs in groundwater was performed using data measured in the dissolved fraction for these metals. Arsenic was evaluated using results measured in the total fraction, because the basis for the arsenic PCUL is a statewide natural background concentration determined using total arsenic.

After the PIHSs were identified, further evaluation was conducted to identify the proposed IHSs as described in Section 6.2. The rationale for the selection of proposed groundwater IHSs is presented in Table 6.1. Based on this evaluation, the proposed groundwater IHSs include the following:

- Arsenic
- GRO
- Total DRO and ORO
- Benzene
- TCE
- Vinyl chloride
- Penta

6.2.2 Soil

The selection process for IHSs in soil from among the COIs identified in the RI Work Plan is described below. Table 6.2 identifies PIHSs in soil from among the COIs identified in the RI Work Plan by screening Site soil data against the PCULs developed in Section 4.0. Table 6.2 presents Sitewide FOE information. For each COI, this table presents the PCUL; information about the number of soil results; whether detected results exceed the PCUL; and the maximum exceedance factor for each COI. All soil results representative of current Site conditions (i.e., currently present in situ) have been included in the FOE table. The COIs that meet the PIHS initial selection criteria

are listed in Table 6.2. Additionally, Appendix D presents the data for all COIs with PCUL exceedances in summary tables.

Once COIs were determined to meet the initial PIHS selection criteria for frequency and magnitude of PCUL exceedance, a more detailed evaluation was performed as described in Section 6.2 to determine if the COI is present at concentrations that may pose a current or future threat to groundwater quality, which is the basis of the majority of the PCULs.

In accordance with WAC 173-340-747(9), groundwater data can be used to demonstrate that soils are protective of groundwater. This demonstration step distinguishes chemicals that are not migrating from soil to groundwater (i.e., incomplete pathway) from those that either are migrating or may do so in the future. The COI may be eliminated as a soil PIHS if exceedances of the leaching PCUL in soil do not correspond to exceedances in groundwater and exceedances of direct contact criteria (human and ecological) are not observed. If exceedances are not observed in groundwater but soil results still exceed a direct contact-based PCUL (e.g., TEE criteria), the PIHS is retained for that exposure pathway only. Table 6.2 presents a discussion of the empirical screening of groundwater data and the determination of PIHSs.[4]

Importantly, as per Ecology directive, this was considered Sitewide. Therefore, if there are exceedances of groundwater PCULs on any property, that COI was retained. This is an extremely conservative approach, because different releases may have different leaching characteristics.

Proposed IHSs were then selected from the PIHSs based on the factors listed in WAC 173-340-703(2). The rationale for the selection of proposed soil IHSs is presented in Table 6.2. Based on this evaluation, proposed soil IHSs include the following:

- Arsenic
- GRO
- Total DRO and ORO
- Benzene
- TCE
- Penta

6.3 PROPOSED CLEANUP STANDARDS

Cleanup standards are defined as a CUL combined with a POC where the CUL applies. Cleanup standards for groundwater and soil are proposed in the following sections.

6.3.1 Groundwater

Groundwater cleanup standards ensure that groundwater leaving the Site is protective of human and ecological receptors in surface water and sediment, and that onsite groundwater is

[4] Of note, dioxins/furans in soil were previously addressed as part of a major interim action excavation performed on the Bulk Terminal Property and are also collocated with penta. Site conditions no longer warrant identifying dioxins/furans as an IHS.

protective of drinking water and ambient air. Proposed cleanup standards have been selected for each of the proposed IHSs identified in Section 6.2.

6.3.1.1 Point of Compliance

Under MTCA (WAC 173-340-720(8)(b)), the standard POC for groundwater is defined as "throughout the site from the uppermost level of the saturated zone to the lowest depth potentially affected by the site," which implies that groundwater will meet CULs throughout the Site within a reasonable restoration time frame.

If it can be demonstrated that it is not practicable to meet groundwater CULs at the standard POC within a reasonable restoration time frame using all practicable methods of treatment in the cleanup per WAC 173-340-720(8)(c) or (d), then a conditional POC (CPOC) may be approved by Ecology. If a CPOC is necessary, MTCA requires that a CPOC be set as close to the contamination source as practicable, not to exceed the property boundary. The FS evaluates whether it is feasible to meet the standard POC for groundwater, or whether a CPOC is required.

6.3.1.2 Proposed Cleanup Levels

For the groundwater IHSs, all pathways considered in the development of PCULs are complete. Therefore, the groundwater PCULs in Table 6.1 are numerically equivalent to the proposed CULs, presented in Section 6.4.

6.3.2 Soil

Soil cleanup standards will ensure that onsite soil is protective of direct contact (human health and ecological risk) pathways and leaching (protection of groundwater) pathways.

6.3.2.1 Point of Compliance

The standard POC for soil is pathway-dependent, as defined in WAC 173-340-740(6)(b-d). The standard POC for each potentially active soil exposure pathway, along with specific application at the Site, is summarized below:

- **Direct Contact.** The POC is soil throughout the site from the ground surface to 15 feet bgs irrespective of receptor, per WAC 173-340-740(6)(d) for human health risk assessment and WAC 173-340-7490(4)(b) for ecological risk assessment. This represents a reasonable estimate of the depth of soil that could be excavated and distributed at the soil surface as a result of site development activities and is consistent with MTCA. This POC is protective of incidental ingestion and dermal contact with soil for any site and does not require the presence of pavement or institutional controls to be protective.
- **Leaching.** The POC is soil throughout the site per WAC 173-340-740(6)(b). In practice, this means that soil samples collected within the vadose zone are typically compared to the site-specific CULs developed for leaching from vadose zone soil, and soil samples collected within saturated soil are typically compared to the site-specific CULs developed for leaching from saturated soil. Although MTCA considers vadose and

saturated zone soils separately with regard to leaching risk, as per Ecology directive, the more conservative assumption that soils are effectively all saturated is used.

- **Vapor Intrusion.** The POC is soil throughout the site from the ground surface to the uppermost water table. Generally, for Site soil, the corresponding depth range for this pathway is from 0 to 5 feet bgs, in accordance with WAC 173-340- 740(6)(c).

6.3.2.2 Proposed Cleanup Levels

For the soil IHSs, all pathways considered in the development of PCULs are complete. Therefore, the soil PCULs in Table 6.2 are numerically equivalent to the proposed CULs, presented in Section 6.4.

6.4 SUMMARY OF IHSS AND PROPOSED CLEANUP STANDARDS

Groundwater and soil IHSs and their proposed cleanup standards are summarized in Table 6.3.

Table 6.3
Summary of Site IHSs and Proposed Cleanup Standards

Proposed IHS	Proposed Cleanup Level		Point of Compliance
	Value	Basis	
Groundwater			
Arsenic	5 µg/L	Statewide natural background	Sitewide
GRO	800 µg/L	Protection of drinking water	Sitewide
Total DRO and ORO	500 µg/L	Protection of drinking water	Sitewide
Benzene	0.44 µg/L	Protection of surface water	Sitewide
TCE	0.5 µg/L	Protection of surface water (PQL-based)	Sitewide
Vinyl chloride	0.2 µg/L	Protection of surface water (PQL-based)	Sitewide
Penta	0.2 µg/L	Protection of surface water (PQL-based)	Sitewide
Soil			
Arsenic	7.3 mg/kg	Natural background	Sitewide
GRO	30 mg/kg	Protection of groundwater [(1)]	Sitewide
Total DRO and ORO	2,000 mg/kg	Protection of groundwater [(1)]	Sitewide
Benzene	0.02 mg/kg	Protection of surface water (PQL-based)	Sitewide
TCE	0.02 mg/kg	Protection of surface water (PQL-based)	Sitewide
Penta	0.05 mg/kg	Protection of surface water (PQL-based)	Sitewide

Note:
1 The CULs for protection of leaching to groundwater and protection of direct contact are equivalent for TPH including GRO and total DRO and ORO.

Abbreviation:
PQL Practical quantitation limit

7.0 Nature and Extent of Contamination

There have been many previous investigations at the Site, including the previous RIs, which provided extensive information regarding site hydrogeology, geology, historical site uses and features, and environmental contamination present.

The sections that follow describe the nature and extent of groundwater and soil contamination, using all available in situ data, which serves to define the "Site" for each of the IHSs identified in Section 6.2.

7.1 NATURE OF IHSS

The IHSs identified for the Site include arsenic, GRO, Total DRO and ORO, benzene, TCE, vinyl chloride, and penta. The chemical and physical properties of the IHSs influence their fate and transport in the environment and the selection of remedial technologies. Table 7.1 presents chemical-specific properties for the IHSs. The following properties were considered especially relevant:

- **Solubility and Hydrophilic Properties:** Chemicals with high aqueous solubilities and low partitioning coefficients (K_d and/or K_{oc}) tend to dissolve into groundwater and remain in groundwater for longer periods of time, increasing their ability to migrate in groundwater. For example, vinyl chloride is hydrophilic and will migrate as fast as the groundwater moves because it does not partition to soil organic matter. Total DRO and ORO is more hydrophobic (low solubilities and high partitioning coefficients) and tends to sorb to soil; therefore, it has moderate to low mobility.
- **Volatility:** Chemicals with low boiling points and high vapor pressures are considered volatile and are likely to move from soil and shallow groundwater into the pores in the unsaturated vadose zone. Once they are present in soil gas, they have the potential to migrate in the vadose zone (from the source area) by diffusion and convection. They also have the potential to enter buildings through cracks in the foundation (vapor intrusion). Vinyl chloride is very volatile (a gas at room temperature). GRO, benzene, and TCE have moderate volatility.
- **Degradability:** Chemicals will degrade to other chemicals due to a host of processes, but the two that are most common are biological degradation and chemical degradation. Chemicals that do not degrade easily are referred to as persistent chemicals. Penta is an example of a persistent chemical. Many chemicals will rapidly degrade under one set of conditions but not under another, so discussions of degradation must include a clear understanding of the conditions necessary for the degradation to occur. TCE is an example of a chemical that readily degrades under anaerobic conditions, whereas TPH degrades readily under aerobic conditions.

7.2 EXTENT OF IHSS IN GROUNDWATER

IHSs in groundwater include arsenic, GRO, Total DRO and ORO, benzene, TCE, vinyl chloride, and penta. A summary of the most recent groundwater data for each of the IHSs is included in the following sections. Sitewide IHSs have been sufficiently delineated for the purpose of the Supplemental Upland RI, which is to collect sufficient information to evaluate and select cleanup alternative(s) for the Site (WAC 173-340-350(1)). A map showing the approximate extents of the groundwater plumes of IHS concentrations that exceed the proposed CULs is presented in Figure 7.1. Comprehensive tables of analytical results for IHSs exceeding the proposed CULs in groundwater are presented in Appendix D.

7.2.1 Arsenic

Arsenic exceeding the proposed CUL of 5 µg/L occurs in limited areas of the Shallow WBZ on the East Waterfront Property in the vicinity of 02MW20 and 02MW19, and in a limited area of the Perched WBZ on the ASKO Property in the vicinity of MW03. These areas of elevated arsenic in groundwater in the Shallow WBZ are isolated in both locations and two areas (02MW19 and MW03) are associated with corresponding elevated arsenic concentrations in soil (discussed in further detail in Section 7.3.1). Analytical results for metals including arsenic in soil and groundwater on the East Waterfront Property are presented in Figure 7.2. The areas of arsenic exceedances in groundwater Sitewide are shown on Figure 7.1. The greatest detected arsenic concentration is 66 µg/L (9.4 times the proposed CUL of 5 µg/L) in the Perched WBZ on the ASKO Property. Arsenic is present at lesser concentrations ranging from 6.7 to 23 µg/L on the East Waterfront Property (1.3 to 4.6 times the proposed CUL). Arsenic concentrations that exceed the proposed CUL are sufficiently delineated by results less than the proposed CUL or, on the ASKO Property, by the absence of a Perched WBZ extending off-property.

7.2.2 TPH

TPH concentrations in groundwater that exceed the proposed CULs are widespread on both the Bulk Terminal and ASKO Properties and present in limited areas on the East Waterfront Property.

TPH distribution in Bulk Terminal Property groundwater is presented in Figure 7.3. On the Bulk Terminal Property, GRO is present at concentrations greater than the proposed CUL of 800 µg/L in the Shallow WBZ on-property, primarily in the vicinity of the former loading racks and USTs (refer to Figure 2.1a for former Site features) where LNAPL is present in groundwater and extends into W. Commodore Way. GRO was not detected at concentrations that exceed the proposed CUL in any Intermediate WBZ wells on the Bulk Terminal Property. The greatest detected concentrations of GRO in groundwater are located surrounding and within the LNAPL area and to the northwest (downgradient) of the LNAPL area with a maximum detected concentration of 10,000 µg/L (12.5 times the proposed CUL of 800 µg/L) at 01MW19.

Total DRO and ORO is present at concentrations greater than the proposed CUL of 500 µg/L in the Shallow WBZ in the vicinity of the former ASTs and loading racks on-property and extend into W. Commodore Way to the north. The greatest detected concentrations of Total DRO and ORO in groundwater are also generally located northwest of the LNAPL area, with a maximum

detected concentration of 9,400 µg/L (18.8 times the proposed CUL of 500 µg/L) at 01MW24. Total DRO and ORO also exceed the proposed CUL to the northeast of the smaller LNAPL area in the vicinity of the former tank yard and to the southwest (refer to Figure 2.1a for former Site features) in a secondary downgradient direction of groundwater flow; the Total DRO and ORO concentration of 1,400 µg/L at 01MW42 exceeds the proposed CUL of 500 µg/L by 2.8 times.

Total DRO and ORO is present at concentrations exceeding the proposed CUL at lesser concentrations (660 and 1,800 µg/L; 1.3 to 3.6 times the proposed CUL of 500 µg/L) at Intermediate WBZ monitoring wells 01MW48 and 01MW51 in W. Commodore Way to the north of the LNAPL area; however, Total DRO and ORO is less than the proposed CUL at Intermediate WBZ monitoring wells at 01MW104 and 01MW111 on the north side of the W. Commodore Way northeast of the LNAPL area, suggesting that Total DRO and ORO impacts in the Intermediate WBZ are limited. Total DRO and ORO is also present at concentrations exceeding the proposed CUL at all of the Intermediate WBZ wells (01MW37, 01MW38, 01MW59) installed on the Bulk Terminal Property (south of the ROW).

In the Shallow WBZ, both GRO and Total DRO and ORO exceeded the proposed CULs at 01MW84 on the north side of W. Commodore Way, suggesting that this TPH groundwater plume may extend onto the East Waterfront Property. However, TPH does not exceed the proposed CULs on the nearest downgradient well (02MW10) on the East Waterfront Property. The TPH plume emanating from the Bulk Terminal Property is delineated in all directions except in a small area to the north where Total DRO and ORO exceeded the proposed CUL in Shallow WBZ well 01MW35 on the north side of W. Commodore Way, to the southwest on-property in the vicinity of Shallow WBZ well 01MW39, and in the vicinity of apparent isolated detections at Shallow WBZ well 01MW99 south of the Property.

TPH distribution relative to the proposed CULs in ASKO Property groundwater is presented in Figure 7.4. On the ASKO Property, Total DRO and ORO concentrations exceed the proposed CUL in Perched WBZ wells on the BNSF parcel to the south and along the BNSF parcel line, and in perched and Shallow WBZ wells on-property to the north of the BNSF parcel. Total DRO and ORO concentrations do not exceed the proposed CUL in any Intermediate WBZ wells on the ASKO Property. GRO concentrations greater than the proposed CUL on the ASKO Property are present in a subset of wells with Total DRO and ORO exceedances. TPH concentrations are generally lower-level on the ASKO Property than on the Bulk Terminal Property. GRO concentrations exceeding the proposed CUL range from 930 to 2,100 µg/L (1.2 to 2.6 times the proposed CUL of 800 µg/L), and Total DRO and ORO concentrations exceeding the proposed CUL range from 820 to 6,200 µg/L (less than 2 times to 12.4 times the proposed CUL of 500 µg/L). TPH concentrations are fully delineated by results less than the proposed CUL on the ASKO Property.

TPH distribution relative to the proposed CULs in East Waterfront Property groundwater is presented in Figure 7.5. On the East Waterfront Property, TPH impacts are limited, with Total DRO and ORO at concentrations that exceed the proposed CULs in discrete areas surrounding Shallow WBZ wells 02MW04 and 02MW07, which are adjacent to areas where interim actions were completed to remove TPH-contaminated soil. The concentrations of Total DRO and ORO are 670 µg/L and 2,000 µg/L at 02MW04 and 02MW07, respectively (1.3 and 4 times the proposed

CUL of 500 µg/L). GRO also exceeds the proposed CUL in the vicinity of 02MW04, where the detected concentration is 3,100 µg/L (3.9 times the proposed CUL of 800 µg/L). TPH concentrations are sufficiently delineated by sample results less than the proposed CULs on the East Waterfront Property.

7.2.3 Benzene

Benzene is present in groundwater at concentrations that exceed the proposed CUL and, like TPH, is widespread on both the Bulk Terminal and ASKO Properties and present in limited areas on the East Waterfront Property.

Benzene distribution in Bulk Terminal Property groundwater is presented in Figure 7.6. On the Bulk Terminal Property, benzene exceeds the proposed CUL of 0.44 µg/L in the Shallow WBZ in the vicinity of the former loading racks and gasoline USTS (refer to Figure 2.1a) and extends into W. Commodore Way to the north. Benzene concentrations exceeding the proposed CUL on the Bulk Terminal Property range from 0.53 to 1,200 µg/L (less than 2 times to 2,700 times the proposed CUL of 0.44 µg/L). Benzene does not exceed the proposed CUL in the Intermediate WBZ or in Shallow WBZ wells along the north side of W. Commodore Way. Benzene concentrations are fully delineated by results less than the proposed CULs on the Bulk Terminal Property.

Benzene distribution in ASKO Property groundwater is presented in Figure 7.7. On the ASKO Property, benzene exceeds the proposed CUL in the Perched WBZ to the south on BNSF and on-property at MW03. Benzene concentrations in the Shallow WBZ exceed the proposed CUL on-property but are less than the proposed CUL in wells to the north in W. Commodore Way, suggesting the benzene plume does not extend off-property. Benzene concentrations are generally lower-level on the ASKO Property than on the Bulk Terminal Property, ranging from 1.0 to 16 µg/L (2.3 to 36 times the proposed CUL of 0.44 µg/L). Benzene does not exceed the proposed CUL in any Intermediate WBZ wells. Benzene concentrations are fully delineated by results less than the proposed CUL on the ASKO Property.

Benzene distribution in East Waterfront Property groundwater is presented in Figure 7.8. On the East Waterfront Property, benzene is present at 3.7 µg/L at Shallow WBZ well 02MW04 (8.4 times the proposed CUL of 0.44 µg/L). Benzene is not present in any other Shallow WBZ wells or Intermediate WBZ wells at concentrations greater than the proposed CUL. Benzene concentrations are fully delineated by results less than the proposed CUL on the East Waterfront Property.

7.2.4 cVOCs

cVOCs are present in groundwater at concentrations that exceed the proposed CULs on the ASKO Property and BNSF parcel only. cVOC distribution in ASKO Property (including the BNSF parcel) groundwater is presented in Figure 7.9. TCE exceeds the proposed CUL of 0.5 µg/L in the Perched WBZ on the BNSF parcel extending onto the ASKO Property to the north. TCE does not exceed the proposed CUL in Shallow WBZ wells located on the BNSF parcel but exceeds the proposed CUL on the ASKO Property in the Shallow WBZ. The greatest TCE concentrations in the Perched WBZ are detected on the BNSF parcel and downgradient to the northeast, ranging from 1.2 to 5,900 µg/L (2.4 times to 11,800 times the proposed CUL of 0.5 µg/L). The greatest TCE concentrations in the

Shallow WBZ are present downgradient of the BNSF parcel on the ASKO Property and range from 3.3 to 2,200 µg/L (6.6 to 4,400 times the proposed CUL of 0.5 µg/L). TCE does not exceed the proposed CUL in any Intermediate WBZ wells except at 01MW78 at the upgradient southern property line and is fully delineated by results less than the proposed CULs on the ASKO Property.

Similar to TCE, vinyl chloride on the ASKO Property also exceeds the proposed CUL of 0.2 µg/L in the Perched WBZ on the BNSF parcel to the south and in both the Perched and Shallow WBZs extending onto the ASKO Property to the north. Vinyl chloride concentrations in the Perched WBZ on the BNSF parcel and downgradient to the northeast range from 0.69 to 39 µg/L (3.5 to 200 times the proposed CUL of 0.2 µg/L). Vinyl chloride concentrations in the Shallow WBZ on the ASKO Property downgradient of the BNSF parcel range from 0.30 to 27 µg/L (1.5 to 135 times the proposed CUL of 0.2 µg/L). Vinyl chloride greater than the proposed CUL is more widespread than TCE and extends further to the north into W. Commodore Way in the Shallow WBZ but does not exceed the proposed CUL in Shallow WBZ wells along the north side of W. Commodore Way. Vinyl chloride is also present at 0.33 µg/L, slightly exceeding the proposed CUL of 0.2 µg/L, in Intermediate WBZ well 01MW108, near the northern property line.

cVOCs were not detected at the laboratory reporting limits in Deep WBZ well 01MW65. cVOCs are fully delineated on the ASKO Property by sample results less than the proposed CULs except in the Intermediate WBZ near the northern property line, where the detected vinyl chloride concentration of 0.33 µg/L slightly exceeds the proposed CUL of 0.20 µg/L (less than 2 times the proposed CUL). However, given this low-level exceedance, it is unlikely that vinyl chloride would be present at concentrations greater than the proposed CUL off-property in the Intermediate WBZ. cVOCs are delineated in the downgradient directions to the north, northeast and northwest in the Shallow WBZ; however, the precise extent of the vinyl chloride plume to the northwest along W. Commodore Way is inferred between wells MW02 and 01MW106.

7.2.5 Penta

Penta is present at concentrations that exceed the proposed CUL in a limited area of the Bulk Terminal Property surrounding wells 01MW01 and 01MW66. These wells are situated at the edge of the area where prior interim action excavations were completed to remove penta-contaminated soil, and penta historically exceeded the proposed CUL in groundwater to the west of the excavation area. The two penta concentrations exceeding the proposed CUL of 0.2 µg/L are 2.1 and 3.6 µg/L, respectively. The area of penta in groundwater that exceeds the proposed CUL is shown on Figure 7.1. Penta in groundwater is localized and fully delineated.

7.3 EXTENT OF IHSS IN SOIL

IHSs in soil include arsenic, GRO, Total DRO and ORO, benzene, TCE, and penta. A comprehensive summary of in situ soil data for each of the IHSs is included in the following sections. Data for soil that has been removed from the Site (refer to Section 3.2) are no longer considered representative of current Site conditions and are not included herein.

Due to the data density of historical soil data, the results are presented relative to the proposed CULs (less than, greater than by less than 2 times the proposed CUL, greater than by more than

2 times the proposed CUL, and greater than by more than 5 times the proposed CUL). Soil results for locations where an IHS is greater than the proposed CULs are presented in Appendix D.

7.3.1 Arsenic

Arsenic concentrations that exceed the proposed CUL of 7.3 mg/kg in soil samples Sitewide are presented on Figure 7.10. Arsenic is present at concentrations slightly greater than (i.e., less than 2 times) the proposed CUL at scattered locations on the Bulk Terminal and ASKO Properties. These low-level exceedances include a single shallow (8 feet bgs) soil sample at the southeast corner of the Bulk Terminal Property, and three shallow (1.5 to 6 feet bgs) soil samples on the ASKO Property in the vicinity of arsenic and collocated TPH and cVOC exceedances in perched groundwater (refer to Figure 7.1).

On the East Waterfront Property, two more elevated arsenic concentrations that exceed the proposed CUL (26 and 30 mg/kg; 3.6 and 4.1 times the proposed CUL of 7.3 mg/kg) are present in shallow soil along the shoreline in the vicinity of former sandblast grit piles. Arsenic in soil is delineated by results less than the proposed CUL in East Waterfront Property soil. These detections are localized and appear to be consistent with historical storage of sandblast grit piles. The lateral and vertical extents of arsenic in shallow soil are not fully delineated in this area; however, arsenic is sufficiently delineated for the purposes of the RI and selection of a remedy. Arsenic results for soil and groundwater on the East Waterfront Property, along with results for other metals, are shown on Figure 7.2.

7.3.2 TPH

TPH concentrations that exceed the proposed CULs are present in soil Sitewide. Sitewide soil samples with GRO concentrations that exceed the proposed CUL of 30 mg/kg (at any depth) are presented in Figure 7.11, and Sitewide soil samples with Total DRO and ORO concentrations that exceed the proposed CUL of 2,000 mg/kg (at any depth) are presented in Figure 7.12.

On the Bulk Terminal Property, soil samples analyzed for TPH are densely spaced, with several hundred in situ sample results.[5] In order to show the data in a format that is useful for understanding the nature and extent of TPH contamination in soil, GRO results relative to the proposed CUL for the 0 to 5 feet bgs, 5 to 10 feet bgs, 10 to 15 feet bgs, and >15 feet bgs depth intervals of Bulk Terminal Property soil are presented in Figure 7.13. Total DRO and ORO results for the same intervals of Bulk Terminal Property soil are presented in Figure 7.14.

GRO that exceeds the proposed CUL on the Bulk Terminal Property is primarily present in the upper 15 feet of soil and is most concentrated in the soil depth intervals surrounding the water table. In the top 10 feet of soil, GRO concentrations that exceed the proposed CUL are clustered primarily in the area where LNAPL is present on groundwater, with scattered GRO exceedances in the central portion of the Bulk Terminal Property and on the ASKO Property to the west. GRO concentrations exceeding the proposed CUL in this interval range from 35 to 760,000 mg/kg

[5] It is important to note that in addition to the analytical results, there are also hundreds of additional field screening results (provided on soil boring logs) that were reviewed to evaluate the distribution of TPH in soil.

(less than 2 times to 25,000 times the proposed CUL of 30 mg/kg). Below 15 feet bgs, GRO exceedances are clustered in the LNAPL area. GRO concentrations are largely delineated by results less than the proposed CUL to the north in W. Commodore Way, with the exception of a single exceedance along the north side of W. Commodore Way. GRO is also delineated vertically for the purposes of the RI below 15 feet bgs, with only seven sample locations with exceedances of the proposed CUL in this depth interval.

Total DRO and ORO concentrations that exceed the proposed CUL on the Bulk Terminal Property follow a similar distribution as GRO on the Bulk Terminal Property but are less widespread. Total DRO and ORO concentrations that exceed the proposed CUL are scattered throughout the Bulk Terminal Property and extend west onto the ASKO Property in the 0 to 5 feet bgs interval and are primarily clustered in the LNAPL area below 5 feet bgs. Total DRO and ORO concentrations exceeding the proposed CUL in the 0 to 15 feet bgs interval range from 2,100 to 35,000 mg/kg (less than 2 times to 18 times the proposed CUL of 2,000 mg/kg). Total DRO and ORO is fully delineated by results less than the proposed CUL to the north in W. Commodore Way and well delineated for the purposes of the RI below 15 feet bgs with only one location with an exceedance in this depth interval.

Soil samples analyzed for TPH are also densely spaced on the ASKO property. GRO results relative to the proposed CUL for the 0 to 8 feet bgs, 8 to 20 feet bgs, 20 to 30 feet bgs, and >30 feet bgs depth intervals of ASKO Property soil are presented in Figure 7.15. Total DRO and ORO results for the same intervals of ASKO Property soil are presented in Figure 7.16.

GRO concentrations exceeding the proposed CUL are scattered throughout the ASKO property and on the BNSF parcel in the 0 to 8 feet bgs depth interval, primarily limited to this interval with only one sample location with an exceedance from 8 to 20 feet bgs. GRO concentrations exceeding the proposed CUL of 30 mg/kg on the ASKO Property are lower-level than on the Bulk Terminal Property, ranging from 52 to 9,700 mg/kg (less than 2 times to 320 times the proposed CUL of 30 mg/kg). GRO is also fully delineated to the north in W. Commodore Way by results less than the proposed CUL. Total DRO and ORO concentrations exceeding the proposed CUL follow the same distribution as GRO in ASKO Property soil; scattered exceedances are present on-property in the 0 to 8 feet bgs interval, and a single sample result exceeds the proposed CUL below 8 feet bgs. Total DRO and ORO concentrations exceeding the proposed CUL on the ASKO Property are also somewhat lower-level than on the Bulk Terminal Property, ranging from 2,200 to 24,000 mg/kg (less than 2 times to 12 times the proposed CUL of 2,000 mg/kg). Total DRO and ORO is delineated by sample results less than the proposed CUL to the north in W. Commodore Way.

GRO and Total DRO and ORO results relative to the proposed CULs on the East Waterfront Property are presented in Figure 7.17. A map of the smaller area on this property with TPH exceedances of the proposed CULs, and analytical results for samples with exceedances, is presented in Figure 7.18. On the East Waterfront Property, TPH concentrations exceeding the proposed CULs are concentrated on the eastern portion of the property where the former utilidor passed to the garage/vehicle maintenance buildings. Interim action excavations were completed to remove TPH in soil in this area but did not extend to the east under the buildings, as described in Section 3.2. GRO and Total DRO and ORO exceedances are generally collocated and present at

depths ranging from approximately 2 feet bgs near the shoreline to a maximum depth of 12.5 feet bgs (one location with an exceedance at this depth) on the southeastern portion of the East Waterfront Property. GRO concentrations exceeding the proposed CUL of 30 mg/kg on the East Waterfront Property range from 42 to 440 mg/kg (less than 2 times 15 times the proposed CUL), and Total DRO and ORO concentrations exceeding the proposed CUL of 2,000 mg/kg range from 2,400 to 23,000 mg/kg (less than 2 times to 12 times the proposed CUL). TPH in soil on the East Waterfront Property is delineated to the east, west, and south by soil samples with results less than the proposed CULs; however, GRO and Total DRO and ORO exceed the proposed CULs at two shallow sample locations at the northeast property corner. The area of TPH exceedances is also well-delineated vertically by underlying sample results less than the proposed CULs, at depths ranging from approximately 4 feet bgs along the shoreline to 15 feet bgs in the southern portion of the East Waterfront Property, as shown on Figure 7.18.

TPH in soil is sufficiently delineated for the purposes of the RI.

7.3.3 Benzene

A map showing the Sitewide extents of benzene concentrations in soil exceeding the proposed CUL is presented in Figure 7.19. Benzene exceedances in soil are present primarily on the Bulk Terminal Property, with fewer scattered exceedances on the ASKO and East Waterfront Properties.

Benzene results relative to the proposed CUL for the 0 to 5 feet bgs, 5 to 10 feet bgs, 10 to 15 feet bgs, and >15 feet bgs depth intervals on the Bulk Terminal Property are shown on Figure 7.20. In shallow soil from 0 to 5 feet bgs, benzene concentrations exceeding the proposed CUL of 0.02 mg/kg are generally present in a concentrated area surrounding the LNAPL area and are also scattered throughout the property extending onto the ASKO Property to the west. Below 5 feet bgs, benzene exceedances are concentrated around the LNAPL area, and scattered exceedances are also present on the ASKO Property. Benzene concentrations exceeding the proposed CUL range from 0.03 to 5,600 mg/kg (less than 2 times to 280,000 times the proposed CUL of 0.02 mg/kg). Benzene is delineated to the north in W. Commodore Way by results less than the proposed CUL. Benzene concentrations exceeding the proposed CUL are present primarily above 15 feet bgs, with scattered exceedances below 15 feet bgs. Benzene concentrations decrease rapidly with depth; from 15 to 20 feet, concentrations range from 1.4 to 41 mg/kg, whereas at 20 feet bgs and below, concentrations range from 0.070 to 1.4 mg/kg. These lower-level benzene exceedances do not appear to cause impacts to groundwater in excess of the proposed CUL; benzene is fully delineated in groundwater downgradient of the area of soil impacts. Therefore, benzene is sufficiently delineated on the Bulk Terminal Property for the purposes of the RI.

Benzene results for the 0 to 8 feet bgs, 8 to 20 feet bgs, 20 to 30 feet bgs, and >30 feet bgs depth intervals on the ASKO Property are shown on Figure 7.21. Scattered benzene exceedances of the proposed CUL of 0.02 mg/kg are present on-property above 20 feet bgs, and benzene concentrations in samples below 20 feet bgs do not exceed the proposed CUL. Benzene concentrations exceeding the proposed CUL on the ASKO Property are significantly lower-level than on the Bulk Terminal Property, ranging from 0.04 to 0.61 mg/kg (2 times to 31 times the

proposed CUL of 0.02 mg/kg). Benzene is fully delineated on the ASKO Property by soil results less than the proposed CUL.

Benzene results on the East Waterfront Property, with analytical results for samples that exceed the proposed CUL, are presented in Figure 7.22. Benzene concentrations exceeding the proposed CUL of 0.02 mg/kg are present primarily on the southeastern portion of the property, where samples collected between 3.5 and 25 feet bgs exceeded the proposed CUL. Benzene concentrations exceeding the proposed CUL on the East Waterfront Property range from 0.039 to 0.21 mg/kg (less than 2 times to 11 times the proposed CUL of 0.02 mg/kg). Benzene is delineated in this area by soil results less than the proposed CUL to the north, south, east, and west and below 25 feet bgs, as shown on Figure 7.22. A single benzene result also slightly exceeds the proposed CUL in shallow soil on the north property line.

Benzene in soil is sufficiently delineated for the purposes of the RI.

7.3.4 TCE

A map showing the Sitewide extents of TCE concentrations in soil exceeding the proposed CUL of 0.02 mg/kg is presented in Figure 7.23. Soil with TCE concentrations exceeding the proposed CUL is present only on the ASKO Property and adjacent BNSF parcel. Soil results relative to the proposed CUL for the 0 to 8 feet bgs, 8 to 20 feet bgs, 20 to 30 feet bgs, and >30 feet bgs soil depth intervals on the ASKO Property are shown on Figure 7.24.

Between 0 and 20 feet bgs, TCE concentrations exceeding the proposed CUL of 0.02 mg/kg are present in soil on the BNSF parcel and extend north onto the ASKO Property. TCE concentrations exceeding the proposed CUL in this depth interval range from 0.031 to 120 mg/kg (less than 2 times to 6,000 times the proposed CUL of 0.02 mg/kg). From 20 to 30 feet bgs and below 30 feet bgs, TCE exceedances are present at the BNSF parcel line and extend to the north. TCE concentrations exceeding the proposed CUL in this depth interval range from 0.1 to 47 mg/kg (5 to 2,400 times the proposed CUL of 0.02 mg/kg). TCE is delineated to the north in W. Commodore Way by results less than the proposed CUL. TCE is also well-delineated vertically for the purposes of the Supplemental Upland RI, with only two samples collected below 30 feet bgs exceeding the proposed CUL.

7.3.5 Penta

A map showing the Sitewide extents of penta concentrations in soil exceeding the proposed CUL of 0.05 mg/kg is presented in Figure 7.25. Penta concentrations exceeding the proposed CUL are primarily present on the Bulk Terminal Property in the vicinity of the former penta mixing tank and AST (refer to Figure 2.1a). A previous interim action excavation to remove penta- and dioxin/furan-contaminated soil in this area was completed in 2012. This excavation fully removed penta in soil to concentrations less than the MTCA Method B direct contact CUL of 2.5 mg/kg that was established as the CUL for the interim action.

Remaining penta concentrations exceeding the proposed CUL in soil range from 0.058 to 0.33 mg/kg (less than 2 times to 6.6 times the proposed CUL of 0.05 mg/kg). Penta concentrations

exceeding the proposed CUL in Bulk Terminal Property soil are primarily present in the upper 15 feet of soil, and well delineated for the purposes of the RI, with only two sample locations with exceedances below 15 feet bgs.

Penta is also present at concentrations exceeding the proposed CUL at scattered locations on the ASKO Property and adjacent BNSF parcel. Penta concentrations exceeding the proposed CUL on the ASKO Property and BNSF parcel are present above 15 feet bgs, range from 0.055 to 0.16 mg/kg (less than 2 times to 3.2 times the proposed CUL of 0.05 mg/kg) and are collocated with TCE exceedances.

Penta on the ASKO Property and BNSF parcel is sufficiently delineated for the purposes of the RI.

7.4 SUMMARY OF IHSS IN SOIL AND GROUNDWATER

The most widespread IHSs in Site groundwater and soil are GRO, Total DRO and ORO, and benzene, which are associated with petroleum releases. Plumes of TPH and benzene-contaminated groundwater, and associated contaminated soil, are present on the majority of the Bulk Terminal Property, extending to the north into W. Commodore Way, consistent with years of petroleum storage, handling, and transport operations. TPH and benzene are also present in limited areas of groundwater and associated soil on the ASKO and East Waterfront Properties and are more localized and likely associated with localized petroleum handling (i.e., filling and moving drums) and pipeline operations. TPH and benzene impacts are generally limited to the uppermost 15 to 20 feet of Site soil and Perched and Shallow WBZ groundwater, with limited impacts present in the Intermediate WBZ.

cVOC concentrations in groundwater and soil exceed the proposed CULs on the BNSF parcel and the majority of the ASKO Property and extend slightly into W. Commodore Way to the north. TCE is present on the BNSF parcel primarily in shallow soil between 3 and 10 feet bgs. TCE in soil north of the BNSF parcel on the ASKO Property ranges from as shallow as 2 feet bgs to depths greater than 30 feet bgs. cVOC impacts to groundwater are limited to the Perched WBZ on the BNSF parcel and are primarily present in the Perched and Shallow WBZs with limited vinyl chloride impacts in the intermediate zone on the ASKO Property. The actual source of TCE is unknown, but the distribution of TCE in the subsurface is consistent with a surface release that impacted the Perched WBZ and migrated downward into the Shallow WBZ and into the silt layer below, with limited migration through the silt layer into the Intermediate WBZ.

Other IHSs—arsenic and penta—are present in groundwater in isolated areas and are associated with localized exceedances of the proposed soil CULs. On the ASKO Property, the presence of arsenic in soil and groundwater is isolated and lies within the plume of cVOC-contaminated groundwater. On the East Waterfront Property, arsenic is encountered in groundwater in areas where arsenic is also elevated in soil consistent, with storage of sandblast grit piles on the ground surface. Arsenic is also present in East Waterfront Property groundwater to the north of the former garage/vehicle maintenance buildings (refer to Figure 2.1b), where soil impacts from arsenic are not present but TPH-impacted soil and groundwater are present upgradient. Arsenic in groundwater in this area may be attributed to this upgradient contamination, which causes reducing conditions that increase the solubility of naturally occurring arsenic (Masscheleyn et al. 1991).

8.0 Conceptual Site Model

The Preliminary Conceptual Site Model (PCSM) presented in Section 6.0 of the RI Work Plan was refined based on recent data collected in accordance with the RI Work Plan and described in Section 5.0 of this report. The PCSM identified potential contaminant release mechanisms, potentially impacted media, and potentially complete contaminant transport and exposure pathways based on current and historical uses and the physical features of the Site.

This section presents the final CSM for the Site, including identification of media of concern, contaminant migration and exposure pathways, and receptors after assessing the nature and extent of IHSs using all available in situ data. Figure 8.1 illustrates the CSM and cross-media contaminant transport pathways that are considered viable as further described in the sections that follow.

8.1 RELEASE MECHANISMS AND HISTORICAL CONTAMINANT SOURCES

The confirmed and suspected sources of historical contaminants in groundwater and soil at the Bulk Terminal, ASKO, and East Waterfront Properties are summarized below for each property. Although the suspected sources are apparent based on years of historical operations at the site as a bulk terminal, details regarding the specific releases are unknown. Sources of IHSs are described in detail in the 2014 RIs (SES 2014a, 2014b, 2014d).

8.1.1 Bulk Terminal Property

Groundwater and soil at the Bulk Terminal Property have been contaminated primarily with TPH, benzene, and penta. Interim cleanup actions completed on the Bulk Terminal Property have removed the majority of penta in soil and significantly reduced the concentrations and extent of penta in groundwater. Previous investigations have also identified a zone of mixed petroleum LNAPL containing primarily GRO and DRO 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 W. Commodore Way, with up to approximately 5 feet of LNAPL present (as measured in monitoring wells) in two separate areas as shown on Figure 7.1.

Former known sources of historical contamination at the Bulk Terminal Property are shown on Figures 2.1a and 8.1 and are as follows:

- 14 former gasoline and diesel 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

Documentation of specific TPH releases is not available, but it is presumed that ongoing releases during transfer of petroleum during fuel transfer activities and leaks from ASTs, USTs and underground structures such as the utilidor contributed to GRO, DRO, ORO, and benzene contamination in surface and shallow subsurface soil over the course of Bulk Terminal operations (1941–2001). The TPH releases migrated downward through the unpaved ground surface and spread laterally on the water table of the Shallow WBZ, creating a large zone of LNAPL floating on groundwater. A portion of this LNAPL area was removed during a prior interim action excavation in 2012, but LNAPL remains in the downgradient direction to the north-northeast of the former operational areas/alignment of the former utilidor and to the south of the excavation in the former tank yard area. Infiltration of stormwater through contaminated soil and dissolution of TPH in groundwater have caused a downgradient plume of TPH and benzene to extend in the presumed downgradient direction(s) from the areas of contaminated soil and LNAPL. TPH contamination in soil and in the LNAPL phase also have the potential to volatilize to soil vapor.

Penta, which was used for only a short time on the Bulk Terminal, impacted a smaller area of soil, likely resulting from one or more surface releases during mixing and transfer into/from the former penta AST. The relatively low solubility of this chemical resulted in a smaller area of groundwater impacts downgradient of the area of contaminated soil. Penta-impacted soil was removed to meet to a target CUL of 2.5 mg/kg by the interim action excavation in 2012, and penta remains at concentrations greater than the proposed CULs only in a limited area of impacted soil and groundwater surrounding the former AST and mixing area.

The presence of a contiguous, low-permeability silt layer beneath the water-bearing soil of the Shallow WBZ and low density of TPH and benzene compounds relative to groundwater have limited the downward migration of contaminants to the Intermediate WBZ; however, lower-level impacts are present in some Intermediate WBZ wells immediately downgradient of the LNAPL area. The Shallow WBZ also thins considerably and is absent in some areas to the northeast of the Bulk Terminal Property, further controlling the horizontal extent of TPH contamination.

Although the findings of this RI conclude that groundwater is primarily expected to be in potential hydraulic connection with the sewer pipe in the Intermediate WBZ, Ecology has noted that the potential for seepage from the Shallow WBZ into the sewer pipe and resultant attenuation of contaminant plumes should be considered in remedy selection. Further assessment of remedial alternatives will require that groundwater remedies are protective of this pathway in all WBZs upgradient of the sewer pipe.

A conceptual cross-section showing the extents of soil and groundwater impacts and mechanisms of contaminant migration on the Bulk Terminal Property is presented in Figure 8.2.

8.1.2 ASKO Property and BNSF Rail Spurs

Groundwater and soil at the ASKO Property have been contaminated primarily with cVOCs, with lesser impacts from TPH, benzene, and arsenic. The specific sources of these contaminants are not known but are likely the result of various operations on or adjacent to the ASKO Property, as shown on Figure 2.1b and 8.1 and are:

- Former BNSF rail spurs
- Former barreling sheds #2 and #3
- Former west and east barrel inclines
- Former ASTs
- Former garage/vehicle maintenance facility and machine shop
- Steam cleaning area
- General waste storage including oils and solvents (former barrel racks)
- Former heating oil and/or waste oil UST(s)

TCE contamination is present in shallow soil on the BNSF parcel near the former rail spur and extends to the northeast on the ASKO Property toward the former ASTs. Isolated areas of TCE contamination are also present in soil on the ASKO Property near the former oil and solvent storage area. Releases of TCE to soil on the BNSF parcel likely originated as surface releases during the course of former operations and migrated downward and outward to the water table of the Perched WBZ. However, there is no documented use of TCE on either the ASKO Property or the BNSF parcel and the specific release mechanism is unknown. The BNSF parcel is not paved (and has not historically been paved), and continued infiltration of stormwater and dissolution in groundwater have created a perched plume of TCE contamination in groundwater that extends from the BNSF parcel rail spur in the downgradient directions to the northwest and northeast. The relatively high density of cVOCs relative to groundwater and the lack of a contiguous low-permeability confining layer between the Perched and Shallow WBZs has allowed cVOC contamination to migrate downward from the Perched WBZ into the Shallow WBZ as it moves downgradient. Vinyl chloride, which is a more mobile cVOC and a breakdown product of TCE, is also present farthest downgradient in groundwater. cVOC contamination is primarily present in the Perched WBZ on the BNSF parcel but is present in Shallow WBZ wells at the property line and downgradient. cVOCs primarily in the Perched WBZ on the BNSF parcel are consistent with soil results that have significantly elevated cVOC concentrations in shallow (0 to 8 feet bgs) soil compared to shallow soil on the ASKO Property. These results suggest that the majority of cVOC contamination was released to the surface in the vicinity of the BNSF parcel property line with the ASKO Property, with potential minor surface impacts due to activities such as steam cleaning or degreasing elsewhere on the ASKO Property and more significant cVOC contaminant mass in deeper intervals on the ASKO Property where it has migrated downward and downgradient. cVOC contamination in soil and high levels of cVOC contamination in perched groundwater also have the potential to volatilize to soil vapor.

TPH and benzene are present to a lesser extent in soil on the ASKO Property and are scattered in shallow soil through the property and on the BNSF parcel, suggesting incidental surface releases from fuel transferring throughout operations. TPH and benzene are distributed similarly to cVOCs in groundwater, with contamination in the Perched WBZ in the upgradient direction migrating downward to the Shallow WBZ as it travels downgradient.

Arsenic contamination is present in soil in a limited area near the former oil and solvent storage area. The source of localized arsenic in soil is not known and may have resulted from use of contaminated soil as fill or from minor operations or material storage that were not well-documented at the Site. This area of arsenic contamination in soil is collocated with shallow TPH contamination in soil that likely resulted from former oil storage or petroleum handling. Infiltration of stormwater through shallow contaminated soil has caused a small plume of arsenic and TPH contamination in one monitoring well (MW03) in the Perched WBZ. This localized area of arsenic and TPH contamination lies within the larger cVOC plume in groundwater.

The presence of a low-permeability silt layer between the Shallow and Intermediate WBZs on the ASKO Property limits the further downward migration of contaminants, and only low-level vinyl chloride impacts have been recently detected in one downgradient Intermediate WBZ near the northern property line. cVOCs have not been detected in groundwater collected from the one Deep WBZ monitoring well located in the centroid of the cVOC plume.

A conceptual cross-section showing the extents of soil and groundwater and mechanisms of contaminant migration on the ASKO Property is presented in Figure 8.3.

8.1.3 East Waterfront Property

Groundwater and soil at the East Waterfront Property have been contaminated primarily with TPH, benzene, and arsenic. Known and suspected former sources of historical contamination at the East Waterfront Property are shown on Figure 2.1b and Figure 8.1 and include the following:

- Former pipeline utilidor
- Former garage/vehicle maintenance
- Former waste oil UST
- Former sandblast grit storage piles
- Vessel staging and maintenance

TPH and benzene are present in soil in the vicinity of the former utilidor and to the north of the former garage/vehicle maintenance facility. Interim cleanup actions completed on the East Waterfront Property in 2013 removed a significant portion of the TPH- and benzene-impacted soil in the vicinity of the utilidor, but localized residual soil contamination remains on the southeastern portion of the property and north of the former warehouse. Infiltration of stormwater and migration of TPH and benzene to the water table of the Shallow WBZ have caused a limited plume of TPH- and benzene-impacted groundwater downgradient of contaminated soil near the former utilidor.

Arsenic is present in shallow soil near the shoreline, consistent with former storage of sandblast grit piles on the ground surface during Icicle Seafoods lease operations, which ceased in 1992. Groundwater is shallow at the shoreline, with the Shallow WBZ present at depths of 1 to 3 feet bgs, and arsenic contamination consistent with stormwater infiltrating through surface soil contamination is encountered in Shallow WBZ shoreline wells on the East Waterfront Property. Arsenic and other metals, or tributyltin (TBT), if present,[6] are expected to be associated with former Icicle Seafoods operational areas.

A conceptual cross-section showing the extents of soil and groundwater and mechanisms of contaminant migration on the East Waterfront Property is presented in Figure 8.2.

8.2 CONTAMINANT TRANSPORT PATHWAYS

Contaminants in groundwater and soil 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 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 Erosion to Sediment.** Contaminated soil can enter surface water via overland flow or erosion of bank soils and deposit as sediments. No soil erosion appears to be occurring at present, but it could be a potential future pathway.
- **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.

8.3 EXPOSURE PATHWAYS

Potential receptors exposed to upland media contamination include both human and ecological receptors. The current complete exposure pathways considered are presented below:

- **Human Exposure via Direct Contact.**
    - **Soil.** This pathway focuses on direct contact exposure to workers entering the subsurface for construction or maintenance activities and directly contacting contaminated soil and/or groundwater during these activities. This pathway is complete on all properties.

[6] Per Ecology's April 16, 2020, letter, TBT will be evaluated in shallow soils on the East Waterfront Property as part of pre-design sample collection to evaluate whether it is present as a result of former Icicle Seafood lease operations on the western portion of the parcel.

  - **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. This pathway is complete on all properties.
  - **Air.** Volatile contaminants in shallow soil and groundwater have the potential to volatilize and rise through the soil column and discharge into indoor air. Comprehensive data have not been collected for this pathway; however, preliminary sampling suggests that indoor air may be impacted on the ASKO Property. Furthermore, the presence of LNAPL on the Bulk Terminal Property and high concentrations of cVOCs in shallow soil and groundwater on the ASKO Property suggests that this pathway may be complete on both of these properties. The lesser volatile concentrations in East Waterfront Property soil and groundwater indicate that the soil vapor is less likely to be impacted on this property. A lack of comprehensive data for this pathway does not preclude the selection of remedy alternatives and remedy selection provided that additional soil vapor intrusion assessment is performed post-remedy and prior to redevelopment of the Property.

- **Terrestrial Receptor Exposure via Direct Contact.** All of the properties include some unpaved areas and vegetation; therefore, exposure to terrestrial receptors is considered a complete pathway.
- **Aquatic Receptor Exposure via Groundwater Discharge to Surface Water.** Contamination could be transported via groundwater to discharge to Salmon Bay. Chemical discharge has the potential to expose aquatic species in surface water to acute or chronic health effects. This pathway is complete for the Property due to groundwater discharge to Salmon Bay at the shoreline of the East Waterfront Property.
- **Benthic Receptor Exposure via Groundwater Discharge.** Contamination could be transported via groundwater to discharge to sediments in Salmon Bay. Chemical discharge has the potential to expose benthic species in sediments to acute or chronic health effects. This pathway is complete for the Property due to groundwater discharge to Salmon Bay at the shoreline of the East Waterfront Property.
- **Human Exposure via Groundwater Discharge to Surface Water or Sediment.** Contamination could be transported via groundwater to discharge to Salmon Bay. Chemical discharge has the potential to expose humans to acute or chronic health effects via consumption of seafood impacted by surface water or sediment contamination, consumption of surface water, or direct contact with sediments during recreational or fishing activities. This pathway is complete for the Property due to groundwater discharge to Salmon Bay at the shoreline of the East Waterfront Property.

It should be noted that there is the potential for future exposure pathways, such as bank erosion, to become complete should Property conditions change in the future that would destabilize soils.

8.4 AREAS AND MEDIA OF CONCERN

Based on the nature and extent of IHSs, described in detail in Sections 7.2 and 7.3, the boundaries of the AOCs that were identified in Section 6.4 of the RI Work Plan (i.e., AOCs were generally defined by their parcel boundaries) were modified slightly based on the CSM and are evaluated in the FS sections. The modified AOCs for the Site include the Upland AOC, which consists of the Bulk Terminal and ASKO Properties and the adjacent W. Commodore Way; the Shoreline AOC, which consists of the East Waterfront Property; and the BNSF AOC, which consists of a portion of the BNSF rail spur parcel south of the eastern portion of the ASKO Property. The BNSF AOC is evaluated in the CSM for the ASKO Property. Remedial actions on the BNSF parcel will be addressed by Ecology under separate authorities outside of the PPCD. Refer to Figure 8.4 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 included within any of the AOCs. There is limited soil and groundwater data that have been collected from within the West Waterfront Property, and although there is no record of operations on this parcel, there is potential for contamination given the ownership and operations on adjoining parcels by TOC.

The media of concern for each AOC are as follows:

- Upland AOC: groundwater, soil, and soil vapor
- Shoreline AOC: groundwater and soil
- BNSF AOC: groundwater and soil

A summary of IHS occurrences per AOC is included in the following sections.

8.4.1 Upland Area of Concern

The upland AOC includes the Bulk Terminal Property, ASKO Property, and adjacent portions of W. Commodore Way.

On the Bulk Terminal Property, TPH and benzene contamination are generally present in soil at concentrations greater than the proposed CULs to depths of 15 feet bgs in the vicinity of the former tank yards, loading racks, and gasoline/diesel USTs (refer to Figure 2.1a for former Site features). Two areas of LNAPL floating on groundwater are present on-property and extending into W. Commodore Way. Soil impacts from TPH and benzene are most concentrated in the vicinity of the larger LNAPL area to the north and extend north into W. Commodore Way. In this area of highly impacted soil, GRO has been detected at concentrations up to 76,000 mg/kg (25,000 times the proposed CUL of 30 mg/kg), Total DRO and ORO has been detected at concentrations up to 35,000 mg/kg (18 times the proposed CUL of 2,000 mg/kg), and benzene has been detected at concentrations up to 5,600 mg/kg (280,000 times the proposed CUL of 0.02 mg/kg). TPH and benzene to the east and south in the former tank yard area in the vicinity of the smaller southern LNAPL area are lower in concentration and more localized. TPH- and

benzene-impacted Shallow WBZ groundwater associated with soil contamination extends in the downgradient directions to the northeast, north, northwest, and west from the contaminated soil areas. Shallow groundwater is also highly impacted in areas surrounding and downgradient of the LNAPL areas, with GRO concentrations up to 10,000 µg/L (12.5 times the proposed CUL of 800 µg/L), Total DRO and ORO concentrations up to 11,000 µg/L (22 times the proposed CUL of 500 µg/L) and benzene concentrations up to 2,600 µg/L (5,900 times the proposed CUL of 0.44 µg/L. The Intermediate WBZ is impacted to a lesser extent by TPH and not impacted by benzene in W. Commodore Way.

Additionally, there is an area of intermittent occurrences of TPH in shallow soil not associated with groundwater impacts above approximately 5 feet bgs along the western property line of the Bulk Terminal Property and extending onto the ASKO Property line (refer to Figure 2.1a). This area of shallow contamination is located near a former barreling shed and was likely caused by small incidental releases during fuel transferring.

A limited area of penta contamination in soil and groundwater is located on the Bulk Terminal Property just west of the TPH- and benzene-contaminated groundwater plume and does not appear to extend off-property. This area was previously remediated by an interim action that achieved its target CULs, and only a small area of residual penta remains. Penta concentrations in soil and groundwater in this area are generally low-level relative to TPH and benzene, with maximum concentrations of 0.33 mg/kg (6.6 times the proposed CUL of 0.05 mg/kg) in soil and 3.6 µg/L (18 times the proposed CUL of 0.2 µg/L) in groundwater.

On the ASKO Property, a fairly continuous area of TCE contamination is present in shallow soil on the BNSF parcel property line and extending from approximately 5 to 28 feet bgs. TCE concentrations up to 120 mg/kg (6,000 times the proposed CUL of 0.02 mg/kg) are present in this interval. There is also an isolated area of deeper (20 to 30 feet bgs) TCE contamination located west of the primary area of soil impacts. Associated cVOC (TCE and other breakdown products) groundwater contamination is present in the Perched and Shallow WBZs on-property, and vinyl chloride extends to a limited area of W. Commodore Way to the north. TCE concentrations are significantly elevated in the Perched WBZ on the upgradient BNSF parcel and in the Perched and Shallow WBZs on the ASKO Property. In these areas, TCE has been detected at concentrations up to 5,900 µg/L (11,800 times the proposed CUL of 0.5 µg/L) in groundwater, and the breakdown product vinyl chloride has been detected at concentrations up to 39 µg/L (200 times the proposed CUL of 0.2 µg/L). The Intermediate WBZ is slightly impacted by vinyl chloride downgradient near the northern property line, where a low-level vinyl chloride concentration of 0.33 µg/L (1.7 times the proposed CUL of 0.2 µg/L) was detected.

TPH and benzene are scattered throughout shallow soil on the ASKO Property and are generally collocated with cVOC-impacted groundwater in the Perched and Shallow WBZs.

A limited area of arsenic- and TPH-impacted shallow soil above 6 feet bgs and perched groundwater is also present within the area of TCE-impacted soil and cVOC-impacted groundwater on the ASKO Property.

Affected media in the Upland AOC include soil and groundwater. Soil vapor is also an affected medium on the ASKO Property based on prior soil gas sampling, and the presence of LNAPL on the Bulk Terminal Property indicates that soil vapor is likely also an affected medium on this property.

8.4.2 Shoreline Area of Concern

The Shoreline AOC includes the East Waterfront Property.

On the East Waterfront Property, TPH and benzene contamination are generally present in soil to depths of 6 feet bgs (extending to 12 feet bgs in a localized area to the south) in the vicinity of the former utilidor and to 3 feet bgs along the shoreline north of the former garage/vehicle maintenance facility. A former interim action excavated the majority of TPH- and benzene-contaminated soil in this area. The remaining contaminated soil that was not excavated contains GRO up to 440 mg/kg (15 times the proposed CUL of 30 mg/kg), Total DRO and ORO up to 23,000 mg/kg (12 times the proposed CUL of 2,000 mg/kg), and benzene up to 0.21 mg/kg (11 times the proposed CUL of 0.02 mg/kg). A limited area of TPH and benzene contamination is present in Shallow WBZ groundwater downgradient of the impacted soil associated with the former utilidor. In this limited area of groundwater contamination, GRO is present at concentrations up to 3,100 µg/L (3.9 times the proposed CUL of 800 µg/L), Total DRO and ORO is present at concentrations up to 2,000 µg/L (4 times the proposed CUL of 500 µg/L), and benzene is present at concentrations up to 3.7 µg/L (8.4 times the proposed CUL of 0.44 µg/L). TPH and benzene concentrations exceeding the proposed CULs are not present in the Intermediate WBZ.

An area of localized elevated arsenic concentrations in soil, ranging from 26 to 30 mg/kg (3.6 to 4.1 times the proposed CUL of 7.3 mg/kg) is present near the shoreline where sandblast grit piles were historically stored on the ground surface. Shallow groundwater is also moderately impacted by arsenic in these areas, with elevated concentrations of 6.7 to 23 µg/L (1.3 to 4.6 times the proposed CUL of 5 µg/L) on the East Waterfront Property.

Affected media in the Shoreline AOC include soil and groundwater. Lower concentrations of volatile contaminants including TPH and benzene in this AOC suggest that soil vapor is not impacted.

8.4.3 BNSF Area of Concern

The BNSF AOC consists of the area surrounding the former rail spur on the BNSF parcel south of the ASKO Property line. On the BNSF AOC, TCE is present in very shallow soil (as shallow as 3 feet bgs) and cVOCs are present only in perched groundwater and in shallow groundwater beginning at the ASKO Property boundary. The BNSF AOC represents the source area for cVOC contamination on the ASKO Property because contamination is shallowest on this property, consistent with close proximity to a surface release(s).The maximum TCE concentration of 120 mg/kg detected in soil at the Site is located at the property line between the BNSF parcel and ASKO Property.

There is also a limited area of TPH impacts in shallow (above 20 feet bgs) soil and perched groundwater in the BNSF AOC near the ASKO Property line. These impacts are likely due to incidental releases during railroad operations and are encompassed by the larger areas of cVOC contamination in soil and groundwater. The actual source of TCE impacts is unknown.

Affected media in the BNSF AOC include soil and groundwater. The presence of highly contaminated shallow soil and perched groundwater suggest additional impacts to soil vapor, but there are currently no buildings present. Ecology is currently in the process of negotiating an Agreed Order (AO) with BNSF to address remedial actions on the BNSF parcel.

8.5 CHEMICAL FATE AND TRANSPORT

The fate and transport of the contaminants are governed by the specific properties of the chemicals and the surrounding environmental conditions at the Site. Of primary concern are the chlorinated ethenes (TCE) that degrade most readily by reductive dechlorination under anaerobic conditions to form DCE and vinyl chloride. Eventually, these breakdown products degrade to ethene/ethane and then carbon dioxide but at a slower rate. DCE and vinyl chloride are very mobile in groundwater but more susceptible to degradation under aerobic conditions than TCE. Petroleum products released at the Site include TPH and BTEX that break down predictably to less toxic and less mobile breakdown products and biodegrade most rapidly under aerobic conditions. Under aerobic conditions, oxygen acts as the electron acceptor, but under anaerobic conditions, naturally occurring organic matter or volatile petroleum products can act as the electron acceptor.

At the Site, the most significant historical releases consisted primarily of TPH and TCE. On the ASKO Property and in the upgradient BNSF AOC, these are collocated in the same general area, resulting in commingling of IHSs that continue to leach from soil to groundwater. In some areas, the commingling resulted in a downward vertical migration in groundwater from the Perched WBZ that carried some fraction of TPH, benzene, and TCE down to the Shallow WBZ.

The Perched and Shallow WBZs likely provide a more oxidizing environment than the deeper Intermediate WBZ and so are not as prone to significant cVOC degradation, resulting in a substantial-sized plume of mixed parent and breakdown products, with vinyl chloride present only in the Intermediate WBZ and along the downgradient edge of the plume.

SVOCs at the Site, primarily penta, are much less mobile. Penta has a low solubility and high affinity for soil organic matter and does not easily degrade. Other compounds detected historically include scattered occurrences of metals (such as arsenic) that have limited to no mobility.

8.6 RECOMMENDATIONS

The nature and extent of contamination have been sufficiently delineated through the former RIs and this Supplemental Upland RI to define the Site and provide the basis for a Supplemental Upland FS to select a final cleanup action in accordance with MTCA (WAC 173-340-350(1)) and

its implementing regulations. The final CSM is considered complete. The FS (the remainder of this document) defines cleanup action areas (CAAs), which are areas that warrant cleanup to protect current or potential future transport or exposure pathways based on the summary of IHSs for the Upland and Shoreline AOCs described above. The FS also evaluates the POCs or CPOCS, identifies remediation levels (RELs) where it is not practicable to meet the proposed CULs, and evaluates the need for institutional controls (ICs) or engineering controls. Finally, the FS identifies components of a preferred remedial alternative and associated compliance monitoring requirements to be implemented pursuant to the PPCD.

9.0 Supplemental Feasibility Study

The remainder of this document presents the Supplemental Upland FS for the Site, which has been developed in accordance with MTCA (WAC 173-340-350(8)). Previous FS reports have been prepared for the Site, as described in Section 9.1; therefore, certain aspects of the FS, such as preliminary screening of remedial alternatives, have not been redone and are incorporated by reference. However, this FS was completed using updated data, input from Ecology, and current Site condition information and includes additional evaluation of remedial technologies where appropriate, the identification of RELs and proposed CULs that are different from previous FSs, the completion of an updated DCA, and selection of a preferred remedial alternative for the Site.

The purpose of the FS is to evaluate cleanup actions that are protective of human health and the environment through elimination, reduction, or control of risks posed through potential exposure and migration pathways present at the Site in full compliance with MTCA and its implementing regulations. The RI sections of this report identify the applicable pathways at the Site, IHSs, proposed Sitewide cleanup standards, and the AOCs. In addition, Section 3.2 also provides a summary of interim cleanup actions that have been completed at the Site, which have removed a significant amount of source mass from the Site. The FS provides detail regarding the development and evaluation of cleanup action alternatives for the upland portion of the Site based on the current nature and extent of contamination and the updated CSM described in Sections 7.0 and 8.0, respectively.

Importantly, this Site will be remediated as part of redevelopment. This means that existing structures are presumed to be demolished and there will be no structures blocking access to important surface or subsurface impacts. This redevelopment assumption is also different from the previous FSs completed in 2014, when portions of the facility were still operational. Furthermore, redevelopment will require paving a portion of the Site (i.e., the Upland AOC), while the East and West Waterfront Properties will remain unpaved in the near term until a user is identified and redevelopment is executed in accordance with their needs. These assumptions are described further during the FS evaluations below. Aquatic sediments below the ordinary high-water mark are addressed in the PPCD by means of a cash out settlement payment to Ecology.

9.1 SUMMARY OF PREVIOUS FEASIBILITY STUDIES FOR THE SITE

In 2014, SES prepared and submitted to Ecology separate FS reports for the Bulk Terminal, ASKO, and East Waterfront Properties (SES 2014d, 2014e, 2014f). Each of the three FSs included a remedial alternatives assessment, cleanup action alternatives analyses, and selection of a preferred cleanup action alternative in accordance with the MTCA requirements for a FS. These FS reports were used as the basis for this Supplemental Upland FS.

Under the VCP, Ecology provided written comments on the RI/FSs in three separate letters (Ecology 2015a, 2015b, 2015c). In all cases, Ecology stated that characterization was sufficient to establish cleanup standards and to select a cleanup action. A brief summary of the recommended cleanup action alternatives for each of the properties, along with a summary of Ecology's

opinions, is included in the following sections. A summary of the previous alternatives, DCA, and Ecology's comments for each of the three properties is included in Table 9.1.

9.1.1 Bulk Terminal Property

The selected cleanup action for the Bulk Terminal was in situ remediation using multi-phase extraction (MPE) for the unsaturated zone, LNAPL, and TPH in groundwater on the Bulk Terminal Property. In addition, the selected cleanup action for the W. Commodore Way ROW included LNAPL excavation with offsite disposal and MPE for residual LNAPL.

In a letter dated November 25, 2015 (Ecology 2015a), Ecology did not agree with MPE as the preferred alternative due to uncertainty of its effectiveness and future need for an Environmental Covenant. Ecology indicated that they prefer a more permanent solution with a shorter restoration time frame, and they also pointed out that the DCA indicated that unsaturated zone and LNAPL excavation with offsite disposal and monitored natural attenuation (MNA) for groundwater would achieve the most environmental benefit for the cost. Ecology tentatively concurred with the selected cleanup action alternative for the W. Commodore Way ROW.

9.1.2 ASKO Property

The selected cleanup action for the ASKO Property was enhanced reductive dechlorination (ERD) by injecting edible oil to address cVOCs in groundwater, DPE to address petroleum hydrocarbons in saturated soil and groundwater, SVE to address GRO and cVOCs in soil, and excavation and offsite disposal for DRO in shallow soil. The selected cleanup alternative also included the installation of a permeable reactive barrier (PRB) containing a mixture of zero-valent iron (ZVI), pea gravel, and sand using large-diameter augers to intercept cVOC-impacted groundwater from the upgradient BNSF parcel.

In a letter dated November 24, 2015 (Ecology 2015b), Ecology did not provide an opinion regarding the selected cleanup action alternative. Ecology only noted that arsenic in groundwater at concentrations greater than MTCA Method A CULs was not addressed in the FS and that the DCA needed to be prepared in accordance with WAC 173-340-360(3)(e).

9.1.3 East Waterfront Property

The selected cleanup action for the East Waterfront Property was excavation with offsite disposal to address petroleum contamination in soil and groundwater at concentrations exceeding MTCA Method A CULs. In a letter dated October 8, 2015 (Ecology 2015c), Ecology tentatively concurred with the selection of this alternative for cleanup of the upland portion of the East Waterfront Property. Ecology specified that soil removal must be completed to achieve petroleum concentrations less than applicable MTCA Method A or Method B CULs and that petroleum concentrations in groundwater must be less than MTCA Method A or B CULs and potentially less than surface water CULs.

9.2 REMEDIAL ACTION OBJECTIVES

Remedial Action Objectives (RAOs) for the Site were developed to specifically identify goals that should be accomplished to meet the minimum requirements of the MTCA Cleanup Regulations (WAC 173-340).

The RAOs are as follows:

- Address significant public concerns by facilitating the redevelopment of a substantial brownfield site with highly desirable industrial and marine-dependent uses.
- Address soil contamination and remediate using normally accepted engineering practices, to protect human health and the environment (ecological receptors) from exposure to hazardous substances via direct contact.
- Reduce, to the extent practicable, concentrations of IHSs in soil on the Property that are long-term sources of continuing groundwater contamination.
- Remediate LNAPL from the Bulk Terminal Property and the adjacent W. Commodore Way ROW to the maximum extent practical to improve groundwater quality.
- Reduce, to the extent practical, concentrations of VOCs in soil and groundwater to reduce or eliminate the potential for vapor intrusion.
- Reduce concentrations of IHSs in groundwater to protect surface water quality in Salmon Bay.
- Minimize risk of shoreline soil bank erosion into sediments.
- Comply with local, state, and federal laws (ARARs; WAC 173-340-710) and site-specific cleanup standards. ARARs specific to the cleanup are more specifically described in Section 13.5 and are limited to applicable federal and state laws and those that Ecology determines are relevant and appropriate.
- Provide for compliance monitoring to evaluate the effectiveness of the preferred cleanup action and to determine that the cleanup standards are met at the POCs, described in Section 6.0 and established for the Site in Section 9.4.

9.3 POINTS OF COMPLIANCE

Per WAC 173-340-200, the POC is “the point or points on a site where CULs established in accordance with WAC 173-340-720 through 173-340-760 shall be attained” and includes standard POCs and CPOCs, as described in Section 6.0. POCs are established for each impacted medium at the Site, as described in the following sections.

9.3.1 Groundwater

Under MTCA (WAC 173-340-720(8)(b)), the standard POC for groundwater is defined as “throughout the site from the uppermost level of the saturated zone to the lowest depth potentially affected by the site,” which implies that groundwater will meet CULs throughout the

Site within a reasonable restoration time frame. Therefore, the standard POC for groundwater is throughout the Site.

Per MTCA (WAC 173-340-720(8)), where it can be demonstrated that it is not practicable to meet the CULs throughout the Site within a reasonable restoration time frame using all practicable methods of treatment, Ecology may approve a CPOC that is as close as practicable to the source area, and typically not to exceed the property boundary. The use of a CPOC may be proposed as part of a cleanup action alternative based on whether the alternative can meet CULs Sitewide within a reasonable restoration timeframe.

9.3.2 Soil

The standard POCs for soil are based on three pathways of exposure:

- **Direct contact.** The standard POC for all direct contact pathways irrespective of receptor is the top 15 feet of soil per WAC 173-340-740(6)(d) for human health risk assessment and WAC 173-340-7490(4)(b) for ecological risk assessment. This POC is protective of incidental ingestion and dermal contact with soil and does not require the presence of pavement or ICs to be protective. At this Site, because Ecology has directed a single CUL per medium, the CUL is driven by leaching to groundwater (below), an equally conservative or more conservative criterion than direct contact,[7] and compliance with direct contact will be assumed.
- **Leaching to groundwater.** The standard POC for the leaching pathway is soil throughout the Site per WAC 173-340-740(6)(b). This is a cross-media pathway for Sitewide soil that is a potential source of chemical impact to groundwater. Compliance will be demonstrated by directly comparing groundwater concentrations at the CPOC in the Upland AOC and at the standard POC in the Shoreline AOC following source area remediation to the proposed CULs. If groundwater at the CPOC meets the proposed CULs, this pathway will be empirically demonstrated to have met soil CULs and will be in compliance.
- **Soil vapor.** The standard POC is from the surface to the uppermost ground water table per WAC 173-340-740(6)(c). The depth to groundwater is variable across the Site. For the Upland AOC, the average depth to groundwater is 10 feet bgs on the Bulk Terminal Property and in W. Commodore Way and 8 feet bgs on the ASKO Property; for the Shoreline AOC, the average depth to groundwater is 8 feet bgs and approximately 2.5 feet bgs along the shoreline. Compliance will be demonstrated empirically by direct sampling of soil vapor or indoor air following source area remediation.

For ecological risk assessment, MTCA allows the use of a CPOC for sites with ICs to prevent excavation of deeper soil per WAC 173-340-7490(4)(a). The CPOC is set at the biologically active soil zone for the direct contact pathway protective of ecological receptors, which is assumed to

[7] The CULs for protection of leaching to groundwater and protection of direct contact are equivalent for TPH including GRO and Total DRO and ORO.

extend to a depth of 6 feet bgs. If ICs are proposed as part of the remedy for the Site, a CPOC may be used for the protection of ecological receptors via the direct contact pathway.

9.3.3 Air

The POC for ambient and indoor air is Sitewide; however, vapor intrusion from subsurface contaminants will occur only in enclosed spaces and structures. Vapor intrusion will be evaluated after the completion of cleanup activities, which will be completed concurrent with redevelopment and be informed by the location and nature of buildings and structures to be constructed.

9.4 CLEANUP ACTION AREAS

The Property is divided into two AOCs (Upland AOC and Shoreline AOC) as described in Section 8.0, to enable a better comparison and evaluation of technologies in this Supplemental Upland FS due to the large size of the Site and the various plumes and source areas. The Upland AOC consists of the Bulk Terminal Property and ASKO Property and includes the W. Commodore Way ROW to the north of both properties. The Shoreline AOC consists of the East Waterfront Property. The BNSF AOC is located upgradient of the Upland AOC and is being addressed under separate cleanup authorities by Ecology. Important conclusions about current data for the IHSs, exposure pathways, and proposed CULs for each AOC are discussed in Section 6.0.

Within the Upland and Shoreline AOCs, there are seven CAAs where the IHSs in soil are similar and can be remediated by the same technologies. Due to the extents of the multiple groundwater plumes at the Site, it is expected that source removal, treatment, or containment of IHSs in soil reasonably impacting groundwater quality must be considered for cleanup to be effective and completed within a reasonable restoration time frame. Therefore, the CAA vertical and horizontal boundaries are defined around distinct source areas where IHS concentrations in soil are greater than the proposed CULs and collocated with groundwater exceedances.[8] Refer to Figure 9.1 for the CAA boundaries. The following sections summarize each CAA and its associated IHSs in soil.

9.4.1 Upland Area of Concern

Within the Upland AOC, there are five CAAs, shown on Figure 9.2, each defined by a distinct footprint of IHSs as described below. Due to the fact that there are multiple IHSs and soil contamination is dispersed and often isolated, the vertical and horizontal boundaries of the CAAs in the Upland AOC were defined to include the majority of a distinct source area. For example, if an isolated soil sample outside a source area has a concentration of an IHS greater than the proposed CUL but is surrounded by samples that do not exceed the proposed CUL, then it was not included in a CAA.

[8] It is important to note that there are concentrations of penta in soil that are greater than the proposed CULs; however, remediation of penta was completed as an interim action, and additional active cleanup for penta is, therefore, not proposed. Penta concentrations in groundwater have been reduced as a result of the interim action, and penta will continue to be monitored in groundwater

9.4.1.1 CAA-1

CAA-1 is on the Bulk Terminal Property within the footprint of the former tank farm and along the southern and southeastern edge of the 2012 excavation area. CAA-1 is separated into two subareas: CAA-1.a and CAA-1.b. CAA-1.a is characterized by shallow and discontinuous soil CUL exceedances (less than 5 feet bgs) of GRO, Total DRO and ORO, and benzene. CAA-1.b is characterized by more continuous contamination in shallow soil with some deeper, discontinuous CUL exceedances. The significant mass of contamination in CAA-1.b extends from 0 to 10 feet bgs. The maximum concentrations of IHSs in CAA-1 are GRO at 9,300 mg/kg (2 feet bgs in CAA-1.a and 7 feet bgs in CAA-1.b), Total DRO and ORO at 16,000 mg/kg (7 feet bgs in CAA-1.b), and benzene at 40 mg/kg (2.5 feet bgs in CAA-1.b). The northwest corner of the CAA is within the GRO and benzene groundwater plumes, and the entire CAA is within the DRO and ORO groundwater plume. CAA-1.a has LNAPL along its northwest boundary, which was measured at thicknesses of 2.8 to 4.4 feet during the April/May 2019 groundwater monitoring event. The LNAPL area is presumed to be approximately 90 feet long and 25 feet wide; the estimated volume of LNAPL contained in soil in this area is approximately 13,000 gallons.[9] CAA-1 includes a primary ongoing source of petroleum (TPH and benzene) to groundwater in the Upland AOC. The distribution of GRO exceeding the CUL in soil according to depth in CAA-1 is shown on Figure 9.3, and the distribution of Total DRO and ORO exceeding the CUL according to depth in CAA-1 is shown on Figure 9.4.

9.4.1.2 CAA-2

CAA-2 is on the Bulk Terminal Property and partially extends into the W. Commodore Way ROW. This CAA is within the area of the former gasoline and diesel USTs, former pump island, and former utilidor. CAA-2 is divided into two subareas, CAA-2.a and CAA-2.b, to differentiate between the Bulk Terminal Property (2.a) and in the W. Commodore Way ROW (2.b). CAA-2 encompasses the larger LNAPL area, which is approximately 200 feet long by 80 feet wide and measured at a maximum thickness of 5.2 feet during the April/May 2019 groundwater monitoring event.[10] The estimated volume of LNAPL contained in soil in this area is approximately 77,000 gallons. CAA-2 has fairly continuous soil impacts greater than the proposed CULs for GRO, Total DRO and ORO, and benzene throughout the CAA to a depth of 20 feet bgs, with the majority of contamination between 0 to 15 feet bgs. There are also a limited number of penta soil exceedances collocated with TPH exceedances near the 2012 interim action excavation extent that are greater than the proposed CUL but less than the criteria used as the CUL during the interim action. The maximum concentrations for GRO and benzene in CAA-2 are 760,000 and 5,600 mg/kg, respectively, in a single sample collected at 12.5 feet bgs near the former TOC office building and pump island; however, these results are an order of magnitude greater than any other result collected at the Site and likely indicative of LNAPL because the sample is located

[9] LNAPL volume was estimated using the average thickness of product measured in well casings and assuming that soils with an average porosity of 30 percent have pore space fully saturated by LNAPL. This estimate is considered the maximum potential volume of LNAPL.

[10] The southwestern extent of the LNAPL plume is not fully defined because it extends beneath the footprint of the office building.

within the presumed extent of the LNAPL area. The maximum concentrations of IHSs in CAA-2 outside of the LNAPL area are all located within the Bulk Terminal Property boundary and include GRO at 14,000 mg/kg (12 feet bgs), benzene at 330 mg/kg (4 feet bgs), Total DRO and ORO at 34,000 mg/kg (12.5 feet bgs), and penta at 0.33 mg/kg (9 feet bgs). CAA-2 is within the GRO, DRO and ORO, and benzene groundwater plumes. CAA-2 includes a primary ongoing source of petroleum (TPH and benzene) to groundwater in the Upland AOC. The distribution of GRO exceeding the CUL in soil according to depth in CAA-2 is shown on Figure 9.5, and the distribution of Total DRO and ORO exceeding the CUL according to depth in CAA-2 is shown on Figure 9.6.

9.4.1.3 CAA-3

CAA-3 is located on the Bulk Terminal and ASKO Properties and includes vadose zone soil impacts. It is within the footprint of the former west and east barrel inclines and former barreling sheds. The CAA is characterized by scattered GRO and Total DRO and ORO CUL exceedances in soil shallower than 7.5 feet bgs. The maximum GRO concentration is 5,100 mg/kg at 2 feet bgs, and the maximum Total DRO and ORO concentration is 24,000 mg/kg at 3 feet bgs. There are also limited exceedances of benzene and TCE in this CAA that are collocated with GRO and Total DRO and ORO. The maximum concentrations of benzene and TCE both occur at a single location at 3 feet bgs and are 0.081 mg/kg and 4.4 mg/kg, respectively. CAA-3 overlaps with a portion of the DRO and ORO plume on the Bulk Terminal Property and a portion of the vinyl chloride plume on the ASKO Property. Soil contamination in CAA-3 does not appear to be a primary contribution to the dissolved-phase plume. The distribution of GRO exceeding the CUL in soil according to depth in CAA-3 is shown on Figure 9.7, and the distribution of Total DRO and ORO exceeding the CUL according to depth in CAA-3 is shown on Figure 9.8. The distribution of TCE exceeding the CUL in soil according to depth in CAA-3 is shown on Figure 9.9.

9.4.1.4 CAA-4

CAA-4 is located on the ASKO Property and includes an area of TCE contamination that originates on the former rail spur in the BNSF AOC and extends from the property line with the BNSF parcel north across more than half of the eastern portion of the ASKO Property. CAA-4 is characterized primarily by soil CUL exceedances of TCE from 2 to 30 feet bgs. CAA-4 is broken into two subareas, CAA-4.a and CAA-4.b, to distinguish between the western portion of the CAA where the majority of contamination exists between 5 and 20 feet bgs and the larger eastern portion of the CAA where most of the source mass is between 5 and 28 feet bgs. The maximum concentration of TCE in soil is 120 mg/kg at a depth of 20 feet bgs immediately adjacent to the BNSF AOC. CAA-4 also has limited and discontinuous exceedances of GRO, Total DRO and ORO, and benzene primarily in shallow vadose zone soils (with the exception of two deeper benzene exceedances at 10.5 and 14 feet bgs), which are all located within the footprint of TCE contamination. The maximum concentrations of these IHS in CAA-4 are GRO at 1,600 mg/kg (7.5 feet bgs), Total DRO and ORO at 3,200 mg/kg (7.5 feet bgs), and benzene at 0.61 mg/kg (7.5 feet bgs). CAA-4 encompasses the ASKO Property GRO and DRO and ORO groundwater plumes and is within the benzene, TCE, and vinyl chloride groundwater plumes. CAA-4 includes a primary ongoing source of cVOCs (TCE and vinyl chloride) and petroleum (TPH and benzene) to groundwater in the Upland AOC. The

distribution of GRO exceeding the CUL in soil according to depth in CAA-4 is shown on Figure 9.7, and the distribution of Total DRO and ORO exceeding the CUL according to depth in CAA-4 is shown on Figure 9.8. The distribution of TCE exceeding the CUL in soil according to depth in CAA-4 is shown on Figure 9.9.

9.4.1.5 CAA-5

CAA-5 is near the former oil and solvent storage barrel racks on the ASKO property and is defined by scattered IHS impacts in vadose zone soil. CAA-5 is characterized primarily by shallow soil exceedances of the proposed CULs for GRO (maximum concentration of 5,300 mg/kg at 2 feet bgs) and Total DRO and ORO (maximum concentration of 7,100 mg/kg at 2 feet bgs). There are also limited collocated arsenic exceedances with a maximum concentration of 9.8 mg/kg at MW03 at 6 feet bgs. This CAA is within the benzene, TCE, and vinyl chloride groundwater plumes and encompasses an area of Total DRO and ORO, benzene, and arsenic impacts to the Perched WBZ at monitoring well MW03. Localized soil contamination in CAA-5 does not appear to be a primary contribution to the dissolved-phase cVOC or petroleum plume. The distribution of GRO exceeding the CUL in soil according to depth in CAA-5 is shown on Figure 9.10, and the distribution of Total DRO and ORO exceeding the CUL according to depth in CAA-5 is shown on Figure 9.11. The distribution of TCE exceeding the CUL in soil according to depth in CAA-5 is shown on Figure 9.12.

9.4.2 Shoreline Area of Concern

Within the Shoreline AOC, there are two CAAs as shown on Figure 9.13, each defined by a distinct footprint of IHSs, as described below. The majority of TPH impacts in soil in the Shoreline AOC were previously excavated as part of an interim action in 2013. There are limited soil and groundwater impacts remaining in this AOC.

9.4.2.1 CAA-6

CAA-6 is located on the East Waterfront Property in the vicinity of the former barrel incline, former utilidor, and former warehouse and garage/vehicle maintenance building. The CAA extends north to the Salmon Bay shoreline. The area is characterized by shallow soil impacts of GRO, Total DRO and ORO, and benzene. CAA-6 is broken into subareas CAA-6.a and CAA-6.b. The depth of soil impacts varies across the CAA with deeper CUL exceedances to approximately 12 feet bgs in the southern portion of the CAA (CAA-6.a) and shallower impacts limited to less than 3 feet bgs in the northern portion closest to the shoreline (CAA-6.b). The maximum concentrations of IHSs are GRO at 420 mg/kg (12.5 feet bgs), Total DRO and ORO at 23,000 mg/kg (3.5 feet bgs), and benzene at 0.21 mg/kg (3.5 feet bgs). CAA-6 contains localized groundwater impacts of GRO, Total DRO and ORO, benzene, and arsenic. CAA-6.a includes a localized ongoing continuous source of petroleum (TPH and benzene) to groundwater in the Shoreline AOC; scattered and shallow soil impacts in CAA-6.b do not appear to be contributing to groundwater contamination.

9.4.2.2 CAA-7

CAA-7 is located on the western shoreline edge of the East Waterfront Property in an area with documented former sandblast grit piles. This area contains exceedances of the proposed CUL for arsenic in surface soil (less than 1 feet bgs) and a portion of the arsenic groundwater plume. Arsenic in soil appears to be a localized source of impacts to groundwater along the shoreline. Arsenic and TBT (if present) at concentrations greater than the proposed CULs have not been fully delineated in soil in CAA-7. The results of pre-remedial investigations for these chemicals may modify the final boundary of CAA-7 in the Shoreline AOC.

9.4.3 BNSF Area of Concern

The BNSF AOC is shown on Figure 9.1 and includes a portion of the former rail spur located on the BNSF parcel located immediately upgradient of and adjacent to the southeastern portion of the ASKO Property (part of the Upland AOC). The BNSF AOC is and will be addressed under separate authorities by Ecology, so a remedial alternative evaluation for the BNSF AOC is not included in this FS and no remedial actions will be implemented on the BNSF AOC under the PPCD.

Ecology issued a Preliminary Determination of Liability for Release of Hazardous Substances letter to BNSF on August 27, 2018 (Ecology 2018), and subsequently issued a Final Determination of Liability for Release of Hazardous Substances letter to BNSF on March 5, 2019 (Ecology 2019a). Ecology and BNSF are currently (at the time of this report) in negotiations regarding an AO for investigation and cleanup of the BNSF AOC. Therefore, remedial technologies such as PRB are necessary to evaluate at the BNSF parcel/ASKO Property boundary to prevent recontamination until the full nature and extent on the BNSF AOC can be evaluated by Ecology and remedy selection is completed.

9.5 REMEDIATION LEVELS

This section discusses the use of RELs at the Site. In accordance with WAC 173 340-200, a REL "means a concentration of a hazardous substance in soil, air, water, or sediment above which a particular cleanup action component will be required as part of a cleanup action at a site." RELs are, by definition, concentrations that exceed cleanup standards and are used when a combination of cleanup action components are necessary to achieve CULs at a POC. A summary of IHSs and proposed CULs for the Property is included in Section 6.0. Cleanup actions that use RELs to meet the cleanup standards at a CPOC are also considered to comply with the cleanup standards. A summary of groundwater and soil IHSs, cleanup standards, and RELs is presented in Table 9.2.

RELs are applicable to this Site because implementation of multiple aggressive removal or treatment technologies will be necessary to achieve proposed CULs for groundwater at the proposed CPOC for the Upland AOC. As explained in the RI, IHS concentrations in soil and groundwater are significantly elevated (in many cases greater than 10,000 times their proposed CULs) and occur in multiple WBZs

in portions of the Site, specifically in the Upland AOC. A summary of the Sitewide nature and extent of contamination is presented in Section 7.0.

RELs are, therefore, proposed only for soil in the Uplands AOC, where the nature and extent of contamination is more widespread, including overlapping IHSs in soil and groundwater. Furthermore, the proposed CULs for the Site include protection of several pathways that are not complete in the Upland AOC (or will be eliminated as part of cleanup and redevelopment), as described in the following sections.

9.5.1 Soil Remediation Levels

The basis for the proposed source area soil RELs in the Upland AOC is to achieve both short- and long-term goals. The short-term goals for the Site are to (1) eliminate the worker direct contact pathway and (2) reduce the potential for vapors to migrate from the subsurface into structures. The long-term goal is to achieve compliance with the proposed CULs in groundwater, as measured at the proposed CPOC in the Upland AOC and throughout the Shoreline AOC. Soil RELs are presented in Table 9.2 and described per IHS below. All soil criteria discussed below are presented in Table 4.2.

Meeting cleanup action requirements where soil RELs are used will be evaluated in accordance with a Compliance Monitoring Plan (CMP) that meets the requirements of WAC 173-340-410. Performance and confirmation monitoring will be developed during engineering design.

9.5.1.1 Arsenic

As part of the Sitewide remedy, the Upland AOC will remain covered in buildings, pavement, or constructed landscape areas in perpetuity, as described in Section 13.0. Pavement (or the presence of constructed landscape areas or buildings) will eliminate both the leaching pathway from the vadose zone and the direct contact pathway for protection of ecological receptors. There are no arsenic exceedances in the saturated zone. No exceedances of the CUL that is protective of human health direct contact were detected (the maximum concentration of arsenic is 30 mg/kg, compared to the MTCA Method C direct contact CUL of 88 mg/kg). Therefore, remediation specific to arsenic contamination at the Site in the Upland AOC is not required, and a REL was not developed.

Arsenic contamination in soil is present in shallow soil at two locations (SS-02 and SS-03) in the Shoreline AOC and will be addressed as part of the remedy. However, a REL has not been established, and the Shoreline AOC remedy will address arsenic in soil to comply with the proposed cleanup standard.

9.5.1.2 TPH and LNAPL

TPH RELs based on conservative residual saturation values are proposed for the Upland AOC. A residual saturation value is defined as the concentration at which the petroleum product is not mobile in groundwater. Selection of residual saturation values as RELs is consistent with

WAC 173-340-747 (3)(g), which states that soil concentrations left on site must not result in the accumulation of LNAPL in groundwater.

Table 15-14 of Ecology's *Concise Explanatory Statement for the Amendments to the Model Toxics Control Act Cleanup Regulation* (Ecology 2001) identifies residual saturation values for different petroleum products relevant to a variety of soil types. Prior sampling of LNAPL in the Upland AOC indicated that it is a mixed product consisting primarily of weathered gasoline and diesel. Soil on the Site is identified primarily as a silty sand with fine to medium sand present in the WBZs, as described in Section 2.5.4. The WBZs consist of thin silty sand transmissive zones where water is present, surrounded by very stiff silt. Most contamination is present in the shallow vadose zone, which consists of silt. Therefore, the residual saturation values for silt to fine sand presented in Table 15-14 (with concentrations of 9,643 mg/kg for gasoline and 22,857 mg/kg for middle distillates/diesel fuel) would be most appropriate for the Site based on geology/hydrogeology. However, to be conservative, fine to medium sand was selected as the soil type of interest for the Site to ensure that RAOs are met. Ecology's Table 15-14 presents a residual saturation value of 5,625 mg/kg for gasoline in fine to medium sand. For middle distillates (e.g., DRO), Table 15-14 presents a value of 13,333 mg/kg.

These values are consistent with studies from the Alaska Department of Environmental Conservation (ADEC). In 2006, ADEC published recommendations from a joint working group that included ADEC, USEPA, and a number of federal stakeholders in Alaska regarding the formation of free product as a function of soil type and petroleum product (ASCWG 2006). The studies proposed residual saturation values of 7,500 mg/kg for GRO and 17,000 mg/kg for middle distillates in fine sand/silt, and 2,800 mg/kg for GRO and 6,500 mg/kg for middle distillates in coarse sand (no values were proposed for fine to medium sand).

For conservatism, the RELs selected for use at the Site are less than those identified in Table 15-14 (Ecology 2001) and by ADEC. RELs proposed for the Upland AOC are 5,000 mg/kg for GRO and 12,000 mg/kg for Total DRO and ORO.

The distribution of GRO and Total DRO and ORO in soil at concentrations greater than the REL according to depth is shown on Figures 9.3 through 9.8, Figure 9.10, and Figure 9.11. GRO and Total DRO and ORO in CAA-1 are shown on Figures 9.3 and 9.4, respectively; GRO and Total DRO and ORO in CAA-2 are shown on Figures 9.5 and 9.6; and GRO and Total DRO and ORO in both CAA-3 and CAA-4 are shown on Figures 9.7 and 9.8. Detected TPH concentrations did not exceed RELs in CAA-5. Soil remediation using the proposed REL of 5,000 mg/kg for GRO would remove approximately 80 percent of the samples with GRO concentrations greater than the proposed CUL, corresponding to removal of approximately 74 percent of the volume of contaminated soil greater than the proposed CUL for GRO. Soil remediation using the proposed REL of 12,000 mg/kg for Total DRO and ORO would remove approximately 83 percent of the samples with DRO and ORO concentrations greater than the proposed CUL, corresponding to removal of approximately 78 percent of the volume of contaminated soil greater than the proposed CUL for Total DRO and ORO.

In addition to RELs for TPH, a visual standard[11] will be applied during remedial actions to confirm that LNAPL is removed. For example, if evidence of LNAPL is observed during excavation, the excavation will be extended until LNAPL is no longer visually observed.

9.5.1.3 Benzene

Benzene contamination in soil is generally limited to exceedances of proposed CULs for the leaching pathway only; only one soil result is greater than the MTCA Method C direct contact criteria for protection of human health of 2,400 mg/kg. It is anticipated that remediation of GRO in soil, which is the source of benzene on Site, will address benzene in soil and allow benzene in groundwater downgradient of the cleanup area to meet proposed groundwater CULs long-term at the CPOC. The location that exceeds direct contact criteria, 01SB09, is in CAA-2 within the presumed extent of LNAPL and will be addressed as part of the CAA-2 remedy; the maximum concentration of GRO is also detected at 01SB09. The REL proposed for benzene is, therefore, based on soil remediation meeting the GRO REL. Once the GRO REL is met, remedial objectives for benzene in soil will be achieved.

9.5.1.4 TCE

TCE is present in soil at concentrations up to 6,000 times the proposed CUL of 0.02 mg/kg. The REL for TCE was defined based on the objectives to (1) be protective of the direct contact pathway using the MTCA Method C direct contact criteria for protection of human health of 1,800 mg/kg and (2) design an effective remediation boundary that targeted the significant area of continuous TCE contamination greater than the proposed CUL of 0.02 mg/kg. The proposed REL for TCE is 1 mg/kg.

The distribution of TCE exceeding the REL in soil according to depth in CAA-3 and CAA-4 is shown on Figure 9.9. The distribution of TCE in soil exceeding the REL in soil according to depth in CAA-5 is shown on Figure 9.12. The REL of 1 mg/kg for TCE would remove 87 percent of the samples with TCE concentrations greater than the proposed CUL, corresponding to removal of approximately 80 percent of the volume of contaminated soil greater than the proposed CUL for TCE.

Cleanup of TCE to the REL will also remove a substantial source of VOCs and would result in decreased risk posed by vapor intrusion.

9.5.1.5 Penta

A soil REL has not been developed for penta for this Supplemental Upland FS. Excavation of penta-impacted soil was completed in 2012 by SES and the target CUL of 2.5 mg/kg was achieved throughout the excavation, as described in Section 3.2.1. Therefore, additional remediation of penta in soil is not warranted. Penta contamination in soil is limited to exceedances of leaching

[11] Specific requirements and performance standards for visual standard criteria will be established as part of engineering design and will be detailed in the EDR and associated Construction Compliance Monitoring Plan (CCMP).

criteria only; all soil results are less than the direct contact criteria of 330 mg/kg and 4.5 mg/kg for protection of human health and ecological receptors, respectively. Although penta is retained as a groundwater IHS, exceedances of the groundwater CUL are limited to two locations on the Bulk Terminal Property, adjacent to the former penta source area in soil. Penta does not currently reach the W. Commodore Way ROW at detectable concentrations. Groundwater monitoring for penta will continue at the CPOC, as described in Section 13.2; therefore, a REL for penta is not proposed.

9.5.2 Groundwater Remediation Levels

Groundwater RELs are not proposed at the Site. As described in Section 10.4, the technologies to be implemented at the Site do not solely address groundwater contamination and instead focus on source removal, treatment, or stabilization/containment in soil to protect groundwater. Therefore, groundwater RELs have not been developed. Soil RELs described in the preceding sections are intended to be protective of groundwater contamination and, when applied, will allow proposed groundwater CULs to be met long-term at the proposed CPOC.

Each IHS will be included as part of long-term groundwater monitoring for the Site, and compliance will be determined based on compliance with the proposed groundwater CULs at the POC or CPOC if one is established.

10.0 Supplemental Cleanup Action Alternative Screening

This section identifies and briefly describes the remedial technologies that were selected for further evaluation as part of the three separate FS reports for the Bulk Terminal, ASKO, and East Waterfront Properties (SES 2014d, 2014e, 2014f). This section also provides a summary of the supplemental evaluation of retained remedial technologies with respect to their effectiveness for the IHSs with additional screening of technologies, consistent with WAC 173-340-350(8)(b).

10.1 SUMMARY OF RETAINED TECHNOLOGIES AND RECOMMENDED ALTERNATIVES

Based on the remedial technology screening completed by SES during the 2014 FSs, the following alternatives were retained for further evaluation to address soil and groundwater contamination at the Site. SES provided a recommendation for a selected alternative per property, as described in the following sections. A summary of these alternatives and their DCA ranking is included in Table 9.1.

10.1.1 Bulk Terminal Property

The following cleanup action alternatives were retained for further evaluation for the Bulk Terminal Property as part of the FS (SES 2014f):

- **Cleanup Action Alternative 1:** Unsaturated zone excavation and offsite disposal; MPE for LNAPL; biosparge/air sparge/SVE for TPH in groundwater.
- **Cleanup Action Alternative 2:** Unsaturated zone excavation and offsite disposal; MPE for LNAPL and TPH in groundwater.
- **Cleanup Action Alternative 3:** Unsaturated zone and LNAPL excavation and offsite disposal; MNA for TPH in groundwater.
- **Cleanup Action Alternative 4:** MPE for the unsaturated zone, LNAPL, and TPH in groundwater.

MNA and groundwater monitoring were a component of each alternative listed above.

Alternative 4 was selected as the recommended alternative for the Bulk Terminal Property. As mentioned in Section 9.1.1, Ecology did not concur with this recommendation and preferred a more reliable and permanent solution with a shorter restoration time frame that does not require an Environmental Covenant. Ecology also noted in their November 25, 2015, letter that the DCA suggested that Alternative 3 would achieve the most environmental benefit for the cost (Ecology 2015a).

10.1.2 W. Commodore Way ROW

The following cleanup action alternatives were retained for further evaluation for the W. Commodore Way ROW as part of the FS (SES 2014f):

- **Cleanup Action Alternative 1:** MPE for LNAPL and TPH in groundwater.
- **Cleanup Action Alternative 2:** LNAPL excavation and offsite disposal; MPE for residual LNAPL; and MNA for TPH in groundwater.

Alternative 2 was selected as the recommended alternative for the W. Commodore Way ROW. Ecology tentatively concurred with the selection of this alternative.

10.1.3 ASKO Property

The following cleanup action alternatives were retained for further evaluation for the ASKO Property as part of the FS (SES 2014d):

- **Cleanup Action Alternative 1:** Excavation with shoring and offsite disposal for TPH and cVOCs in soil and groundwater.
- **Cleanup Action Alternative 2:** ERD and DPE for cVOCs in groundwater; SVE for cVOCs and GRO in soil, and excavation for DRO in soil.
- **Cleanup Action Alternative 3:** In situ chemical oxidation (ISCO) for cVOCs in groundwater; DPE for TPH in groundwater; SVE for cVOCs and GRO in soil; and excavation for DRO in soil.
- **Cleanup Action Alternative 4:** Electrical resistance heating (ERH) for cVOCs in groundwater; DPE for TPH in groundwater; SVE for cVOCs and GRO in soil; and excavation for DRO in soil.

MNA, groundwater monitoring, and a PRB wall with ZVI between the ASKO Property and BNSF parcel were components of each alternative listed above.

Alternative 2 was selected as the recommended alternative. Ecology did not provide an opinion on whether they agreed with this selection.

10.1.4 East Waterfront Property

The following cleanup action alternatives were retained for further evaluation for the East Waterfront Property as part of the FS (SES 2014e):

- **Cleanup Action Alternative 1:** Excavation with offsite disposal.
- **Cleanup Action Alternative 2:** Air sparging with SVE.
- **Cleanup Action Alternative 3:** DPE.

MNA and groundwater monitoring were a component of each alternative listed above.

Alternative 1 was selected as the recommended alternative, and Ecology tentatively concurred with the selection. TOC completed the proposed cleanup action excavation in 2013, prior to submittal of the RI/FS in June 2014. A summary of this excavation was not provided in the 2014 RI or FS for the East Waterfront Property. The soil excavation included the excavation and offsite disposal of 1,700 CY of petroleum-contaminated soil (refer to Figure 3.4 for the excavation limits), which was the maximum extent practical at the time, with the exception of along the shoreline in the northeastern portion of the excavation. Post-excavation results collected by SES indicated that residual TPH- and benzene-contaminated soil remained at concentrations greater than the MTCA Method A CULs along the northeastern portion of the shoreline and on the eastern portion of the excavation extending beneath the existing shed and garage. TPH contamination remains present immediately adjacent to and beneath these structures. The soil excavation did not fully achieve cleanup action objectives set forth by Ecology in their October 2015 opinion letter (Ecology 2015c); therefore, additional cleanup is necessary on the East Waterfront Property to meet cleanup action objectives.

10.2 SUPPLEMENTAL CLEANUP ACTION ALTERNATIVE ASSESSMENT

As part of this Supplemental Upland FS, Floyd|Snider reviewed the previously evaluated technologies and Ecology's comments summarized in Section 10.1 and Table 9.1 and eliminated several remedial technologies based on the DCAs presented in the FSs and their initial ranking and the ability for a remedial technology to address the IHSs within a reasonable time frame. In general, remedial technologies with lower environmental benefit per cost were eliminated from additional evaluation. Specifically, less permanent technologies with longer restoration time frames such as SVE, air sparging, DPE, and MPE, were not retained for further evaluation. In addition, ISCO was not retained because it does not appear to be a cost-effective or feasible technology due to complexities associated with chemical oxidation including the size of the plumes, the presence of multiple collocated sources (TPH and TCE), the geology and hydrogeology (multiple WBZs within soils that are predominantly silt/silty sand) at the Site, and the safety measures that would be necessary to implement this technology over such a large area.

The remedial technologies retained were then further evaluated with respect to their effectiveness for the IHSs are described in the following sections.

10.2.1 Soil Excavation with Offsite Disposal

Excavation of contaminated soil and offsite landfill disposal could be used to address soil IHSs, which would also address groundwater IHSs. The technology could be used to remove all soil contamination to a selected soil concentration (CUL or REL) or be implemented to a limited extent to remove focused areas of soil contamination (hot spots). Soil excavation could be implemented in combination with other technologies depending on the extent of contamination left in place following a focused removal. If excavation were conducted as a focused removal, additional actions would be required to manage exposure for the contaminants remaining on the Site.

Excavation can be used as either a standalone technology or in combination with other remedial technologies, would successfully achieve the RAOs, and could be implemented given the Site physical conditions.

10.2.2 LNAPL Excavation with Offsite Disposal

Excavation of LNAPL and offsite landfill disposal could be used to address areas of LNAPL, which would also address groundwater IHSs, specifically TPH and benzene. The technology could be used to remove LNAPL to the maximum extent practical. LNAPL excavation could be implemented in combination with other technologies. Specially, LNAPL excavation would occur concurrently with excavation of TPH-contaminated soil. LNAPL excavation, in conjunction with other technologies, would successfully achieve the RAOs and could be implemented given the Site physical conditions.

10.2.3 In Situ Thermal Treatment

In situ thermal treatment uses the addition of a heat source (i.e., ERH) combined with vapor extraction. As the soil is heated, volatile contaminants in soil are destroyed or volatilized, then extracted via SVE wells, and treated at the surface prior to discharge. Thermal treatment can be very effective for the removal of cVOCs at hazardous waste levels.

In situ thermal treatment via ERH has been proven effective for the removal of volatile contaminants at sites with established source areas. Thermal treatment can remove greater than 95 percent of the source mass in the treatment zone. Thermal treatment can be effectively implemented to the necessary depths where contamination is present at the Site if a sufficient power supply is available and not impeded by Site activities. Thermal treatment has a short restoration time frame: Contaminant removal from the subsurface is typically complete in 1 year or less of active heating. Due to the high concentrations of TCE present at the Site and the large quantity of remaining source mass, thermal treatment would be most effective in removing most of the vadose zone source mass. The area of TCE soil contamination spans multiple WBZs; therefore, the use of other technologies may be required following completion of thermal treatment to treat or degrade the groundwater plume.

Thermal treatment is a viable source removal technology for the Site because of its effectiveness in cVOC destruction in a short period of time. This technology could successfully achieve the RAOs and could be implemented given the Site physical conditions.

10.2.4 Enhanced Reductive Dechlorination

Biological treatment via ERD is a viable technology for cVOC plume treatment on the ASKO Property because it has been proven effective for enhancing and accelerating reduction of TCE concentrations in groundwater at similar sites. Natural dechlorination processes have been observed in downgradient portions of the plume (as evidenced by the presence of vinyl chloride in downgradient portions of the cVOC plume on the ASKO Property), so it would likely be effective in accelerating dechlorination of source area groundwater. ERD implementation is fairly simple

and involves periodic injection of substrate through injection wells. As with any in situ technology, success is highly dependent on the ability to deliver the substrate to the affected areas. ERD as a standalone technology to remediate the source areas is not expected to reduce chemical concentrations to acceptable levels in a reasonable restoration time frame; however, ERD as a groundwater plume remediation measure would be more effective when applied in combination with other source control technologies, enabling a reduced restoration time frame to be potentially achieved. When used in combination with other remedial technologies, ERD could assist in successfully achieving the RAOs and could be implemented given the Site physical conditions.

10.2.5 Permeable Reactive Barrier

PRB walls intercept and passively treat contaminated groundwater flowing from an upgradient source. PRB walls are typically installed perpendicular to the direction of groundwater flow and rely on the natural movement of the groundwater to bring contaminants in contact with PRB wall media to eliminate the need for mechanical systems and/or groundwater and vapor treatment. For treatment of chlorinated compounds, reactive material such as ZVI media can be placed inside the PRB in bulk or mixed with sand.

PRBs are generally constructed in one of two configurations, either as a “funnel and gate” configuration to direct the contaminated groundwater to a PRB, or as a linear wall that intersects the plume. Barrier walls can also be constructed using trenching, soil mixing, or injection well methods.

Groundwater flows according to its natural gradient through the PRB, where the reactive media within the wall react with the dissolved chemicals in groundwater. PRB walls do not remediate the source area itself but decrease the contaminant solubility or otherwise immobilize the chemicals migrating from the source area with the groundwater. PRB walls can also be used to treat migration of dissolved contaminants upgradient of remediated areas to maintain effectiveness of remedial actions. The life span and effectiveness of a PRB wall is dependent on the mass of chemicals passing through the wall, which can be mitigated by reduction of source material upgradient of the PRB wall.

The use of a PRB was previously identified in the 2014 ASKO Property FS (SES 2014d) as a viable technology for the Site to reduce cVOC concentrations migrating from the upgradient BNSF parcel (BNSF AOC). This technology would prevent recontamination of remediated areas, would assist in achieving the RAOs, and could be implemented given the Site physical conditions.

10.2.6 Surface Capping

When implemented with ICs, capping could be used to address soil IHSs through management of the exposure pathways and erosion pathways. Surface capping design would likely vary by location and future expected Site use. The goal of capping would be to manage the direct contact by humans and ecological receptors and erosion pathways and to reduce surface water infiltration and contaminant leaching to groundwater. Cap technologies can be designed to

consist of either (1) impermeable or semipermeable paving or (2) placement of permeable clean compacted soil or gravel over contaminated soil. Capping used in combination with groundwater remedial technologies, such as source removal, would successfully achieve the RAOs and could be implemented given the Site physical conditions.

10.2.7 Monitored Natural Attenuation

MNA is a remedial process that involves routine groundwater sampling and analysis to monitor the results of one or more naturally occurring physical, chemical, or biological processes that reduce the mass, toxicity, volume, or concentration of chemicals in site soils and/or groundwater. MNA is a mechanism by which COCs are reduced (often slowly) through natural means without other control, removal, treatment, or aquifer-modifying activities. These in situ processes may include biodegradation; dispersion; dilution; sorption; volatilization; and chemical or biological stabilization, transformation, or destruction of contaminants. MNA cannot typically be implemented as a sole remediation method while source areas (i.e., LNAPL) remain. This alternative typically requires groundwater monitoring over a period of many years to verify that attenuation is occurring and to ensure that progress is made toward meeting the RAOs and cleanup standards.

MNA is not capable of significantly reducing contaminant mass at hazardous waste or LNAPL sites, and, therefore, cannot meet the RAOs within a reasonable restoration time frame by itself. However, natural dechlorination is occurring in downgradient portions of the cVOC plume on the ASKO Property, as evidenced by the presence of TCE breakdown products (*cis*-1,2-DCE and vinyl chloride). Therefore, aquifer conditions indicate that natural attenuation processes will continue to occur regardless of what remedial technologies are implemented at the Site, and this FS considers MNA a realistic long-term component of any remedy considered for this Site, especially for downgradient portions of the cVOC and TPH plumes, and is retained for further evaluation.

10.2.8 Institutional Controls

ICs are legal and administrative non-engineered controls intended to restrict human activities in such a way as to prevent or reduce potential exposure to contaminants. ICs as a standalone technology would not reduce, destroy, or remove chemical contamination beyond that which would occur via natural processes, but would instead be implemented in addition to other technologies to meet RAOs, ensure long-term protectiveness of the selected remedy, prevent exposure to contaminated soil and groundwater, and implement protective management procedures to be utilized during potential future redevelopment and maintenance activities (e.g., utility work).

ICs would be implemented with any technology that leaves soil contamination in place at concentrations greater than direct contact criteria or in excess of CULs. ICs that may be implemented at the Site for soil could include a requirement for installation and maintenance of pavement over contaminated soil remaining at the Site. ICs could be developed to address the direct contact and erosion pathways.

ICs would be also implemented with any technology that leaves groundwater contamination in place. ICs that may be implemented for groundwater could include current and future restrictions on groundwater withdrawals and use and procedures for management of groundwater during dewatering or excavation.

When used in combination with other remedial technologies, ICs would successfully achieve the RAOs and could be implemented given the Site physical conditions.

10.2.9 Engineering Controls

Engineering controls are physical measures constructed to block exposure pathways and reduce or eliminate contaminant exposure to ecological and human receptors. Engineering controls can be used as permanent measures or as temporary measures to prevent exposure to the contamination until a permanent cleanup is implemented.

Engineering controls vary in nature and scope. Examples of engineering controls include installation of a vapor mitigation system or barrier during building construction, placement of an indicator layer on top of contaminated soil, the use of engineered equipment or access controls (e.g., fencing) to prevent or limit contact with contaminated soil, or installation of pavement and a stormwater conveyance system to help minimize infiltration of stormwater through contaminated soil. Engineering controls require maintenance in perpetuity to assure proper function and prevent exposure.

10.3 ADDITIONAL REMEDIAL TECHNOLOGY SCREENING AND TREATABILITY TESTING

The recommended cleanup action alternatives for the Upland AOC were not implemented by TOC, and Ecology either did not agree with the recommended alternative (Bulk Terminal Property) or did not provide an opinion (ASKO Property). Therefore, additional evaluation and testing of remedial technologies for the Upland AOC was completed, as described in the following sections.

10.3.1 Additional Remedial Technology Screening

Additional remedial technologies were reviewed and considered to address both soil and groundwater contamination at the Site. Due to the nature and extent of soil and groundwater contamination, technology review focused on technologies that addressed the source area soils (to improve groundwater quality) and could be implemented as part of development.

10.3.1.1 In Situ Solidification and Stabilization

In situ solidification and stabilization (ISS) is an established remediation technology used to treat contaminated materials by blending soils in situ with a binder (e.g., cementitious/pozzolanic reagents) to achieve immobilization of contaminants and LNAPL through stabilization and solidification processes. The solidification process involves encapsulation of contaminated materials (i.e., physically trapped) to form a solid material that restricts contaminant leaching by reducing hydraulic conductivity and increasing compressive strength and media durability. The stabilization process involves chemical reactions between reagents and contaminated materials

to reduce the leachability of targeted contaminants by transforming them to insoluble/stable forms. Stabilization achieves treatment by binding free liquids, immobilizing targeted contaminants, and/or reducing the solubility of the contaminants.

ISS monoliths are generally constructed using various techniques including single large-diameter auger (LDA) mixing, high-speed rotary mixing devices, and excavator bucket mixing. Certain techniques are limited by depth, such as excavator-mounted mixing methods that can achieve mixing up to 20 feet bgs. Drill rig-mounted LDA mixing can achieve mixing up to 90 feet bgs. Additional support equipment for ISS operations includes a batch plant for grout preparation, material staging and laydown areas, and shallow subsurface obstruction removal equipment (i.e., excavator).

Prepared grout is mixed with soils in situ to form a homogenous mixture. ISS treatment areas are overlapped to ensure 100 percent coverage of the targeted area, which results in a continuous solidified/stabilized monolith. Samples are obtained from the ISS-treated soil immediately after mixing to evaluate efficacy of treatment to performance goals, which generally include unconfined compressive strength (UCS) and hydraulic conductivity. Due to displacement of in situ soils and addition of grout, treated soils typically expand and excess “swell” material is created during implementation. Swell material is generally estimated as 30 percent of the total ISS volume and may be managed through benching of the ISS treatment areas prior to ISS implementation and/or use of swell as backfill or grading material.

ISS is a viable technology for the Site because of its effectiveness in immobilizing contaminants and reducing leaching of contaminants into groundwater in a very short period. Additionally, unlike other in situ technologies that rely on effective distribution and contact of treatment reagents with contamination through injection or distribution of a temperature gradient, ISS ensures 100 percent of the targeted soils are mechanically mixed with the treatment reagents (e.g., cement). The lifespan of ISS treatment is dependent on intrusive activity and geochemical properties in the groundwater. However, it is expected that ISS treatments can last over 100 years. This technology could successfully achieve the RAOs and could be implemented given the Site physical conditions.

10.3.2 Treatability Studies

Treatability studies were performed for ISS and PRB technologies to evaluate the effectiveness of the reagents for treating Site contaminants and to collect data for use in future design stages. Soil and groundwater samples were collected from both the ASKO and Bulk Terminal Properties on March 14, 2019, for use in both the ISS and PRB treatability studies. A summary of the ISS and PRB treatability studies are included in Appendix E and Appendix F, respectively.

10.3.2.1 In Situ Solidification and Stabilization

The ISS treatability study was conducted to evaluate the reagents and dosages for ISS treatment based on testing results for UCS, hydraulic conductivity, and leaching assessment (Appendix E). Soil samples were composited by property and tested for baseline geologic index property parameters

including moisture content, pH, Unified Soil Classification System soil classification, grain size, Atterberg limits, organic content, and unit weight. Each composite was also tested for total concentrations for a subset of COCs including BTEX, TCE, and *cis*-1,2-DCE by USEPA Method 8260C and GRO and DRO by USEPA Method 8015D. A baseline leaching assessment (USEPA Method 1316) was conducted for each untreated composite for the analytes listed above.

Three ISS mix designs were tested for each composite for a total of six ISS mixes. Reagents tested included Portland cement type II, ground granulated blast furnace slag, and Premium Gel Bentonite. ISS mixes were tested for geotechnical parameters including pH (immediately after mixing) and moisture content, unit weight, UCS (at 7, 14, and 28 days of cure), and hydraulic conductivity (at 28 days of cure). All ISS mixes exceeded the performance goals of a UCS greater than 50 pounds per square inch and a hydraulic conductivity of less than 1.0×10^{-6} centimeters per second. Selected ISS mixes were also tested for leaching (USEPA Method 1315) and evaluated for reduction in leaching compared to the baseline leaching assessment. All tested ISS mixes achieved a greater than 96 percent reduction in leaching for the COCs tested.

10.3.2.2 Permeable Reactive Barrier with Zero-Valent Iron

The PRB column study (Appendix F) was conducted to evaluate two types of commercially available ZVI for the degradation of cVOCs using Site soil and groundwater: granular ZVI (gZVI) and microscale ZVI (mZVI). For the gZVI, the column was packed with 100 percent gZVI. For mZVI, the column was packed with a mixture of 1 percent by weight mZVI and 99 percent geologic material to simulate an injected mZVI-amended subsurface zone. A control column was set up using 100 percent geologic material. Site groundwater containing cVOCs and TPH was pumped through the columns equating to a specific pore volume per day. Water samples were collected from the influent, along the column length, and from the effluent and analyzed for pH, oxidation-reduction potential, cVOCs, dissolved hydrocarbon gases, TPH, BTEX, cations, anions, total organic carbon, total dissolved solids, and alkalinity.

TCE was degraded from influent concentrations to non-detect after a residence time of approximately 13.5 and 14.2 hours for mZVI and gZVI, respectively. *cis*-1,2-DCE was also fully degraded for the gZVI column but was not fully degraded for the mZVI column. Vinyl chloride was not detected in either column. While both ZVI columns indicated a gradual loss of ZVI reactivity, the mZVI column had a faster than expected ZVI consumption, likely due to TCE degradation to *cis*-1,2-DCE and interference from dissolved TPH with TCE and *cis*-1,2-DCE migration to ZVI surfaces. Therefore, it is recommended that an engineering safety factor be included in the ZVI volume design calculations for the proposed ZVI PRB to ensure long-term efficiency. Based on the results of the treatability testing, the recommended ZVI product for future implementation of the PRB is gZVI because both TCE and *cis*-1,2-DCE were degraded with gZVI compared to only TCE with mZVI.

10.4 SUMMARY OF RETAINED REMEDIAL TECHNOLOGIES

Supplemental screening of remedial technologies that are known to be effective for IHSs based on their use at other cleanup sites with similar contaminants was completed in accordance with WAC 173-340-350(8)(b). Based on an updated evaluation of remedial technologies that are

capable of meeting the RAOs, the following remedial technologies were retained for potential implementation in one or more CAAs:

- **Soil excavation and offsite disposal,** for removal of source areas (for all IHSs) in vadose zone or saturated soil in all CAAs. Source removal, including removal of the most contaminated mass, is the most aggressive and permanent technology and will improve groundwater quality.
- **LNAPL excavation and offsite disposal,** for removal of shallow vadose zone TPH- and benzene-impacted soil and LNAPL in CAA-1 and CAA-2. Source area soil and LNAPL removal, including removal of the most contaminated mass, is an aggressive and permanent technology and will improve groundwater quality.
- **ISS,** for source area soil and LNAPL solidification/stabilization (for all IHSs) in the Upland AOC CAAs. ISS encapsulates and solidifies contaminants in place, which reduces the migration of contaminants to surrounding groundwater.
- **ERH,** for source area vadose zone and saturated soil impacts in a portion of the Upland AOC (CAA-4 and CAA-5). This technology is well suited to high-concentration cVOC source areas.
- **ERD,** for treatment of cVOCs in soil and groundwater in a portion of the Upland AOC (CAA 4 and CAA-5). ERD is primarily a groundwater cleanup technology that can also remediate soil by accelerating the desorption of TCE from soil to groundwater, where it is destroyed in situ.
- **PRB,** for use on the upgradient portion of CAA-4 in the Upland AOC. PRB is a temporary solution to address high cVOC concentrations in the Perched WBZ located upgradient on the BNSF AOC until BNSF can define the nature and extent and select a remedial alternative for that site.
- **Surface capping,** for both the Upland and the Shoreline AOC CAAs. Surface capping has been retained for use in combination with other more aggressive technologies to address the direct contact for all IHSs, leaching, and vapor intrusion pathways at the Site.
- **MNA,** for both the Upland and the Shoreline AOC CAAs. MNA is retained for use in combination with other more aggressive technologies that are expected to address source area soil and improve source area groundwater quality.
- **ICs,** for both the Upland and the Shoreline AOCs. The use of industrial CULs or RELs will require an IC to restrict human activities in such a way as to prevent or reduce potential exposure to contaminants.
- **Engineering controls,** for the Upland AOC. Engineering controls, such as a vapor barrier or vapor mitigation system, may be used to prevent or reduce potential exposure to contaminants.

These technologies may be implemented as standalone treatments or in combination with other technologies as appropriate depending on subsurface conditions. These retained technologies were evaluated for each CAA and then aggregated into Sitewide alternatives for further evaluation as described in Section 11.0.

11.0 Identification of Cleanup Action Alternatives

The retained technologies described in Section 10.4 have been aggregated into cleanup action alternatives for soil and groundwater contamination at the Property and compiled into Sitewide alternatives, as described in the following sections. These alternatives include a range of potential cleanup alternatives for each of the CAAs, ranging from most protective to least protective. Due to the significant differences between the CAAs, not all technologies are applicable to all CAAs based on the nature and extent of IHSs. Furthermore, for the Upland AOC, not all technologies that are applicable to the ASKO Property are applicable to the Bulk Terminal Property. As such, and at the direction of Ecology, different technologies were evaluated separately for each parcel before determining combined approaches appropriate for the Upland AOC.

11.1 SITEWIDE CLEANUP ACTION ALTERNATIVES

The alternatives were selected to address both soil and groundwater contamination at the Property and were developed to address the contamination within both the Upland and Shoreline AOCs. The six alternatives presented will be evaluated according to the MTCA DCA procedures in Section 12.0, to compare the costs and benefits of the cleanup alternatives, and to identify the alternative that is permanent to the maximum extent practicable.

Several interim actions have been completed at the Site as described in Section 3.2. Additional remedial technologies were evaluated to address remaining IHS contamination in both soil and groundwater in the Upland AOC. Specifically, TPH and benzene are present in soil and groundwater throughout the Upland AOC, and a significant mass of TCE is present in soil on the ASKO Property that has resulted in a TCE and vinyl chloride groundwater plume. In addition, two significant areas of LNAPL are present in the Upland AOC that warrant active cleanup. Conservative decision criteria were established as shown on Figure 11.1 for consideration in the development of alternatives for the Upland AOC portion of the Site based on the nature and extent of IHSs in soil and groundwater in each CAA.

Additional remedial technologies were not evaluated for the Shoreline AOC because a partial cleanup (as an interim action) has been completed, the area that requires active cleanup is limited in extent, and soil excavation and offsite disposal is a permanent solution. Therefore, soil excavation and offsite disposal will be a component of all Sitewide cleanup action alternatives for the Shoreline AOC.

A summary of each of the six Sitewide alternatives is included in Table 11.1, with a brief description included in the sections below. PRB, groundwater monitoring, and ICs are included in each of the six alternatives and are summarized in Sections 11.2, 11.3, and 11.4, respectively. All proposed alternatives address remediation of groundwater by removing, treating, or containing source area soil. Groundwater concentrations of certain IHSs in the Upland AOC are more than 10,000 times the proposed CULs. No single technology can reliably reduce concentrations in groundwater 10,000 times within a reasonable restoration time frame. Therefore, a CPOC for

groundwater within the W. Commodore Way ROW has been proposed for all alternatives (refer to Section 13.0). The alternatives are presented from most protective to least protective. The cost estimates for each alternative are included in Appendix G.

11.1.1 Alternative A.1

This alternative includes excavation of soil with IHS concentrations greater than the CULs in all CAAs, removal of LNAPL using normally accepted engineering practices, offsite disposal, installation of a PRB wall with ZVI, post-remedy groundwater monitoring, capping with pavement or buildings in the Upland AOC, and ICs for the Upland AOC. Refer to Figure 11.2. The estimated cost for Alternative A.1 is $16,151,000, as shown in Table G.1 and detailed in Table G.2 of Appendix G.

11.1.2 Alternative A.2

This alternative includes excavation of soil with IHS concentrations greater than the RELs and any IHSs greater than 2 times the soil CUL where there are corresponding groundwater impacts greater than 2 times the groundwater CUL (refer to Figure 11.1) in CAA-1, CAA-2, CAA-3, and CAA-4. Alternative A.2 also includes removal of LNAPL using normally accepted engineering practices, excavation of soil with IHS concentrations greater than the CULs (CAA-6.a, CAA-6.b, and CAA-7), offsite disposal of excavated soil, installation of a PRB wall with ZVI, post-remedy groundwater monitoring, capping with pavement or buildings in the Upland AOC, and ICs for the Upland AOC. Refer to Figure 11.3. The estimated cost for Alternative A.2 is $12,244,000, as shown in Table G.1 and detailed in Table G.3 of Appendix G.

11.1.3 Alternative B

This alternative includes excavation of soil with IHS concentrations greater than RELs and any COIs greater than 2 times the soil CUL where there are corresponding groundwater impacts greater than 2 times the groundwater CUL (refer to Figure 11.1) in CAA-1, CAA-2.b, CAA-3, and CAA-5; removal of LNAPL using normally accepted engineering practices; ISS to address source area soil (CAA-2.a, CAA-4.a and CAA-4.b); installation of an interceptor trench adjacent to and upgradient of the ISS monolith in CAA-4.a and CAA-4.b and PRB wall with ZVI; excavation of soil with IHS concentrations greater than the CULs (CAA-6 and CAA-7); offsite disposal of excavated soil; post-remedy groundwater monitoring; capping with pavement or buildings in the Upland AOC; and ICs for the Upland AOC. Refer to Figure 11.4. The estimated cost for Alternative B is $8,251,000, as shown in Table G.1 and detailed in Table G.4 of Appendix G.

11.1.4 Alternative C

This alternative includes excavation of soil with IHS concentrations greater than RELs and any IHSs greater than 2 times the soil CUL where there are corresponding groundwater impacts greater than 2 times the groundwater CUL (refer to Figure 11.1) in CAA-1, CAA-2.b, CAA-3, and CAA-5; removal of LNAPL using normally accepted engineering practices; ISS to address source area soil with IHS concentrations greater than RELs (CAA-2.a, CAA-4.a, and CAA-4.b); in situ

treatment and ERD of the TCE groundwater plume using a trademarked colloidal biomatrix and sulfidated mZVI mixture within and east of CAA-5; installation of an interceptor trench adjacent to and upgradient of the ISS monolith in CAA-4.a and CAA-4.b and PRB wall with ZVI; excavation of soil with IHS concentrations greater than the CULs (CAA-6 and CAA-7); offsite disposal of excavated soil; post-remedy groundwater monitoring; capping with pavement or buildings in the Upland AOC; and ICs for the Upland AOC. Refer to Figure 11.5. The estimated cost for Alternative C is $7,821,000, as shown in Table G.1 and detailed in Table G.5 of Appendix G.

11.1.5 Alternative D

This alternative includes excavation of soil with IHS concentrations greater than RELs (CAA-1.a and CAA-2.a and 2.b); removal of LNAPL using normally accepted engineering practices; ERH to 20 feet bgs to address source area soil with IHS concentrations greater than RELs (CAA 4.a and CAA-4.b); excavation of soil with IHS concentrations greater than the CULs (CAA-6 and CAA 7); offsite disposal of excavated soil; installation of a PRB wall with ZVI; post-remedy groundwater monitoring; capping with pavement or buildings in the Upland AOC; and ICs for the Upland AOC. Refer to Figure 11.6. The estimated cost for Alternative D is $7,404,000, as shown in Table G.1 and detailed in Table G.6 of Appendix G.

11.1.6 Alternative E

This alternative includes excavation of soil with IHS concentrations greater than RELs in CAA-1.a and CAA-2.b; removal of LNAPL using normally accepted engineering practices; ISS to address source area soil with IHS concentrations greater than RELs (CAA-2.a, CAA-4.a, and CAA-4.b); excavation of soil with IHS concentrations greater than the CULs (CAA-6 and CAA-7); offsite disposal of excavated soil; installation of a PRB wall with ZVI; post-remedy groundwater monitoring; capping with pavement or buildings in the Upland AOC; and ICs for the Upland AOC. Refer to Figure 11.7. The estimated cost for Alternative E is $6,727,000, as shown in Table G.1 and detailed in Table G.7 of Appendix G.

11.2 PROTECTION MEASURES FOR OFFSITE IMPACTS FROM BNSF AOC

For all the Sitewide alternatives identified above, protection measures must be implemented between the upgradient BNSF AOC, where significant TCE impacts remain in shallow soil and Perched WBZ groundwater, due to the risk for recontamination after cleanup. Cleanup and redevelopment activities are expected to occur relatively quickly (within the next several years), but the BNSF AOC characterization and cleanup are likely years in the future. The nature and extent have not been fully defined in the BNSF AOC and an AO has not been executed between BNSF and Ecology. Therefore, the installation of protection measures is necessary.

11.2.1 PRB Wall with Zero-Valent Iron

For Alternatives A.1, A.2, and D, the installation of a PRB wall is recommended. The PRB wall would be installed on the ASKO Property boundary and extend the length of known off-property soil impacts (approximately 120 feet). The PRB wall would be a minimum of 3 feet wide, 15 feet

deep, and backfilled with gZVI aggregate to treat cVOC-impacted groundwater migrating from the BNSF AOC.

11.2.2 Interceptor Trench and PRB Wall with Zero-Valent Iron

For Alternatives B, C, and E, the installation of an interceptor trench with a smaller PRB wall is recommended. The interceptor trench would be installed following the ISS and would use the ISS monolith, which will act as a low permeability physical barrier to divert groundwater through the trench. The interceptor trench would be approximately 120 feet long, 3 feet wide, and 15 feet deep. The trench would be backfilled with drain rock in order to collect groundwater along the property boundary at the edge of the ISS monolith and convey it through a PRB wall backfilled with gZVI aggregate. The PRB wall would be approximately 15 feet long, 3 feet wide, and 15 feet deep.

11.3 SITEWIDE GROUNDWATER

MNA for groundwater is a component of each of the alternatives described above, and, therefore, post-remedy groundwater monitoring would be part of each alternative after source removal, stabilization, treatment, or destruction. Specific details for long-term groundwater monitoring will be included in a Groundwater Monitoring Plan (GMP), which would describe required post-construction monitoring and adaptive management to ensure the long-term protectiveness of the selected remedy. The draft GMP will be included as an appendix to the CAP and will be updated post-remedy as part of a Long-Term CMP (LTCMP).

11.4 INSTITUTIONAL CONTROLS

ICs are legal and administrative controls intended to restrict human activities in such a way as to prevent or reduce potential exposure to contaminants and would be included as part of any selected remedy for the Upland AOC. Specific ICs for the Site would include restrictions on land use, resource use (i.e., prohibit the use of groundwater within Site boundaries as drinking water), and a provision for maintaining pavement as a barrier to subsurface soil contamination, if warranted.

A Soil and Remedial Element Management Plan (SREMP) would be prepared as part of the ICs to outline specific source areas and depths where soil contamination that remains in place at concentrations greater than proposed CULs would limit land use. Any activities that would be proposed within these restricted areas would require compliance with the SREMP, which would outline health and safety protocols along with soil handling and management procedures. The SREMP will also provide details for routine inspection and maintenance of remedial elements (such as pavement and monitoring wells) and will be part of the LTCMP.

The Site is in a designated industrial zone of the City of Seattle. Under current zoning, residential uses of the parcels that comprise the Site would be prohibited.

12.0 Remedial Alternatives Evaluation and Disproportionate Cost Analysis

In this section, the cleanup alternatives developed for the Site are evaluated against the MTCA requirements for a cleanup remedy per WAC 173-340-360.

12.1 REMEDIAL ALTERNATIVE EVALUATION

This section provides a summary of the requirements and criteria that each remedial alternative is evaluated against in accordance with MTCA per WAC 173-340-360(2). Each of the proposed remedial alternatives are screened relative to mandatory "MTCA Threshold Requirements" and "Other MTCA Requirements" for evaluation described in Section 12.1.1. An updated DCA was conducted to identify the alternative(s) that are "permanent to the maximum extent practicable," using DCA evaluation criteria. Based on these evaluations, a Preferred Remedial Alternative is selected for recommendation to Ecology. Recommendations for the Preferred Remedial Alternative for the Site are described in Section 13.0.

12.1.1 Model Toxics Control Act Threshold Requirements

WAC 173-340-360(2) states that when multiple cleanup action components are implemented for a single site, the overall cleanup action components shall also meet the minimum requirements of WAC 173-340-360(2)(a):

- **Protect Human Health and the Environment.** Protection of human health and the environment shall be achieved through implementation of the selected remedial action.
- **Comply with Cleanup Standards.** Cleanup standards, as defined by MTCA, include CULs for hazardous substances present at the site; the location, or POC, where the CULs must be met; and any regulatory requirements that may apply to the site due to the type of action being implemented and/or the location of the site.
- **Comply with Applicable State and Federal Laws.** WAC 173-340-710 states that cleanup standards shall comply with applicable state and federal laws. Section 13.5 identifies the ARARs for the preferred alternative for this Site.
- **Provide for Compliance Monitoring.** MTCA requires that all selected cleanup alternatives provide for compliance monitoring as described in WAC 173-340-410. Compliance monitoring includes protection monitoring during remedial implementation to monitor short-term risks and confirm protection of human health and the environment during construction activities. Performance monitoring will assess short-term remedy effectiveness and confirm compliance with the CULs immediately following remedial implementation. Confirmation monitoring will evaluate long-term effectiveness of the remedial action following attainment of the cleanup standards.

Cleanup alternatives that meet the threshold requirements must also fulfill other requirements described in WAC 173-340-360(2)(b). These additional requirements include the following:

- **Use Permanent Solutions to the Maximum Extent Practicable.** The use of permanent solutions to the maximum extent practicable for a cleanup action is analyzed according to the procedure described in WAC 173-340-360(3). Preference is given to alternatives that implement permanent solutions, defined in MTCA as actions that can meet cleanup standards "without further action being required at the site being cleaned up or any other site involved with the cleanup action, other than the approved disposal of any residue from the treatment of hazardous substances" (WAC 173-340-200). Under WAC 173-340-360(2)(h), a DCA is required for a cleanup action that uses RELs.
- **Provide for a Reasonable Restoration Time Frame.** A cleanup action shall provide for a reasonable restoration time frame. The factors to be considered when determining the reasonable restoration time frame are listed in WAC 173-340-360(4)(b) and include, but are not limited to, the potential risks posed by the site, the practicability of achieving a shorter restoration time frame, and the current and expected future use of the site.
- **Consideration of Public Concerns.** Public involvement must be initiated according to the requirements set forth in WAC 173-340-600. Ecology's decision on alternative selection was presented for public comment in the draft CAP.

12.2 EVALUATION OF THRESHOLD REQUIREMENTS

All six of the proposed Sitewide remedial alternatives meet the MTCA Threshold Requirements as described below:

- **Protection of Human Health and the Environment.** The alternatives proposed provide varying degrees of protection of human health and the environment through methods of contaminated mass removal (e.g., excavation, ERD, ERH), mass stabilization (ISS), or passive treatment with a PRB wall. All of the alternatives proposed are capable of achieving the proposed CULs for protection of groundwater discharge to surface water, as measured at the CPOC.
- **Comply with Cleanup Standards.** Cleanup standards for soil are expected to be met by all alternatives through the proposed active remediation methods or by implementing engineering controls and ICs to prevent exposure. Groundwater CULs are anticipated to be met at the CPOC by all alternatives over the predicted restoration time frame.
- **Comply with Applicable State and Federal Laws.** All alternatives address and comply with all relevant and applicable state and federal laws relevant to this project, as described in Section 13.4.
- **Provide for Compliance Monitoring.** All alternatives would include compliance monitoring throughout the cleanup area per WAC 173-340-410. For any alternative

selected as the preferred remedy, a GMP would be prepared as part of the LTCMP and would include long-term groundwater monitoring to be conducted following completion of cleanup activities to evaluate compliance with proposed CULs at the CPOC.

12.3 EVALUATION OF RESTORATION TIME FRAME

Site-specific groundwater conditions may be taken into consideration under WAC 173-340-360(4)(b) when considering the definition of a reasonable restoration time frame and whether it is practicable to achieve a shorter restoration time frame. IHSs are present at concentrations in groundwater between 10 to 12,000 times the proposed CUL, and the groundwater plumes are expansive with a significant amount of dissolved-phase mass. Therefore, it is not considered practicable to achieve a restoration time frame shorter than 10 years. Because all of the alternatives include a considerable amount of source removal, stabilization, or treatment/destruction, the predicted restoration time frames for groundwater between 10 to 15 years are all reasonable. The restoration time frame for groundwater to meet proposed cleanup standards at the CPOC for the Upland AOC for each Alternative is as follows:

- Alternative A.1: 10 years
- Alternative A.2: 15 years
- Alternative B: 15 years
- Alternative C: 15 years
- Alternative D: 15 years
- Alternative E: 15 years

The restoration time frame for groundwater throughout the Shoreline AOC is predicted to be 5 years for all alternatives, which is significantly less than the predicted Sitewide restoration time frames.

12.4 DISPROPORTIONATE COST ANALYSIS

The MTCA DCA is used to evaluate whether a cleanup action uses permanent solutions to the maximum extent practicable, as determined by the level of attainment of specific criterion defined within WAC 173-340-360(3)(f). An updated DCA was completed for the Site as part of this FS. The relative benefits and costs associated with each alternative are compared using seven evaluation criteria. As stated in MTCA, the cost of an individual alternative is determined disproportionate "if the incremental costs of the alternative over that of a lower cost alternative exceed the incremental degree of benefits achieved by the alternative over that of the other lower cost alternative" (WAC 173-340-360(3)(e)(i)).

Evaluation of disproportionate cost compares each alternative against the most permanent alternative presented, as determined by attainment of MTCA criteria, which factor into the overall permanence of each alternative. This can be a qualitative or quantitative analysis, and in

the instance that multiple alternatives possess equivalent benefits, the lower-cost alternative will be selected. The seven criteria defined in MTCA (WAC 173-340-360(f)) include protectiveness, permanence, cost, effectiveness over the long-term, management of short-term risks, technical and administrative implementability, and considerations of public concerns:

- **Protectiveness.** Overall protectiveness of human health and the environment, including the degree to which existing risks are reduced, the time required to reduce these risks, and the overall improvement in environmental quality.
- **Permanence.** The degree to which the alternative permanently reduces the toxicity, mobility, or volume of hazardous substances.
- **Cost.** The cost to implement the alternative, consisting of construction, net present value of any long-term costs, and agency oversight costs that are recoverable.
- **Effectiveness over the Long-Term.** Long-term effectiveness consists of the degree of certainty that the alternative will be successful, the reliability of the alternative during the period of time hazardous substances are expected to remain on site at concentrations greater than CULs, the magnitude of the residual risk with the alternatives in place, and the effectiveness of controls in place to control risk while contaminants remain on site.
- **Management of Short-Term Risks.** Short-term risks consist of the risk to human health and the environment associated with the alternative during construction and implementation and the effectiveness of measures taken to control those risks.
- **Technical and Administrative Implementability.** The ability of the alternative to be implemented is based on whether the alternative is technically possible and meets administrative and regulatory requirements, and if all necessary services, supplies, and facilities are readily available.
- **Consideration of Public Concerns.** These considerations involve whether the community has concerns regarding the alternative and, if so, to what extent the alternative addresses those concerns.

As part of the DCA conducted for this FS, each alternative was ranked and assigned a numerical score for each DCA criterion on a scale of 1 to 10, where a score of 10 represents the highest benefit and a score of 1 represents the lowest benefit. Each numerical score was then multiplied by a weighting value, and the scores were summed to determine the total alternative benefit score. As directed by Ecology, the weighting values used in this FS are as follows:

- Protectiveness: 30%
- Permanence: 40%
- Effectiveness over the long-term: 20%
- Management of short-term risks: 5%
- Technical and administrative implementability: 2.5%
- Consideration of public concerns: 2.5%

The alternatives are evaluated relative to their ability to comply with the criteria listed above and are compared to both each other and the criteria. Because some alternatives provide a similar degree of compliance with a given criterion, the associated evaluation statements may be the same or similar. Estimated costs for each alternative are summarized in Table 12.1 and presented in detail in Appendix G. The following sections provide a brief summary of each of the DCA criteria and discuss the rationale for why each alternative was scored in relation to the other alternatives. DCA criteria aspects that were considered equal for all alternatives, and, therefore, did not influence the scoring distribution, are not discussed in the following sections. A full description of all aspects evaluated under each criterion for the alternatives is included in Table 12.2.

12.4.1 Protectiveness

Protectiveness was evaluated based on the degree to which existing risks were reduced, time required to reduce risks and attain cleanup standards, risks resulting from alternative implementation, and improvement in overall environmental quality. Alternative A.1 is considered the most protective remedy because it would remove the most soil contamination with concentrations greater than CULs from the Site, has the shortest restoration time frame for groundwater (10 years), and has the highest overall improvement in environmental quality. Alternative A.1 was scored a 10. Alternative A.2 includes the second greatest volume of soil removal and was scored a 9. Alternatives B and C were both scored an 8 for removing or stabilizing in place similar volumes of soil contamination greater than RELs or soil impacting groundwater. Alternative C leaves more soil in place to be protected by ICs than Alternative B, but includes additional in situ treatment for TCE in groundwater near CAA-5. They both have the same anticipated restoration time frames (15 years) and are considered to have equal improvement in environmental quality. Alternatives D and E are considered the least protective remedies because they leave the most contamination in place to be protected by ICs. These alternatives were scored a 5.

12.4.2 Permanence

Permanence was evaluated based on the degree of reduction of contaminant toxicity, mobility, volume, adequacy of destruction of hazardous substances, reduction or elimination of release sources, degree of irreversibility, and risk of treatment residuals. Alternative A.1 was scored the highest at a 10 because it proposes the greatest reduction in contaminant volume. Alternative A.2 was scored the second highest at an 8 because it removes most soil contamination with concentrations greater than RELs. Alternatives B and C were both scored a 7 because they each involve stabilizing a portion of contamination through ISS. ISS is considered an irreversible technology, but not as permanent as removing or destroying contamination because the stabilized material (monolith) would remain in place. Therefore, it received a lower score than excavation. Alternative D was scored a 6 because ERH would reduce contamination concentrations greater than RELs, and some contamination would remain in place. Alternative E was scored the lowest because it involved stabilizing contamination through ISS and leaves the most contamination in place to be controlled by ICs and a pavement cap.

12.4.3 Effectiveness over the Long-Term

Long-term effectiveness was evaluated based on the degree of certainty of success, reliability while contaminants remain on site, magnitude of residual risk, and effectiveness of controls to manage residual risk. Alternative A.1 was scored a 10 because it would remove the most soil contamination from the Site and, therefore, has the highest certainty of success to achieve groundwater CULs in the shortest restoration time frame. Alternative A.2 was scored an 8 because, similar to Alternative A.1 but to a lesser degree, it includes only excavation and removal of soil, which is a highly reliable technology to meet cleanup goals. Alternatives B and C were both scored a 7 because they utilize ISS to similar degrees, which has a higher residual risk for contaminants remaining solidified on site. Alternatives D and E were scored a 5 because while both alternatives utilize known technologies with a high certainty for success, they both leave a greater volume of contamination in place that is to be protected by ICs and a pavement cap.

12.4.4 Management of Short-Term Risk

Short-term risk management was evaluated based on the risk to human health and the environment created by implementing the remedy and the effectiveness of controls to manage the short-term risk. Alternatives C and E were scored the highest with an 8 because they propose the least amount of contaminated material handling from either excavating contaminated soil for offsite disposal or in situ mixing of contaminated soil with grout. Alternatives A.2 and B were scored a 7 because they require more contaminated soil handling than Alternatives C and E. Alternative D would require less contaminated material handling but would have other unique risks posed from installing and operating the ERH system. Alternative A.1 was scored the lowest with a 4 because it proposes a substantially larger amount of contaminated material handling and transporting off site than the other alternatives and, therefore, put the most risk onto the general public and the environment.

12.4.5 Technical and Administrative Implementability

Technical and administrative feasibility was evaluated based on technical possibility; availability of facilities, services, and material; administrative and regulatory requirements; project scale and complexity; monitoring requirements; access requirements; and integration with existing and future operations. Alternative A.2 was scored the highest with an 8 because it is reasonable in scale, utilizes common technologies with many local contractors capable of successfully completing the work, and does not require any additional permits or monitoring requirements compared to the other alternatives. Alternative E was scored a 7 because it is smaller in scale compared to the other alternatives, but ISS would require a contractor with experience performing ISS remediation and require quality assurance testing during construction. Alternatives B and C were both scored a 6 because they are moderate in scale compared to the other alternatives and utilize ISS. Alternative D was scored a 6 because, although the scale is smaller compared to Alternatives B and C, ERH would require a specialty contractor to complete the work and there is additional performance testing required throughout the treatment phase. Alternative A.1 was scored a 6 because although it utilizes only excavation, which is a common technology, it proposes the largest scale remediation compared to the other alternatives, would

require a significant amount of coordination, and would require complex shoring and dewatering design to complete the deep excavation.

12.4.6 Consideration of Public Concerns

Public concerns will be reviewed following the public comment period and will be addressed as part of the final remedial alternative selection and design. Most of the Site is currently vacant with a significant amount of contamination. It is anticipated that the public would have minimal concern with cleanup and redevelopment of the Site. Scoring for consideration of public concerns was provided by Ecology and is generally based on the anticipated public perception of protectiveness for each alternative. Alternative A.1 was scored an 8; Alternatives A.2, B, and C were each scored a 7; and Alternatives D and E were scored a 6.

12.4.7 Cost

Costs were estimated for each alternative and include costs for construction, long-term monitoring, operations and maintenance, permitting, and agency oversight costs. In addition, all costs include sales tax, and a 20 percent design contingency. Estimated costs for each alternative are summarized in Table 12.1 and presented in detail in Appendix G. The costs for each alternative are listed below:

- Alternative A.1: $16,151,000
- Alternative A.2: $12,244,000
- Alternative B: $8,251,000
- Alternative C: $7,821,000
- Alternative D: $7,404,000
- Alternative E: $6,727,000

12.5 IDENTIFICATION OF PREFERRED ALTERNATIVE

Based on the alternative evaluation presented in the previous sections and in Tables 12.1 and 12.2, the total benefit per unit of cost achieved[12] are Alternative A.1: 5.91, Alternative A.2: 6.72, Alternative B: 8.82, Alternative C: 9.37, Alternative D: 7.50, and Alternative E: 7.77. Alternative C is selected as the Preferred Remedial Alternative. Section 13.0 describes the Preferred Remedial Alternative in greater detail. These results indicate Alternative C as the option that is permanent to the maximum extent practicable.[13]

[12] The benefit per unit cost ratio is calculated by dividing the total weighted benefit score by the estimated alternative cost (standardized by dividing by $10 million) for that alternative.

[13] Ecology completed an independent check of the DCA using different weightings and separating the DCAs for the ASKO and Bulk Terminal Properties. No DCA was required for the East Waterfront Property because a permanent cleanup, as defined under MTCA, is being proposed for that area. Ecology's analysis also identified Alternative C as the most permanent to the maximum extent practicable.

13.0 Recommendations for the Preferred Remedial Alternative

The Preferred Remedial Alternative for the remediation of soil and groundwater, which is proposed by TOC Seattle Terminal, LLC, to Ecology for selection and implementation at the Property, is described in greater detail in the following sections. This section explains how the Preferred Remedial Alternative complies with MTCA, RAOs, and associated ARARs for the lowest cost per degree of benefit, providing the highest level of environmental benefit and permanence per dollar spent, and making it the most permanent to the maximum extent practicable remedy proposed.

13.1 DESCRIPTION OF PREFERRED REMEDIAL ALTERNATIVE

Alternative C is selected as the Preferred Remedial Alternative for the Property (refer to Figure 13.1) and includes the following:

- Excavation and offsite disposal of soil with IHS concentrations greater than RELs and soil with IHS concentrations greater than the CUL and less than the REL where there are groundwater impacts greater than 2 times the groundwater CUL using normally accepted engineering practices in CAA-1, CAA-2.b, CAA-3, and CAA-5
- LNAPL removal using normally accepted engineering practices in CAA-1.a and CAA-2
- ISS to address source area soil with IHS concentrations greater than RELs in CAA-2.a and CAA-4
- In situ treatment and ERD of the TCE groundwater plume along northern border of CAA-5, using a trademarked colloidal biomatrix and sulfidated mZVI mixture
- Installation of an interceptor trench adjacent to and upgradient of the ISS monolith in CAA-4.a and CAA-4.b and PRB wall with ZVI
- Excavation of contaminated soil with IHS concentrations greater than CULs using normally accepted engineering practices in CAA-6 and CAA-7 and offsite disposal
- Capping and ICs for the Upland AOC

The Preferred Remedial Alternative is a comprehensive final remedy for the Property that complies with all the applicable remedy selection requirements under MTCA. This alternative provides the greatest environmental benefit for the associated cost based on the DCA presented in Section 12.0 and Table 12.2.

Together, the individual technologies manage the exposure pathways to contamination at the Property. The Preferred Remedial Alternative for soil and groundwater would provide the following functions:

- Address significant public concerns by facilitating the redevelopment of a substantial brownfield site with highly desirable industrial and marine dependent uses.
- Removal of LNAPL, which is a continuing source to groundwater using normally accepted engineering practices.

- Decrease the mass of IHSs in soil (approximately 80 percent removal of soil volume containing TPH, benzene, TCE, and arsenic greater than the CULs), which will improve groundwater quality at the selected POCs within a reasonable restoration time frame.
- Address the direct contact pathway for IHSs across the entire Site, which is protective of the direct exposure pathway for human health and ecological receptors. The POC for direct contact is 15 feet bgs.
    - In the Upland AOC, there will be residual contamination at concentrations greater than the CULs left in place between 0 and 15 feet bgs. The direct contact pathway in these areas (CAA-1.b, CAA-3, and CAA-5) will be addressed by capping and enforceable ICs.
    - In the Shoreline AOC, soil with IHS concentrations greater than the proposed CULs will be removed, effectively eliminating this exposure pathway.
- Reduce the potential for vapor intrusion as part of redevelopment.
- Provide for groundwater monitoring throughout the restoration time frame to verify that source removal and treatment were effective in reducing IHS concentrations in groundwater within the predicted restoration time frame.

The Preferred Remedial Alternative will support redevelopment activities, which assume continued industrial or industrial/commercial use at the Site. As previously mentioned, the City of Seattle zoning prohibits residential use, so the Property will remain industrial for the foreseeable future. After remedy implementation, redevelopment in the Upland AOC will include the installation of buildings, pavement, and constructed landscape areas, which will cover the surface and act as a barrier to subsurface soil and is protective of the direct contact exposure pathway both for humans and ecological receptors. As such, the development will be part of the remedial action. ICs (implemented with an Environmental Covenant) would be required for the Upland AOC to maintain the integrity of the cap and would include an SREMP. Long-term post-remedy groundwater monitoring will ensure the long-term protectiveness of the remedy.

The scope of the preferred cleanup is based on the data reported in this and previous RIs. However, several data gaps remain from the RI that will be investigated as part of pre-remedial design. The data from these additional investigations could impact the scope of the preferred cleanup as follows:

- Metals, East Waterfront Property: The vertical and lateral extent of metal concentrations in excess of CULs in shallow soils has not been fully delineated. Additional data will be collected during the pre-remedial design investigation to verify the excavation extents.
- TBT, East Waterfront Property: The potential presence of this contaminant will be investigated as part of the pre-remedial design investigation to evaluate if cleanup of TBT is necessary.

The preferred cleanup for the Upland AOC relies on excavation and ISS in certain areas and natural attenuation in other areas, to reduce IHSs in groundwater to below CULs at a POC within a reasonable restoration time frame (Section 13.9). Because there is some uncertainty in predicting IHS reduction rates with these measures, contingency measures may need to be implemented if IHSs are not declining at the expected rate. The need for additional action will be predicated on groundwater monitoring results, with a decision point established 5 years after the remedial construction is complete (Section 13.3).

13.1.1 Soil Excavation with Offsite Disposal

Contaminated soil will be removed from CAA-1, CAA-2.b, CAA-3, CAA-5, CAA-6, and CAA-7, as shown on Figure 13.1, using standard excavation means and methods. Excavated soil will be transported off site to a permitted Subtitle D landfill for disposal. Excavated areas will be backfilled and restored with a gravel surface until redevelopment of the properties, which is anticipated to be completed after remediation. Removal of contaminated soil to proposed CULs or RELs is anticipated to bring groundwater into compliance with proposed CULs at the proposed CPOC within the predicted restoration time frame of 15 years and throughout the Shoreline AOC within the predicted restoration time frame of 5 years.

Specific details regarding excavation in each of the CAAs is described below. Excavation limits may differ from the depths or lateral dimensions specified below to remove soils with concentrations greater than applicable CULs or RELs as determined by compliance sampling.

- **CAA-1.a:** Soil will be excavated to 5 feet bgs to remove soil contaminated with GRO, Total DRO and ORO, and benzene at concentrations greater than the proposed RELs. LNAPL from this area will be removed using normally accepted engineering practices, as discussed in Section 13.1.2. Dewatering or shoring are not anticipated to be necessary to complete the excavation. The total estimated volume of soil from CAA-1.a is 1,300 CY.
- **CAA-1.b:** This area will be excavated to 10 feet bgs to remove deeper soil contaminated with GRO, Total DRO and ORO, and benzene at concentrations greater than the proposed RELs. Approximately 800 CY of soil will be removed from CAA-1.b. Dewatering and shoring or laying back side slopes may be necessary to complete the excavation.
- **CAA-2.b:** Soil will be excavated to remove soil contaminated with GRO, Total DRO and ORO, and benzene at concentrations greater than the proposed RELs to a depth of 15 feet bgs. LNAPL from this area will be removed using normally accepted engineering practices, as discussed in Section 13.1.2. Due to the location of the excavation in the W. Commodore Way ROW, it is anticipated that shoring will be required in the northern portion of the excavation to limit disturbance in the ROW and to protect any subsurface utilities. The water table is approximately 12 to 15 feet bgs in this area, and, therefore, limited dewatering is anticipated to be necessary to complete the excavation. Dewatering water will be treated on site and discharged to

sanitary sewer under the appropriate permit. The total estimated volume of soil to be excavated from CAA-2.b is 2,100 CY.

- **CAA-3:** 800 CY of soil will be excavated from CAA-3 to remove soil contaminated with GRO, Total DRO and ORO, and TCE at concentrations greater than the proposed RELs to a depth of 5 feet bgs. Removal of this soil will also remove most collocated benzene concentrations greater than CULs.
- **CAA-5:** A hotspot area of DRO and ORO and arsenic contamination collocated with localized groundwater DRO and ORO CUL exceedances in the Perched WBZ will be excavated to 5 feet bgs to remove source soils. Approximately 200 CY of contaminated soil will be removed from CAA-5.
- **CAA-6:** Soil will be excavated to remove the remaining GRO, Total DRO and ORO, and benzene at concentrations greater than the proposed CULs. This includes excavation to a depth of 12 feet bgs in the southern portion of CAA 6.a, excavation to 6 feet bgs in the northern portion of CAA-6.a, and excavation to 3 feet bgs in CAA-6.b. Dewatering or shoring are not expected to be necessary as part of construction. The total estimated volume of soil to be excavated from CAA-6 is 1,300 CY.
- **CAA-7:** Soil will be excavated to an anticipated maximum depth of 1 foot bgs to remove shallow arsenic soil impacts greater than proposed CUL along the shoreline. The actual extents of the shallow excavation will be determined in the field by sample collection, either prior to or concurrent with design. The total estimated volume of soil to be excavated from CAA-7 is 60 CY.

13.1.2 LNAPL Removal

An estimated 90,000 gallons of LNAPL are present in soil in CAA-1 (13,000 gallons) and CAA-2 (77,000 gallons). LNAPL will be removed in CAA-1.a and CAA-2.b using a combination of excavation and vacuum extraction. Contaminated soil and LNAPL will be excavated using standard excavation means and methods, and LNAPL removal will be facilitated by vacuum extraction of visible LNAPL during excavation using a vacuum truck. LNAPL will be transported off site to a permitted facility for disposal.

In CAA-2.a, LNAPL will be treated in situ, as described in Section 13.1.3.

13.1.3 In Situ Solidification and Stabilization

Source area soil IHS concentrations greater than RELs and LNAPL will be treated using ISS. ISS will be implemented to key into the lower permeability silt layer in treatment areas, which are anticipated to be 23 feet bgs in CAA-2.a and 30 feet bgs in CAA-4.

Construction of the ISS treatment will be performed by overlapping ISS columns and/or cells with a drill-mounted auger, excavator bucket, or excavator-mounted rotary equipment. The conceptual ISS layout as presented on Figure 13.1 presents conceptual auger mixing columns in CAA-4 and excavator mixing in CAA-2.a. Appropriate equipment will be selected as part of design

and will be based on the lithology and vertical limits for the ISS treatment. Ancillary equipment required for ISS operations may include reagent storage silos, temporary reagent batch plant, grout pumps, crane mats, generator, forklift, manlift, hydraulic sampling device, and support excavator.

Reagents will be mixed in an onsite batch plant to create a grout mixture that will be delivered via pumps to the ISS mixing area. ISS will be performed by mechanically mixing the grout with the contaminated soils (including LNAPL) in overlapping columns and/or cells to create a homogenous monolith to encapsulate and solidify contaminants. Mixing will be conducted from the surface to the bottom treatment elevation. Swell material is estimated to be approximately 30 percent of the total ISS volume and may be managed through benching of the ISS treatment areas prior to ISS implementation (i.e., excavation of surface soils to allow swell management within the treatment area) and/or use of swell as backfill or grading material during redevelopment. Management of swell material will be further assessed during the engineering design phase and in consultation with Ecology.

Immediately after installation of ISS columns/cells, discrete depth samples will be collected from the column/cell using a hydraulic sampling device. Samples will be molded and cured prior to testing for conformance with performance criteria such as UCS and hydraulic conductivity.

13.1.4 In Situ Treatment of the TCE Plume

In situ groundwater treatment will be conducted within and east of CAA-5, near the northern edge of the ASKO Property, to address the TCE plume. A proprietary reagent mixture of S-MicroZVI, Bio-Dechlor INOCULUM Plus (BDI Plus), and PlumeStop will be injected under low pressure into the subsurface using a direct push drill rig to provide even distribution within the Shallow WBZ target treatment zone, which is expected to be 20 to 30 feet bgs. The combination of these reagents will provide a long-term (estimated at greater than 10 years) barrier to facilitate cleanup of the TCE plume by creating a passive treatment zone of chemical reduction and bioremediation. The proposed PlumeStop barrier is approximately 160 feet long and 15 feet wide, as shown on Figure 13.1.

S-MicroZVI provides abiotic destruction and limits the amount of daughter products produced as part of the ERD process. BDI Plus is an enriched natural microbial consortium capable of stimulating rapid dichlorination of TCE. PlumeStop is a colloidal liquid activated carbon that creates an in situ flow-through passive treatment zone that allows sorption of dissolved-phase contaminants to the carbon, which is expected to result in a relatively rapid reduction of TCE concentrations in the groundwater plume.

13.1.5 Interceptor Trench and Permeable Reactive Barrier Wall

To mitigate upgradient offsite impacts migrating onto the ASKO Property from the BNSF AOC, a PRB wall with an interceptor trench will be installed to treat cVOCs and TPH in the Perched WBZ upgradient of the CAA-4 ISS treatment area. The low permeability of the ISS monolith and the high permeability of the interceptor trench will divert Perched WBZ groundwater to the PRB wall

(gZVI treatment zone). This PRB along the property boundary with the BNSF parcel will create a barrier between untreated groundwater on the BNSF parcel and treated areas on the ASKO Property, and will reduce the potential for recontamination.

The interceptor trench will be installed along the length of the ISS monolith in CAA-4 with a total length of approximately 120 feet. The interceptor trench will be approximately 3 feet wide and 15 feet deep. The PRB treatment zone will be installed at the downgradient end of the interceptor trench along the western edge of the ISS monolith (refer to Figure 13.1). The PRB wall will be approximately 15 feet long, 3 feet wide, and 15 feet deep and will be designed with enough residence time for COCs to be treated to a minimum 90 percent concentration reduction. The PRB wall will intercept the perched groundwater, which is located at approximately 5 to 7 feet bgs; will have a nominal treatment depth of approximately 2 to 4 feet bgs; and will terminate at 15 feet bgs, for a total effective vertical thickness of 11 to 13 feet.

Both the interceptor trench and PRB wall could be installed using typical excavation means and methods. The interceptor trench will be backfilled with drain rock to 2 feet bgs to the nominal depth of the trench and backfilled with sand from ground surface to the start of the drain rock layer. For the PRB wall, gZVI will be installed over the effective vertical thickness (i.e., from 2 to 4 feet bgs to 15 feet bgs) and backfilled with sand from ground surface to the start of the gZVI layer.

13.1.6 Capping

Isolated and intermittent detections of IHSs at concentrations greater than the proposed CULs exist in shallow vadose-zone soil outside the CAAs for which it would be difficult and not cost-effective to implement an active remedial technology. Shallow soil concentrations that are present at concentrations greater than the proposed CULs will be addressed by capping with pavement, constructed landscape areas, or buildings during redevelopment and ICs to protect human health and ecological receptors from direct contact with contaminated soil. ICs will require that the caps be maintained as barriers in perpetuity.

13.1.7 Groundwater Monitoring and Point of Compliance

MNA for groundwater is a component of the preferred alternative after source soils are addressed via excavation and ISS, and, therefore, post-remedy groundwater monitoring will be required after remedy implementation. The GMP will describe long-term post-construction groundwater monitoring and adaptive management to ensure the long-term protectiveness of the selected Sitewide remedy. Groundwater compliance will be determined based on a comparison of groundwater data to proposed CULs at the CPOC, as described in the following sections.

13.1.7.1 Proposed Conditional Point of Compliance for Groundwater

TCE is present in groundwater in the Upland AOC (on the ASKO Property) at a maximum concentration of 5,900 µg/L, which is almost 12,000 times the proposed CUL of 0.5 µg/L. In addition, benzene is present in groundwater (on the Bulk Terminal Property) at a maximum

concentration of 2,600 µg/L, which is 5,900 times the proposed CUL of 0.44 µg/L. Vinyl chloride is present at a maximum concentration of 39 µg/L, which is 200 times the proposed CUL of 0.2 µg/L. Other IHSs in groundwater (TPH, arsenic, and penta) are generally present at concentrations between 10 and 20 times the proposed CULs. It is not technically feasible to achieve these proposed groundwater CULs at the standard POC on an industrial property within a reasonable restoration time frame using all practicable methods of treatment. An evaluation of the remedial alternatives and an updated DCA are presented in Section 12.0, and the preferred alternative described in Section 13.0 is a permanent solution to the maximum extent practical and provides the most environmental benefit for the estimated cost. The restoration time frame for the preferred alternative is 15 years, assuming the use of RELs, capping, ICs, and a proposed CPOC as part of the remedy.

The proposed CPOC for groundwater is the south side of W. Commodore Way adjacent to the ASKO Property and the western portion of the Bulk Terminal Property. Along the eastern portion of the Bulk Terminal Property, the proposed CPOC shifts to the Bulk Terminal Property northern parcel boundary. Refer to Figure 13.1 for the CPOC location. The current ownership for the parcels that comprise the Upland AOC is the center line of W. Commodore Way.

Compliance at the CPOC would be measured by direct sampling of groundwater in monitoring wells that are within W. Commodore Way, as appropriate. The existing well network along W. Commodore Way is robust and well suited for compliance sampling for both the Shallow and the Intermediate WBZs, as appropriate. The actual monitoring well network will be defined in the GMP, which will be prepared as part of the LTCMP.

Given that the extent of contamination in the Shoreline AOC is limited, the preferred remedy is anticipated to achieve groundwater compliance with the proposed CULs throughout the Shoreline AOC within a reasonable restoration time frame. Compliance with the CULs in this area downgradient of the CPOC will be measured at both interior and shoreline monitoring wells, to be defined in the GMP.

13.1.8 Institutional Controls

ICs, in the form of an Environmental Covenant, will be required for the Upland AOC and will require a deed restriction that restricts future uses of the properties, consistent with industrial uses and CULs. The Site is in a designated industrial zone of the City of Seattle, which prohibits residential use of parcels. Where an environmental covenant is required, and in consultation with TOC Seattle Terminal, LLC, Ecology will prepare the Environmental Covenant consistent with WAC 173-340-440 and RCW 64.70. After approval by Ecology, TOC Seattle Terminal, LLC, will record the covenant with the office of the King County Auditor. ICs will require implementation of an Ecology-approved SREMP specifying soil management procedures for future subsurface work in areas where a cap is present. The SREMP, which will be prepared as part of the LTCMP, will define specific source areas and depths where soil contamination that remains in place at concentrations greater than proposed CULs would limit land use. Any activities that would be proposed within these restricted areas will require compliance with the SREMP, which will outline health and safety protocols along with soil handling and management procedures and

notification requirements. The SREMP will also include measures to prevent soil erosion and transport to surface water and inspection and maintenance of remedial elements such as pavement and monitoring wells. These procedures will be applicable to any future redevelopment or maintenance that involves ground-disturbing activities.

13.2 COMPLIANCE MONITORING REQUIREMENTS

Compliance monitoring to ensure the protectiveness of the preferred cleanup remedy will be implemented in accordance with WAC 173-340-410, Compliance Monitoring Requirements. Detailed monitoring elements for construction will be described in a CCMP, which will be prepared as part of remedial design. The CCMP will include a Healthy and Safety Plan, Sampling and Analysis Plan and Quality Assurance Project Plan, and Inadvertent Discovery Plan for monitoring and compliance monitoring and sample collection during remedy implementation. The CCMP will be included as an appendix to the Engineering Design Report (EDR), which will describe the approach and criteria for the engineering design of soil and groundwater cleanup actions at the Site. A post-remedy LTCMP will describe required monitoring after remedy implementation to ensure the long-term protectiveness of the remedy and will include a revised GMP, SREMP, Contingency Vapor Intrusion Plan (if needed), and an updated Healthy and Safety Plan.

The objectives of compliance monitoring as stated in WAC 173-340-410 are the following:

- **Protection Monitoring** is used to confirm that human health and the environment are adequately protected during construction of the cleanup action and post-construction monitoring. Protection monitoring requirements will be described in Site-specific Health and Safety Plan(s) that address worker activities during remedy construction and post-construction monitoring.
- **Performance Monitoring** is used to confirm that the cleanup action has attained cleanup standards and other performance standards. Performance monitoring will be conducted throughout each phase of remedy construction to document that remedial goals are being achieved.
- **Confirmation Monitoring** is used to confirm the long-term effectiveness of the cleanup action after completion of the preferred remedy. Confirmation monitoring will include long-term monitoring to document that CULs continue to be attained.

13.3 CONTINGENCY ACTIONS

Contingency actions may be required if additional risk reduction measures are needed after remedy implementation. Specific details regarding contingency actions will be outlined in the EDR, and contingency action triggers will be updated post-remedy in the LTCMP. The contingency measures are anticipated to include the following:

- Engineering controls, such as the installation of a vapor barrier or vapor mitigation system, may be necessary during redevelopment (e.g., installation of new buildings) if post-remediation vapor intrusion assessment determines that there is a potential risk for vapor intrusion.

- Focused groundwater treatment, such as the injection of edible oil for ERD or other groundwater amendments, may be warranted if post-remediation groundwater monitoring suggests that groundwater may not achieve the proposed CULs within the predicted restoration time frame. Potential contingency remedial measures will be further described in the EDR, and triggers for the contingency actions will be detailed in the post-remedy LTCMP.

13.4 COMPLIANCE WITH MTCA

The Preferred Remedial Alternative for soil and groundwater meets the minimum requirements for selection of a cleanup action under MTCA (WAC 173-340-360(2)(a)) because it is protective of human health and the environment, complies with cleanup standards, complies with applicable state and federal laws, and provides for compliance monitoring. The Preferred Remedial Alternative meets the other MTCA requirements for selection of a cleanup action, including using permanent solutions to the maximum extent practicable, providing for a reasonable restoration time frame, and consideration of public concerns. Exposure pathways will be addressed through contaminant removal and disposal in a landfill, encapsulation of subsurface contamination and reduction of contaminant leaching through ISS, capping, and MNA. ICs will be developed to manage contamination that would remain in place in the Upland AOC at concentrations greater than proposed CULs.

13.5 COMPLIANCE WITH ARARS

Compliance with ARARs is a minimum requirement for cleanup actions. ARARs are often categorized as location-specific, action-specific, or chemical-specific, as described below and summarized in Table 13.1.

- **Location-Specific ARARs** are requirements that are applicable to the specific area where the Site is located and can restrict the performance of activities, including cleanup actions, solely because they occur in specific locations.
- **Action-Specific ARARs** are requirements that are applicable to certain types of activities that occur or technologies that are used during the implementation of cleanup actions. Waste disposal regulations are an example of an action-specific ARAR.
- **Chemical-Specific ARARs** are applicable to the types of contaminants present at the Site. The cleanup of contaminated media at the Site must meet the proposed CULs developed under MTCA; these CULs are considered chemical-specific ARARs.

The Preferred Remedial Alternative complies with all applicable ARARs. Location-specific ARARs will be met through compliance with all applicable state and federal regulations based on the physical location of the Site. Action-specific ARARs will be met through implementation of construction activities in compliance with all applicable construction-related requirements such as disposal for excavated soil. Chemical-specific ARARs will be met through compliance with proposed CULs.

Implementation of the Preferred Remedial Alternative would typically trigger a suite of environmental permits; however, cleanup actions conducted under a CD with Ecology (PPCD) are exempt from the state and local ARAR procedural requirements, such as permitting and approval requirements. Cleanup actions must, however, demonstrate compliance with the substantive requirements of those ARARs (WAC 173-340-710(9)). This exemption applies to procedural permitting requirements under the Washington State Water Pollution Control Act, the Solid Waste Management Act, the Shoreline Management Act, and local laws requiring permitting such as City of Seattle regulations. Cleanup actions are not exempt from procedural requirements of federal ARARs.

13.6 COMPLIANCE WITH RAOS

The Preferred Remedial Alternative will comply with all RAOs through the combination of selected remedial technologies. Excavation and ISS in the Upland AOC to address contaminated soil with IHS concentrations greater than RELs will minimize the direct contact pathway risk, reduce the significant sources of IHSs to groundwater to improve groundwater quality, and reduce VOCs in soil and groundwater to reduce the risk of vapor intrusion. LNAPL will also be removed or stabilized through ISS and excavation on the Bulk Terminal Property. In situ groundwater treatment of the TCE plume will reduce dissolved-phase mass and improve groundwater quality. Contaminated soil with IHS concentrations greater than the proposed CULs that will remain in the Upland AOC that could pose a risk to the direct contact and vapor intrusion pathways will be controlled through ICs, a cap (pavement, constructed landscape areas, or buildings), and future vapor intrusion investigation and engineering controls, if warranted, as part of redevelopment.

Excavation on the Shoreline AOC to address contaminated soil with IHS concentrations greater than proposed CULs will eliminate the direct contact pathway to human health and ecological receptors, reduce sources of IHSs to groundwater to improve groundwater quality, and eliminate the risk of contaminated soil bank erosion to sediments pathway.

13.7 PROPERTY OWNERSHIP AND ACCESS

Cantera is a prospective purchaser and is currently in a due diligence process to evaluate environmental contamination and other feasibility issues associated with the Property prior to purchase. A precondition to closing of the purchase is for Cantera to reach agreement with Ecology on an acceptable remedial approach and PPCD. Cantera will be assigning its rights under the asset purchase agreement to TOC Seattle Terminal, LLC, at the time of closing. It is anticipated that TOC Seattle Terminal, LLC, would close the purchase in late summer 2020, in conjunction with final entry of the PPCD for the Site. Once TOC Seattle Terminal, LLC, is the owner of the Property, they would have full access to the Property as needed to implement the majority of the Preferred Remedial Alternative, subject to coordination with the City of Seattle regarding proposed construction in the ROW. The proposed excavation in the W. Commodore Way ROW (CAA-2.b) is within the legal parcel boundary for the Bulk Terminal but would require coordination with the City of Seattle regarding substantive requirements for construction-related permits for work in the ROW prior to implementation.

13.8 TYPES AND AMOUNTS OF HAZARDOUS SUBSTANCES TO REMAIN IN PLACE

The amount of hazardous substances that would remain in place following implementation of the preferred alternative includes:

- **Upland AOC:** Some soil contamination at concentrations greater than proposed CULs and RELs will remain in place in the Upland AOC following remedy implementation. Contact with residual contamination will be prevented by capping and ICs; the Upland AOC will be capped in perpetuity by buildings, constructed landscape areas, or pavement to be constructed during redevelopment. The integrity of the cap and subsurface development restrictions will be regulated by ICs and an SREMP. The SREMP will include a map that shows the location, type, and range of concentrations of contaminants that remain below the cap. The following is a conservative estimate of the contaminated soil volume (untreated) that would remain in place in the Upland AOC after implementation of the preferred alternative. This estimate does not account for the discontinuous nature of the contamination and, therefore, the total volume of contaminated soil that is estimated to remain in place below the cap is likely much less than predicted.
    - CAA-1.a: Approximately 1,500 CY of contaminated soil with IHS concentrations greater than CULs would remain in place beneath a cap. The maximum concentrations of IHSs that would remain in situ following remediation are 940 mg/kg of GRO at 2.5 feet bgs, 12,000 mg/kg of Total DRO and ORO at 2 feet bgs, and 14 mg/kg of benzene at 2 feet bgs.
    - CAA-1.b: Approximately 1,100 CY of contaminated soil with IHS concentrations greater than CULs and, to an extent, RELs would remain in place beneath a cap. The maximum concentrations of IHSs that would remain in situ following remediation are 2,800 mg/kg of GRO at 2.5 feet bgs, 2,700 mg/kg of Total DRO and ORO at 10.5 feet bgs, and 40 mg/kg of benzene at 2.5 feet bgs.
    - CAA-2: Approximately 4,700 CY of contaminated soil with IHS concentrations greater than CULs would remain in place beneath a cap. The maximum concentrations of IHSs that would remain in situ (and not encapsulated) following remediation are 4,300 mg/kg of GRO at 15 feet bgs, 11,000 mg/kg of Total DRO and ORO at 15 feet bgs, and 7.7 mg/kg of benzene at 15 feet bgs.
    - CAA-3: Approximately 1,800 CY of contaminated soil with IHS concentrations greater than CULs and, to an extent, RELs would remain in place beneath a cap. The maximum concentrations of IHSs that would remain in situ following remediation are 9,700 mg/kg of GRO at 13 feet bgs, 8,300 mg/kg of Total DRO and ORO at 2 feet bgs, 0.25 mg/kg of benzene at 13 feet bgs, and 4.4 mg/kg of TCE at 3 feet bgs.
    - CAA-4: Approximately 4,300 CY of contaminated soil with IHS concentrations greater than CULs would remain in place beneath a cap. The maximum concentrations of IHSs that would remain in situ (and not encapsulated) following remediation are 1,600 mg/kg of GRO at 7.5 feet bgs, 3,200 mg/kg of Total DRO

and ORO at 7.5 feet bgs, 0.61 mg/kg of benzene at 7.5 feet bgs, and 0.82 mg/kg of TCE at 16 feet bgs.

- CAA-5: Approximately 1,100 CY of contaminated soil with IHS concentrations greater than CULs and, to an extent, RELs would remain in place beneath a cap. The maximum concentrations of IHSs that would remain in situ following remediation are 4,700 mg/kg of GRO at 6 feet bgs, 5,300 mg/kg of Total DRO and ORO at 5 feet bgs, 5.4 mg/kg of TCE at 22.5 feet bgs, and 14 mg/kg of arsenic at 8 feet bgs.
- Outside of CAAs: Approximately 3,000 CY of contaminated soil with IHS concentrations greater than CULs would remain in place beneath a cap. The maximum concentrations of IHSs that would remain in situ following remediation are 1,500 mg/kg of GRO at 2 feet bgs (located along the north boundary of the Bulk Terminal Property east of CAA-2), 11,000 mg/kg of Total DRO and ORO at 15 and 20 feet bgs (located in W. Commodore Way ROW), 1.4 mg/kg of benzene at 20 feet bgs (located north of CAA-2 in W. Commodore Way), 0.21 mg/kg of TCE at 3 feet bgs (located west of CAA-4), and 14 mg/kg of arsenic at 8 feet bgs (located in the southeast corner of the Bulk Terminal Property).

As mentioned above, the estimates of the volume of contaminated soil to remain in place are presumed to be greater than actual conditions due to the discontinuous presence of IHSs at concentrations greater than proposed CULs in soil. It should also be noted that these contaminants have likely been present in the subsurface at the Site for at least 50 years[14] and the plumes are relatively stable considering this time frame. Additionally, the preferred alternative focuses on removal or encapsulation of the highest contaminant mass areas, and implementation of the preferred remedy will ultimately reduce overall groundwater contaminant concentrations. Based on this information, the residual contamination that would be left in place is not anticipated to result in conditions that would prohibit achievement of the proposed CULs at the CPOC within the specified restoration time frame. As previously discussed, localized groundwater impacts are expected to decline over time and are projected to meet the proposed CULs at the CPOC within a 15-year restoration time frame.

- **Shoreline AOC:** Excavation in CAA-6 and CAA-7 will be designed to remove TPH-(with benzene) and arsenic-contaminated soil to the proposed CULs. The expectation is that there will not be any hazardous substances in soil that will remain in place at concentrations greater than the CULs after remedy implementation. Localized groundwater impacts are expected to decline over time and are expected to meet the proposed CULs throughout the Shoreline AOC within a 5-year restoration time frame.

[14] Site operations began in the 1940s, and it is likely that some contamination originated in the earlier operation years, approximately 75 years ago.

13.9 RESTORATION TIME FRAME

The restoration time frame for the preferred cleanup action alternative is estimated to be 15 years, which is the estimated time for groundwater to achieve compliance with the cleanup standards at the CPOC. The anticipated restoration time frames differ by media and are as follows:

- **Upland AOC Soil:** RELs are expected to be met following completion of soil excavation, LNAPL removal, and ISS, which is expected to take approximately 4 to 6 months from the start of construction. After construction completion and redevelopment of the Upland AOC, capping will be placed to limit direct contact for human and ecological receptors with contaminated soils at concentrations greater than the CULs that will remain in place. ICs and an SREMP will be implemented to manage future exposures.
- **Shoreline AOC Soil:** Cleanup standards are expected to be met following completion of soil excavation, which is expected to take less than 1 month.
- **Upland AOC Groundwater:** CULs are expected to be met at the CPOC within 15 years from completion of the Upland AOC construction.
- **Shoreline AOC Groundwater:** CULs are expected to be met within 5 years from completion of the Shoreline AOC construction.

13.10 SUMMARY OF ESTIMATED REMEDY COSTS

Estimated costs for the recommended Preferred Remedial Alternative are presented in Appendix G (Table G.5). The costs associated with remedy implementation consist of capital construction costs, long-term monitoring costs following remedy completion, and agency oversight that will include periodic reviews of the constructed remedy. The estimated costs for remedy construction of the Preferred Remedial Alternative are as follows:

- Agency oversight, engineering design/reporting, planning, and permitting costs associated with remedy implementation are estimated to be $350,000.
- Construction capital costs that include construction and engineering oversight for soil excavation and ISS, including offsite disposal, are estimated to be approximately $5.34 million.
- Long-term groundwater monitoring costs were estimated based on semiannual monitoring for 2 years after remedy implementation, then annual monitoring thereafter for a period of 13 years, with estimated costs of $290,700.

The total project cost for the Preferred Remedial Alternative, which includes a 20 percent ($1,303,000) contingency cost, is estimated to be $7.82 million.

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Time Oil Bulk Terminal PPA

Supplemental Upland Remedial Investigation and Feasibility Study

Tables

Table 4.1
Groundwater Preliminary Cleanup Levels [1]

Chemicals of Interest	CAS No.	Protection of Drinking Water		Protection of Surface Water					Protection of Sediment	Protection of Indoor Air	Adjustment Factors		Most Stringent Risk-Based Criteria [8]	Proposed PCUL [9]
				Protection of Aquatic Life		Protection of Human Health								
		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 - Consumption of Water + Organisms CWA Section 304	WA WQS Consumption of Water + Organisms WAC 173-201A	WA Toxics Rule Consumption of Water + Organisms 40 CFR 131.45	Criteria Protective of the Lesser of SMS SCO and Human Health Criteria [4]	MTCA Method C Groundwater Criteria Protective of Volatilization to Soil Vapor then Indoor Air [5]	Natural Background [6]	Practical Quantitation Limit [7]		
Metals [10]														
Arsenic [11]	7440-38-2	5.8E-02	5.8E-01	1.9E+02	1.5E+02	1.8E-02	1.0E+01	1.8E-02	9.6E+00	na	5.0E+00	1.0E+00	5.0E+00	5.0E+00
Barium	7440-39-3	3.2E+03	2.0E+03	na	na	1.0E+03	na	na	na	na	na	1.0E+00	1.0E+03	1.0E+03
Cadmium	7440-43-9	8.0E+00	5.0E+00	1.0E+00	7.2E-01	na	na	na	1.6E-02	na	na	2.0E-01	1.6E-02	2.0E-01
Chromium [12]	7440-47-3	5.0E+01	1.0E+02	1.8E+02	7.4E+01	na	na	na	4.7E-05	na	na	1.0E+00	4.7E-05	1.0E+00
Lead	7439-92-1	1.5E+01	1.5E+01	2.5E+00	2.5E+00	na	na	na	4.3E-03	na	na	5.0E-01	4.3E-03	5.0E-01
Mercury	7439-97-6	2.0E+00	2.0E+00	1.2E-02	7.7E-01	na	na	na	1.0E-01	6.4E-01	na	1.0E-02	1.2E-02	1.2E-02
Selenium	7782-49-2	8.0E+01	5.0E+01	5.0E+00	na	1.7E+02	1.2E+02	6.0E+01	4.2E+01	na	na	1.0E+00	5.0E+00	5.0E+00
Silver	7440-22-4	8.0E+01	na	3.4E+00	3.2E+00	na	na	na	9.1E-01	na	na	2.5E-01	9.1E-01	9.1E-01
Total Petroleum Hydrocarbons														
Gasoline-range organics [13]	GRO	8.0E+02	na	na	na	na	na	na	na	na	na	1.0E+02	8.0E+02	8.0E+02
Diesel- and oil-range organics [14]	DRO	5.0E+02	na	na	na	na	na	na	na	na	na	5.0E+01	5.0E+02	5.0E+02
Volatile Organic Compounds														
Benzene	71-43-2	8.0E-01	5.0E+00	na	na	5.8E-01	4.4E-01	na	na	2.4E+01	na	3.5E-01	4.4E-01	4.4E-01
1,2-Dibromoethane	106-93-4	2.2E-02	5.0E-02	na	na	na	na	na	na	2.7E+00	na	1.0E+00	5.0E-02	1.0E+00
1,2-Dichloroethane [11]	107-06-2	4.8E-01	4.8E+00	na	na	9.9E+00	9.3E+00	8.9E+00	na	4.2E+01	na	1.0E+00	4.8E+00	4.8E+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 [11]	156-59-2	1.6E+01	1.6E+01	na	na	na	na	na	na	na	na	1.0E+00	1.6E+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
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
Methyl tert-butyl ether	1634-04-4	2.4E+01	na	na	na	na	na	na	na	6.0E+03	na	1.0E+00	2.4E+01	2.4E+01
Tetrachloroethene	127-18-4	2.1E+01	5.0E+00	na	na	1.0E+01	4.9E+00	2.4E+00	na	1.0E+02	na	1.0E+00	2.4E+00	2.4E+00
Trichloroethene [11]	79-01-6	5.4E-01	4.0E+00	na	na	6.0E-01	3.8E-01	3.0E-01	na	8.4E+00	na	5.0E-01	3.0E-01	5.0E-01
Vinyl chloride [11]	75-01-4	2.9E-02	2.9E-01	na	na	2.2E-02	2.0E-02	na	na	3.5E+00	na	2.0E-01	2.0E-02	2.0E-01
Semivolatile Organic Compounds—PAHs														
Benz(a)anthracene	56-55-3	2.3E-01	na	na	na	1.2E-03	1.4E-02	1.6E-04	1.3E-03	na	na	6.0E-02	1.6E-04	6.0E-02
Benzo(b)fluoranthene	205-99-2	2.3E-01	na	na	na	1.2E-03	1.4E-02	1.6E-04	3.9E-04	na	na	6.0E-02	1.6E-04	6.0E-02
Benzo(k)fluoranthene	207-08-9	2.3E-01	na	na	na	1.2E-02	1.4E-02	1.6E-03	3.9E-04	na	na	6.0E-02	3.9E-04	6.0E-02
Benzo(a)pyrene	50-32-8	2.3E-02	2.0E-01	na	na	1.2E-04	1.4E-03	1.6E-05	4.9E-04	na	na	6.0E-02	1.6E-05	6.0E-02
Chrysene	218-01-9	2.3E+00	na	na	na	1.2E-01	1.4E+00	1.6E-02	1.2E-03	na	na	6.0E-02	1.2E-03	6.0E-02
Dibenz(a,h)anthracene	53-70-3	2.3E-01	na	na	na	1.2E-04	1.4E-03	1.6E-05	2.6E-04	na	na	6.0E-02	1.6E-05	6.0E-02
Indeno(1,2,3-c,d)pyrene	193-39-5	2.3E-01	na	na	na	1.2E-03	1.4E-02	1.6E-04	1.4E-04	na	na	6.0E-02	1.4E-04	6.0E-02
cPAH TEQ [15]	CPAHTEQ	2.3E-02	na	na	na	1.2E-04	1.4E-03	1.5E-02	4.9E-04	na	na	6.0E-02	1.2E-04	6.0E-02

Table 4.1
Groundwater Preliminary Cleanup Levels [1]

Chemicals of Interest	CAS No.	Protection of Drinking Water		Protection of Surface Water					Protection of Sediment	Protection of Indoor Air	Adjustment Factors		Most Stringent Risk-Based Criteria [8]	Proposed PCUL [9]
				Protection of Aquatic Life		Protection of Human Health								
		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 - Consumption of Water + Organisms CWA Section 304	WA WQS Consumption of Water + Organisms WAC 173-201A	WA Toxics Rule Consumption of Water + Organisms 40 CFR 131.45	Criteria Protective of the Lesser of SMS SCO and Human Health Criteria [4]	MTCA Method C Groundwater Criteria Protective of Volatilization to Soil Vapor then Indoor Air [5]	Natural Background [6]	Practical Quantitation Limit [7]		
Semivolatile Organic Compounds—PAHs (cont.)														
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	8.7E-01	na	na	2.0E-01	2.0E-03	2.0E-01
Dioxins/Furans														
Dioxin/furan TEQ [15]	DFTEQ	6.7E-07	3.0E-05	na	na	5.0E-09	6.4E-08	1.3E-08	na	na	na	5.0E-06	5.0E-09	5.0E-06

Notes:

PCUL is based on the PQL provided by Friedman & Bruya, Inc., and Fremont Analytical, Inc.

1 Concentrations are presented in µg/L. Criteria 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 Criteria for protection of sediment via groundwater discharge are based on a modified MTCA fixed parameter three-phase partitioning model (WAC 173-340-747, equation 747-1). The lower of the sediment criteria for protection of human health direct contact (including beach play, clamming, and net fishing pathways), bioaccumulation, and benthic species was selected as the target concentration.

5 Groundwater criteria for vapor intrusion were calculated per Ecology's 2018 guidance, as updated (Appendix B of Ecology 2009).

6 The Puget Sound-wide background arsenic concentration from 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 PQL values from Friedman & Bruya, Inc., and Fremont Analytical, Inc., of Seattle, Washington.

8 The PCUL 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.

9 The PCUL for each chemical was adjusted for 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 PCUL is a promulgated surface water criterion, the applicable fraction is identified in the surface water regulation. Subsequent evaluation of groundwater data relative to the PCUL will be performed relative to the fraction regulated in surface water.

11 The MCL was not "sufficiently protective" per WAC 173-340-720 (i.e., excess cancer risk exceeds 1 in 100,000 [1 x 10^{-5}] or the hazard quotient exceeds one), and the MCL was therefore adjusted either to 10 times MTCA Method B if a cancer-based cleanup level, or equal to MTCA Method B if a non-cancer based cleanup level.

12 Where both were available, the lower of total chromium and chromium(III) cleanup levels were selected.

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

14 Due to the presence of multiple petroleum sources at the Site, diesel- and oil-range organics concentrations may be evaluated separately in the future (during cleanup or compliance monitoring) if it can be demonstrated that soil or groundwater concentrations are associated with more than one distinct petroleum sources.

15 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
CAS	Chemical Abstracts Service
CFR	Code of Federal Regulations
cPAH	Carcinogenic polycyclic aromatic hydrocarbon
CWA	Clean Water Act
Ecology	Washington State Department of Ecology
MCL	Maximum contaminant level
µg/L	Micrograms per liter
mg/L	Milligrams per liter
MTCA	Model Toxics Control Act
na	Not available
NRWQC	National Recommended Water Quality Criteria
PAH	Polycyclic aromatic hydrocarbon
PCUL	Preliminary cleanup level
PQL	Practical quantitation limit
SCO	Sediment Cleanup Objective
SMS	Sediment Management Standards
TEQ	Toxic equivalent
WA	Washington
WAC	Washington Administrative Code
WQS	Water Quality Standard

Table 4.2

Soil Preliminary Cleanup Levels [1]

Chemicals of Interest	CAS No.	Protection of Direct Contact		Protection of Groundwater Leaching			Adjustment Factors		Most Stringent Risk-Based Criteria [8]	Proposed PCUL [9]
		MTCA Method C Cleanup Levels—Direct Contact [2]	Terrestrial Ecological Indicator Soil Concentrations [3]	Protect Surface Water/Sediment via Groundwater [4]	Protect Drinking Water via Groundwater [5]	Protect Indoor Air via Groundwater [6]	Washington State Natural Background [6]	Practical Quantitation Limit [7]		
Metals										
Arsenic	7440-38-2	8.8E+01	7.0E+00	1.5E-01	1.5E-01	na	7.3E+00	1.0E+00	7.3E+00	7.3E+00
Barium	7440-39-3	7.0E+05	1.0E+02	4.1E+01	8.3E+01	na	na	1.0E+00	4.1E+01	4.1E+01
Cadmium	7440-43-9	3.5E+03	1.4E+01	1.1E-04	3.5E-02	na	7.7E-01	5.0E-01	7.7E-01	7.7E-01
Chromium [10]	7440-47-3	5.3E+06	6.7E+01	4.7E-05	1.0E+02	na	4.8E+01	1.0E+00	4.8E+01	4.8E+01
Lead	7439-92-1	1.0E+03	1.2E+02	4.3E-02	1.5E+02	na	2.4E+01	1.0E+00	2.4E+01	2.4E+01
Mercury	7439-97-6	1.1E+03	5.5E+00	6.3E-04	1.0E-01	3.3E-02	7.0E-02	5.0E-02	7.0E-02	7.0E-02
Selenium	7782-49-2	1.8E+04	3.0E-01	2.6E-02	2.6E-01	na	na	5.0E-01	2.6E-02	5.0E-01
Silver	7440-22-4	1.8E+04	2.0E+00	7.8E-03	6.9E-01	na	na	1.0E-01	7.8E-03	1.0E-01
Total Petroleum Hydrocarbons										
Gasoline-range organics [11]	GRO	3.0E+01	5.0E+03	na	3.0E+01	na	na	5.0E+00	3.0E+01	3.0E+01
Diesel-range organics	DRO	na	6.0E+03	na	na	na	na	5.0E+01	6.0E+03	6.0E+03
Diesel- and oil-range organics [12]	ORO	2.0E+03	na	na	2.0E+03	na	na	2.5E+02	2.0E+03	2.0E+03
Volatile Organic Compounds										
Benzene	71-43-2	2.4E+03	na	3.7E-04	4.2E-03	2.0E-02	na	2.0E-02	3.7E-04	2.0E-02
1,2-Dibromoethane	106-93-4	6.6E+01	na	4.4E-05	8.8E-04	2.4E-03	na	5.0E-02	4.4E-05	5.0E-02
1,2-Dichloroethane	107-06-2	1.4E+03	na	3.0E-03	3.0E-03	2.7E-02	na	2.0E-02	3.0E-03	2.0E-02
1,1-Dichloroethene	75-35-4	1.8E+05	na	6.1E-03	6.1E-03	2.5E-01	na	2.0E-02	6.1E-03	2.0E-02
cis-1,2-Dichloroethene	156-59-2	7.0E+03	na	9.7E-03	9.7E-03	na	na	2.0E-02	9.7E-03	2.0E-02
trans-1,2-Dichloroethene	156-60-5	7.0E+04	na	6.3E-02	6.3E-02	na	na	2.0E-02	6.3E-02	6.3E-02
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	9.2E-03	9.2E-03	2.3E+00	na	5.0E-02	9.2E-03	5.0E-02
Tetrachloroethene	127-18-4	2.1E+04	na	6.4E-03	1.3E-02	2.7E-01	na	2.5E-02	6.4E-03	2.5E-02
Trichloroethene	79-01-6	1.8E+03	na	3.4E-04	4.5E-03	9.5E-03	na	2.0E-02	3.4E-04	2.0E-02
Vinyl chloride	75-01-4	1.8E+02	na	9.1E-06	1.3E-04	1.6E-03	na	2.5E-02	9.1E-06	2.5E-02
Semivolatile Organic Compounds—PAHs [13]										
Benzo(a) anthracene	56-55-3	1.3E+02	na	5.1E-04	7.4E-01	na	na	1.0E-02	5.1E-04	1.0E-02
Benzo(b) fluoranthene	205-99-2	1.3E+02	na	1.8E-03	2.5E+00	na	na	1.0E-02	1.8E-03	1.0E-02
Benzo(k) fluoranthene	207-08-9	1.3E+02	na	4.3E-03	2.5E+00	na	na	1.0E-02	4.3E-03	1.0E-02
Benzo(a)pyrene	50-32-8	1.3E+02	1.2E+01	1.4E-04	1.7E+00	na	na	1.0E-02	1.4E-04	1.0E-02
Chrysene	218-01-9	1.3E+03	na	4.3E-03	8.2E+00	na	na	1.0E-02	4.3E-03	1.0E-02
Dibenz(a,h) anthracene	53-70-3	1.3E+02	na	2.6E-04	3.7E+00	na	na	1.0E-02	2.6E-04	1.0E-02
Indeno(1,2,3-c,d)pyrene	193-39-5	1.3E+02	na	4.3E-03	7.2E+00	na	na	1.0E-02	4.3E-03	1.0E-02
cPAH TEQ [14]	CPAHTEQ	1.3E+02	1.2E+01	1.0E-03	2.0E-01	na	na	1.0E-02	1.0E-03	1.0E-02
Semivolatile Organic Compounds—Other										
Pentachlorophenol	87-86-5	3.3E+02	4.5E+00	1.1E-05	5.6E-03	na	na	5.0E-02	1.1E-05	5.0E-02

Table 4.2
Soil Preliminary Cleanup Levels [1]

Chemicals of Interest	CAS No.	Protection of Direct Contact		Protection of Groundwater Leaching			Adjustment Factors		Most Stringent Risk-Based Criteria [8]	Proposed PCUL [9]
		MTCA Method C Cleanup Levels—Direct Contact [2]	Terrestrial Ecological Indicator Soil Concentrations [3]	Protect Surface Water/Sediment via Groundwater [4]	Protect Drinking Water via Groundwater [5]	Protect Indoor Air via Groundwater [6]	Washington State Natural Background [6]	Practical Quantitation Limit [7]		
Dioxins/Furans										
Chlorinated dibenzo-p-dioxins	DIOX	na	2.0E-06	na	na	na	na	na	2.0E-06	2.0E-06
Chlorinated dibenzofurans	FUR	na	2.0E-06	na	na	na	na	na	2.0E-06	2.0E-06
Dioxin/furan TEQ [14]	DFTEQ	1.7E-03	na	na	na	na	5.2E-06	5.0E-06	1.7E-03	1.7E-03

Notes:

PCUL is based on the PQL provided by Friedman & Bruya, Inc., and Fremont Analytical, Inc.

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

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

3 The criteria for the TEE are based on MTCA Table 749-3 wildlife Ecological Indicator Soil Concentrations.

4 Criteria for protection of surface water and sediment via groundwater discharge are based on the MTCA fixed parameter three-phase partitioning model (WAC 173-340-747, equation 747-1). A site-specific Kd of 0.9% has been used in the calculation. The lower of the groundwater PCULs protective of surface water/sediment was selected as the target concentration.

5 Criteria for protection of drinking water via groundwater discharge are based on the MTCA fixed parameter three-phase partitioning model (WAC 173-340-747, equation 747-1). A site-specific Kd of 0.9% has been used in the calculation. The MCL (or the MTCA Method B cleanup level if the MCL was not available) was selected as the target concentration, consistent with Ecology guidance (Ecology 2019).

6 Values from Ecology's Natural Background Soil Metals Concentrations in Washington State (Ecology 1994) are used for the 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.

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

8 The PCUL for each chemical is based on the lowest of the protection of industrial (Method C) direct contact, terrestrial receptors, and leaching ARARs protective of surface water and sediment for the appropriate soil zone, adjusted for background and the PQL in accordance with WAC 173-340-705(6), as appropriate.

9 The PCUL for each chemical was adjusted for the PQL in accordance with WAC 173-340-705(6), as appropriate.

10 Where both were available, the lower of total chromium and chromium(III) cleanup levels were selected.

11 The PCUL for protection of drinking water is the MTCA Method A cleanup level presented in WAC Table 740-1, which is calculated accrdoing to the preocedures in WAC 173-340-747. The PUCL assumes benzene is present. MTCA Method C CULs for protection of direct contact are equivalent to MTCA Method A CULs.

12 The PCUL for protection of drinking water is the MTCA Method A cleanup level presented in WAC Table 740-1, which is based on the prevention of free product accumulation on groundwater. MTCA Method C CULs for protectoin of direct contact are equivalent to MTCA Method A CULs. Due to the presence of multiple petroleum sources at the Site, diesel- and oil-range organics concentrations may be evaluated separately in the future (during cleanup or compliance monitoring) if it can be demonstrated that soil or groundwater concentrations are associated with more than one distinct petroleum sources.

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

14 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 Requirer	na	Not available
CAS	Chemical Abstracts Service	PAH	Polycyclic aromatic hydrocarbon
cPAH	Carcinogenic polycyclic aromatic hydrocarbon	PCUL	Preliminary cleanup level
Ecology	Washington State Department of Ecology	PQL	Practical quantitation limit
IRIS	Integrated Risk Information System	TEE	Terrestrial Ecological Evaluation
MCL	Maximum contaminant level	TEQ	Toxic equivalent
mg/kg	Milligrams per kilogram	WAC	Washington Administrative Code
MTCA	Model Toxics Control Act		

Table 5.1
Groundwater Elevations and Well Construction Details

Well ID	Installation Date	Top of Casing Elevation (feet NAVD 88)	Surface Elevation 2019 (feet NAVD88)	Designated WBZ at Installation	Revised WBZ 2019	Location	Screened Interval (feet below top of casing)
01MW01	09/11/1999	46.41	39.50	Shallow	Shallow	BT	10-25
01MW02	09/11/1999	44.77	33.30	Shallow	Shallow	BT-ROW	10-25
01MW03	09/11/1999	44.22	33.03	Shallow	Shallow	BT-ROW	10-25
01MW05	09/11/1999	45.28	32.03 (1)	Shallow	Shallow	BT	10-25
01MW06	11/21/2000	47.73	37.10	Shallow	Shallow	BT	10-25
01MW07	11/27/2000	45.09	22.99	Shallow	Shallow	ASKO	8-18
01MW08	11/27/2000	45.15	--	Shallow	Shallow	BT	9-25
01MW09	11/27/2000	43.87	--	Shallow	Shallow	BT-ROW	9-25
01MW10	11/27/2000	44.95	34.23 (1)	Shallow	Shallow	BT-ROW	10-25
01MW11	11/28/2000	46.04	25.09	Shallow	Shallow/Intermediate	BT-ROW	15-30
01MW12	11/21/2000	45.78	41.96	Shallow	Shallow	BT	4-19
01MW13	11/17/2000	46.35	42.50	Shallow	Shallow	BT	5-20
01MW14	07/17/2001	Decommissioned					
01MW15	07/19/2001	50.83	29.11	Shallow	Shallow	ASKO	10-30
01MW16	07/19/2001	44.86	30.37	Shallow	Shallow	BT-ROW	10-20
01MW17	07/19/2001	59.33	--	Shallow	Shallow	BT	20-30
01MW18	03/11/2002	45.09	31.56 (1)	Shallow	Shallow	BT	5-20
01MW19	03/11/2002	45.27	32.78	Shallow	Shallow	BT	5-20
01MW20	03/11/2002	46.18	33.68	Shallow	Shallow	BT	5-20
01MW21	12/02/2002	Decommissioned					
01MW22	12/02/2002	Decommissioned					
01MW23	12/02/2002	Decommissioned					
01MW24	12/03/2002	44.35	39.42	Shallow	Shallow	BT	4-19
01MW25	12/03/2002	Decommissioned					
01MW26	12/04/2002	Decommissioned					
01MW27	12/04/2002	47.18	41.59	Shallow	Shallow	BT	4-19
01MW28	12/05/2002	45.48	36.90 (1)	Shallow	Shallow	BT	5-22
01MW29	12/05/2002	45.49	36.71 (1)	Shallow	Shallow	BT	5-19
01MW30	04/21/2006	44.42	--	Shallow	Shallow	BT-ROW	15-28
01MW31	07/06/2006	43.80	--	Shallow	Shallow	BT-ROW	5-15
01MW32	07/06/2006	44.33	--	Shallow	Shallow/Intermediate	BT-ROW	17-27
01MW33	07/07/2006	44.42	36.59	Shallow	Shallow	BT-ROW	5-20
01MW34	07/07/2006	45.21	25.45	Shallow	Shallow	BT-ROW	10-20
01MW35	07/07/2006	44.55	25.44	Shallow	Shallow	BT-ROW	10-20
01MW36	07/07/2006	45.19	26.25	Shallow	Shallow	BT-ROW	10-20
01MW37	09/07/2006	48.58	40.03	Shallow	Shallow/Intermediate	BT	7.5-22.5
01MW38	09/07/2006	48.57	41.95	Shallow	Shallow/Intermediate	BT	7.5-22.5
01MW39	09/07/2006	48.79	38.49	Shallow	Shallow	BT	7-22
01MW40	09/07/2006	49.01	39.02	Shallow	Shallow	BT	7-22
01MW41	09/08/2006	Decommissioned					
01MW42	09/08/2006	47.89	40.93	Shallow	Shallow	BT	7-22
01MW43	09/08/2006	45.65	39.01 (1)	Shallow	Shallow/Intermediate	BT	7-22
01MW44	09/13/2006	49.46	27.95	Shallow	Shallow	ASKO	15-30
01MW45	09/13/2006	45.89	22.79	Shallow	Shallow	ASKO	12-27
01MW46	09/13/2006	46.68	22.28	Shallow	Shallow	ASKO	13-28
01MW47	11/29/2016	43.87	25.34	Shallow	Shallow	BT-ROW	6-21
01MW48	11/30/2016	44.72	21.72	Intermediate	Intermediate	BT-ROW	28-32
01MW49	12/21/2006	44.93	26.88	Shallow	Shallow/Intermediate	BT-ROW	15-25
01MW50	12/21/2006	43.48	21.09	Shallow	Shallow/Intermediate	BT-ROW	15-25
01MW51	12/22/2006	44.17	22.46	Intermediate	Intermediate	BT-ROW	29-39
01MW52	12/05/2007	43.5	--	Shallow	Shallow	ASKO-ROW	14-24
01MW53	12/05/2007	43.11	20.10	Shallow	Shallow	ASKO-ROW	16-26
01MW54	11/13/2008	49.25	19.70	Intermediate	Intermediate	ASKO	38-43
01MW55	11/13/2008	50.37	28.47	Shallow	Shallow	ASKO	16-31
01MW56	11/14/2008	44.50	22.63	Shallow	Shallow	ASKO	16-26
01MW57	11/14/2008	45.77	19.31	Intermediate	Intermediate	ASKO	35.5-40.5
01MW58	11/14/2008	52.00	26.20	Shallow	Shallow	ASKO	25.5-35.5
01MW59	11/17/2008	46.49	35.79	Shallow	Shallow/Intermediate	BT	13-28
01MW60	12/29/2008	58.01	29.26	Shallow	Shallow	ASKO	24.5-39.5
01MW61	12/29/2008	58.93	--	Shallow	Shallow	ASKO	22-37.5
01MW62	12/30/2008	58.54	28.48	Shallow	Shallow	ASKO	24-39
01MW63	12/30/2008	54.38	30.10	Shallow	Shallow	ASKO	19.5-31.5
01MW64	03/17/2009	57.74	27.50	Shallow	Shallow	ASKO	25-40
01MW65	03/18/2009	50.42	14.92	Deep	Deep	ASKO	52-62
01MW66	08/03/2009	47.33	39.23	Shallow	Shallow	BT	12-22
01MW67	07/23/2009	44.4	37.39	Shallow	Shallow	BT	9-24
01MW68	07/23/2009	45.35	35.28 (1)	Shallow	Shallow	BT	6.5-22
01MW69	07/24/2009	44.14	35.14	Shallow	Shallow	BT	9-24
01MW70	02/11/2010	58.14	50.91	Perched	Perched	ASKO	5-20
01MW71	02/11/2010	58.38	51.08	Perched	Perched	ASKO	5-20
01MW72	03/10/2010	46.33	42.34 (1)	Shallow	Shallow	BT	3-12
01MW73	03/10/2010	46.25	42.22 (1)	Shallow	Shallow	BT	2.5-21
01MW74	03/10/2010	46.17	44.74	Shallow	Shallow	BT	4-21.5
01MW75	03/10/2010	46.30	42.12	Shallow	Shallow	BT	3-18
01MW76	02/28/2011	45.79	19.87	Intermediate	Intermediate	ASKO	35-40
01MW77	03/01/2011	50.30	20.85	Intermediate	Intermediate	ASKO	36-41
01MW78	03/02/2011	58.17	20.89	Intermediate	Intermediate	ASKO	45-50
01MW79	03/03/2011	54.36	45.64	Perched	Perched	ASKO	4-19

Table 5.1
Groundwater Elevations and Well Construction Details

Well ID	Installation Date	Top of Casing Elevation (feet NAVD 88)	Surface Elevation 2019 (feet NAVD88)	Designated WBZ at Installation	Revised WBZ 2019	Location	Screened Interval (feet below top of casing)
01MW80	04/18/2011	44.83	21.27	Shallow	Shallow	ASKO	20-28
01MW81	04/18/2011	45.86	--	Shallow	Shallow	ASKO	19.5-28.5
01MW82	04/18/2011	45.68	--	Shallow	Shallow	ASKO	19-27
01MW83	04/19/2011	42.67	--	Shallow	Shallow	EW	14-24
01MW84	04/19/2011	43.62	25.72	Shallow	Shallow	BT-ROW	17-23
01MW85	04/20/2011	44.05	20.65	Shallow	Shallow	ASKO-ROW	18-27
01MW86	04/20/2011	44.8	26.93	Shallow	Shallow	BT-ROW	14-24
01MW87	04/20/2011	45.27	29.45	Shallow	Shallow	BT-ROW	11-21
01MW88	04/21/2011	45.10	25.96	Shallow	Shallow	BT-ROW	11-21
01MW89	04/21/2011	43.26	19.96	Shallow	Shallow	ASKO-ROW	18-26
01MW90	12/29/2011	46.66	42.81	Shallow	Shallow	BT	3-18
01MW91	12/29/2011	46.52	--	Shallow	Shallow	BT	3-18
01MW92	08/16/2012	58.47	50.17	Perched	Perched	BNSF	6-16
01MW93	08/16/2012	58.92	28.98	Shallow	Shallow	BNSF	23.5-38.5
01MW94	08/17/2012	58.50	27.95	Shallow	Shallow	BNSF	28-40
01MW95	08/17/2012	59.29	29.81	Shallow	Shallow	BNSF	27-37
01MW96	05/07/2013	59.51	48.71	Perched	Perched	BNSF	5-15
01MW97	05/07/2013	58.73	50.48	Perched	Perched	BNSF	5-15
01MW98	05/07/2013	57.73	50.80	Perched	Perched	BNSF	5-15
01MW99	03/25/2015	66.01	41.81	Shallow	Shallow	BT	20-30
01MW100	03/25/2015	63.68	41.67	Shallow	Shallow	BT	20-30
01MW101	04/23/2019	44.57	25.77	Shallow	Shallow	BT-ROW	17-21
01MW102	04/23/2019	44.44	25.69	Shallow	Shallow	BT-ROW	10-20
01MW103	04/22/2019	45.79	dry	Shallow	Shallow	BT-ROW	7-17
01MW104	04/24/2019	44.12	19.87	Intermediate	Intermediate	BT-ROW	28-33
01MW105	04/22/2019	46.17	33.36	Shallow	Shallow	BT	5-15
01MW106	04/24/2019	43.68	20.68	Shallow	Shallow	ASKO-ROW	15-25
01MW107	04/24/2019	39.69	16.18	Shallow	Shallow	ASKO-ROW	17-27
01MW108	04/22/2019	44.94	19.95	Intermediate	Intermediate	ASKO	30-35
01MW109	07/18/2019	52.22	dry	Shallow	Shallow	BT-ROW	8-18
01MW110	07/18/2019	46.84	--	Shallow	Shallow	BT	11-21
01MW111	07/18/2019	46.78	--	Intermediate	Intermediate	BT-ROW	30-35
02MW01	09/13/1999	24.07	--	Shallow	Shallow	EW	10-20
02MW02	09/13/1999	Decommissioned					
02MW03	09/13/1999	27.78	18.99	Shallow	Shallow	EW	10-20
02MW04	09/13/1999	27.07	18.87	Shallow	Shallow	EW	10-20
02MW05	09/13/1999	36.45	24.03	Intermediate	Intermediate	EW	20-35
02MW06	11/21/2000	26.55	19.08	Shallow	Shallow	EW	9-19
02MW07	11/22/2000	20.78	18.83	Shallow	Shallow	EW	1.5-11.5
02MW08	04/21/2006	39.62	25.19	Shallow	Shallow	EW	13-22
02MW09	10/11/2007	Damaged					
02MW10	10/11/2007	28.62	--	Shallow	Shallow	EW	2.5-7.5
02MW11	10/11/2007	Decommissioned					
02MW12	10/12/2007	Decommissioned					
02MW13	12/05/2007	30.05	--	Shallow	Shallow	EW	5-15
02MW14	11/17/2008	30.97	--	Shallow	Shallow	WW	5-15
02MW15	04/23/2015	27.2	24.66	Shallow	Shallow	EW	5-15
02MW16	04/23/2015	27.14	18.96	Shallow	Shallow	EW	5-15
02MW17	04/29/2019	20.73	18.76	Shallow	Shallow	EW	1-11
02MW18	04/26/2019	23.98	18.98	Shallow	Shallow	EW	4-14
02MW19	04/26/2019	21.63	19.07	Shallow	Shallow	EW	3-13
02MW20	04/25/2019	20.07	18.78	Shallow	Shallow	EW	1-11
02MW21	04/26/2019	20.96	17.36	Intermediate	Intermediate	EW	18-28
02MW22	04/26/2019	19.48	17.89	Intermediate	Intermediate	EW	17-27
MW01	04/17/2006	46.44	23.89	Shallow	Shallow	ASKO	18-28
MW02	04/17/2006	46.73	22.27	Shallow	Shallow	ASKO	18-28
MW03	04/18/2006	46.20	36.77	Perched	Perched	ASKO	7-13.5
MW04	04/18/2006	46.27	24.62	Shallow	Shallow	ASKO	18-28
MW05	04/19/2006	45.82	25.92	Shallow	Shallow	ASKO	19-29
MW06	04/19/2006	45.76	23.24	Shallow	Shallow	ASKO	18-28

Notes:

1 Elevation corrected for presence of LNAPL floating on groundwater.

-- Not measured.

Abbreviations:

ASKO ASKO Hydraulic Property
BNSF BNSF parcel
BT Bulk Terminal Property
EW East Waterfront Property
NAVD 88 North American Vertical Datum of 1988
ROW Right of way
WBZ Water-bearing zone

Table 5.2
Vertical Gradients in Groundwater

Well ID	Water-Bearing Zone	Location	Date	Depth to Water (feet)	Screen Top	Screen Bottom	Vertical Gradient
01MW79	Perched	ASKO	5/2/19	8.72	4	19	-1.11
01MW63	Shallow	ASKO	5/2/19	24.28	19.5	31.5	
01MW71	Perched	ASKO	5/2/19	7.3	5	20	-1.19
01MW62	Shallow	ASKO	5/2/19	30.06	24	39	
01MW97	Perched	BNSF	5/14/19	8.25	5	15	-1.02
01MW93	Shallow	BNSF	5/14/19	29.94	23.5	38.5	
01MW98	Perched	BNSF	5/14/19	6.93	5	15	-0.95
01MW94	Shallow	BNSF	5/14/19	30.55	28	40	
MW03	Perched	ASKO	5/3/19	9.43	7	13.5	-0.95
MW04	Shallow	ASKO	5/3/19	21.65	18	28	
01MW86	Shallow	ROW	5/1/19	17.87	14	24	-0.47
01MW48	Intermediate	ROW	7/18/19	23	28	32	
01MW102	Shallow	ROW	5/6/19	18.75	10	20	-0.55
01MW104	Intermediate	ROW	5/3/19	26.89	28	33	
01MW62	Shallow	ASKO	5/2/19	30.06	24	39	-0.49
01MW78	Intermediate	ASKO	5/2/19	37.5	45	50	
01MW55	Shallow	ASKO	5/2/19	21.9	16	31	-0.51
01MW77	Intermediate	ASKO	7/18/19	24.95	36	41	
01MW44	Shallow	ASKO	5/2/19	21.51	15	30	-0.46
01MW54	Intermediate	ASKO	7/18/19	29.55	38	43	
01MW45	Shallow	ASKO	5/2/19	23.1	12	27	-0.17
01MW76	Intermediate	ASKO	5/3/19	26	35	40	
02MW08	Shallow	EW	5/3/19	14.43	13	22	-0.07
02MW05	Intermediate	EW	5/3/19	11.95	20	35	
02MW17	Shallow	EW	4/29/19	18.76	1	11	-0.04
02MW21	Intermediate	EW	7/18/19	17.36	18	28	
02MW20	Shallow	EW	4.25.2019	18.78	1	11	-0.04
02MW22	Intermediate	EW	7/18/19	17.89	17	27	

Abbreviations:

ASKO ASKO Hydraulic Property
BNSF BNSF parcel
EW East Waterfront Property
ROW Right of way

Table 5.3
RI Analytical Results: Metals in Groundwater

				Location	02MW07		02MW17	02MW18		02MW19		02MW20		MW03
				Parcel	East Waterfront- Shoreline		East Waterfront- Shoreline	East Waterfront- Shoreline		East Waterfront- Shoreline		East Waterfront- Shoreline		ASKO
				Water-Bearing Zone	Shallow		Shallow	Shallow		Shallow		Shallow		Perched
				Sample ID	02MW07-050319	02MW07-072519	02MW17-050619	02MW18-050619	02MW18-072519	02MW19-050619	02MW19-072519	02MW20-050619	02MW20-072519	MW03-050319
				Sample Date	05/03/2019	07/25/2019	05/06/2019	05/06/2019	07/25/2019	05/06/2019	07/25/2019	05/06/2019	07/25/2019	05/03/2019
Chemical of Interest	**CAS No.**	**Units**	**PCUL**											
Arsenic (total)	7440-38-2	µg/L	5		4.2	3.9	1.8	3.6	1.9	**23**	**14**	**6.7**	**12**	**66**
Arsenic (dissolved)	7440-38-2	µg/L	5		--	3.7	--	--	1.9	--	**14**	--	**12**	--
Barium (total)	7440-39-3	µg/L	1,000		22	35	27	37	29	71	60	17	20	--
Barium (dissolved)	7440-39-3	µg/L	1,000		--	34	--	--	28	--	62	--	21	--
Cadmium (total)	7440-43-9	µg/L	0.20		0.20 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	--
Cadmium (dissolved)	7440-43-9	µg/L	0.20		--	0.2 U	--	--	0.2 U	--	0.2 U	--	0.2 U	--
Chromium (total)	7440-47-3	µg/L	1		**2.1**	1.00 U	1 U	**1.4**	1 U	**2.4**	1 U	1 U	1 U	--
Chromium (dissolved)	7440-47-3	µg/L	1		--	1.00 U	--	--	1 U	--	1 U	--	1 U	--
Lead (total)	7439-92-1	µg/L	0.50		**6.0**	0.50 U	0.5 U	0.5 U	0.5 U	**3.1**	0.5 U	0.5 U	0.5 U	--
Lead (dissolved)	7439-92-1	µg/L	0.50		--	0.50 U	--	--	0.5 U	--	0.5 U	--	0.5 U	--
Mercury (total)	7439-97-6	µg/L	0.012		***0.10 U***	***0.10 U***	***0.10 U***	***0.10 U***	***0.10 U***	***0.10 U***	***0.10 U***	***0.10 U***	***0.10 U***	--
Mercury (dissolved)	7439-97-6	µg/L	0.012		--	***0.10 U***	--	--	***0.10 U***	--	***0.10 U***	--	***0.10 U***	--
Selenium (total)	7782-49-2	µg/L	5		1.0 U	1.0 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	--
Selenium (dissolved)	7782-49-2	µg/L	5		--	1.0 U	--	--	1 U	--	1 U	--	1 U	--
Silver (total)	7440-22-4	µg/L	0.91		0.25 U	0.10 UJ	0.25 U	0.25 U	0.1 UJ	0.25 U	0.1 UJ	0.25 U	0.1 UJ	--
Silver (dissolved)	7440-22-4	µg/L	0.91		--	0.10 UJ	--	--	0.1 UJ	--	0.1 UJ	--	0.1 UJ	--

Notes:

-- Not analyzed.

Italics Reporting limit exceeds criteria.

RED/BOLD Detected exceedance of PCUL.

Abbreviations:

CAS Chemical Abstracts Service

µg/L Micrograms per liter

PCUL Preliminary cleanup level

RI Remedial Investigation

Qualifiers:

U Analyte was not detected at the given reporting limit.

UJ Analyte was not detected at the given reporting limit, which is considered to be an estimate.

Table 5.4
RI Analytical Results: TPH and BTEX in Groundwater

			Chemical of Interest	Gasoline-Range Organics	Diesel-Range Organics	Oil-Range Organics	Total DRO & ORO	Benzene	Ethylbenzene	Toluene	Xylene (total)
			CAS No.	GRO	DRO	ORO	DRO+ORO	71-43-2	100-41-4	108-88-3	1330-20-7
			PCUL	800	NA	NA	500	0.44	NA	NA	NA
			Units	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
Parcel	**Water-Bearing Zone**	**Location**	**Sample ID**	**Sample Date**							
Bulk Terminal	Shallow	01MW01	01MW01-043019	04/30/2019	100 U	50 U	250 U	250 U	0.35 UJ	1 U	1 U	3 U
Bulk Terminal-W. Commodore Way	Shallow	01MW02	01MW02-050119	05/01/2019	**900**	740 (1)	250 U	**740**	**220**	5.1	2.8	5.6
Bulk Terminal-W. Commodore Way	Shallow	01MW03	01MW03-050119	05/01/2019	**2,000**	440 (1)	250 U	440	**570**	1.3	6.2	6.3
Bulk Terminal	Shallow	01MW03	01MW03-050119-D	05/01/2019	**1,900**	440 (1)	250 U	440	**610**	1	5.3	5
Bulk Terminal	Shallow	01MW06	01MW06-043019	04/30/2019	100 U	490 (1)	250 U	490	**0.53**	1 U	1 U	3 U
Bulk Terminal	Shallow	01MW12	01MW12-043019	04/30/2019	100 U	590 (1)	250 U	**590**	**3**	1 U	1 U	3 U
Bulk Terminal	Shallow	01MW13	01MW13-050119	05/01/2019	100 U	1,500 (1)	650 (1)	**2,200**	0.35 UJ	1 U	1 U	3 U
Bulk Terminal	Shallow	01MW19	01MW19-043019	04/30/2019	**10,000**	1,900 (1)	250 U	**1,900**	**2,600**	570	66	510
Bulk Terminal	Shallow	01MW24	01MW24-043019	04/30/2019	**6,100**	8,700 (1)	690 (1)	**9,400**	**1,200**	64	12	46
Bulk Terminal	Shallow	01MW27	01MW27-043019	04/30/2019	100 U	110 (1)	250 U	110	**2.6**	1 U	1 U	3 U
Bulk Terminal-W. Commodore Way	Shallow	01MW34	01MW34-050119	05/01/2019	--	110 (1)	250 U	110	--	--	--	--
Bulk Terminal-W. Commodore Way	Shallow	01MW35	01MW35-050119	05/01/2019	100 U	550 (1)	250 U	**550**	0.35 UJ	1 U	1 U	3 U
Bulk Terminal-W. Commodore Way	Shallow	01MW36	01MW36-050119	05/01/2019	--	190 (1)	250 U	190	--	--	--	--
Bulk Terminal	Shallow	01MW39	01MW39-043019	04/30/2019	--	1,400 (1)	300 U	**1,400**	--	--	--	--
Bulk Terminal	Shallow	01MW40	01MW40-043019	04/30/2019	--	1,100 (1)	250 U	**1,100**	0.35 UJ	1 U	1 U	3 U
Bulk Terminal	Shallow	01MW42	01MW42-043019	04/30/2019	--	960 (1)	410 (1)	**1,400**	--	--	--	--
Bulk Terminal	Shallow	01MW42	01MW42-043019-D	04/30/2019	--	920 (1)	390 (1)	**1,300**	--	--	--	--
Bulk Terminal-W. Commodore Way	Shallow	01MW47	01MW47-050119	05/01/2019	--	--	--	--	**800**	28	5.3	9.1
Bulk Terminal-W. Commodore Way	Shallow	01MW49	01MW49-050119	05/01/2019	100 U	850 (1)	250 U	**850**	0.35 UJ	1 U	1 U	3 U
Bulk Terminal-W. Commodore Way	Shallow	01MW50	01MW50-050119	05/01/2019	--	390 (1)	250 U	390	--	--	--	--
Bulk Terminal	Shallow & Intermediate	01MW59	01MW59-043019	04/30/2019	--	860 (1)	250 U	**860**	--	--	--	--
Bulk Terminal	Shallow	01MW66	01MW66-043019	04/30/2019	100 U	250 (1)	250 U	250	0.35 UJ	1 U	1 U	3 U
Bulk Terminal	Shallow	01MW67	01MW67-043019	04/30/2019	--	190 (1)	250 U	190	--	--	--	--
Bulk Terminal	Shallow	01MW69	01MW69-043019	04/30/2019	--	--	--		**0.74**	9.5	1 U	13
Bulk Terminal	Shallow	01MW74	01MW74-043019	04/30/2019	100 U	50 U	250 U	250 U	0.35 UJ	1 U	1 U	3 U
Bulk Terminal	Shallow	01MW75	01MW75-050119	05/01/2019	--	740 (1)	250 U	**740**	0.35 UJ	1 U	1 U	3 U
Bulk Terminal-W. Commodore Way	Shallow	01MW84	01MW84-050119	05/01/2019	**8,400**	2,800 (1)	250 U	**2,800**	***5 U***	390	7.5	250
Bulk Terminal-W. Commodore Way	Shallow	01MW86	01MW86-050119	05/01/2019	**6,500**	3,700 (1)	420 (1)	**4,100**	**1,200**	130	19	580
Bulk Terminal-W. Commodore Way	Shallow	01MW87	01MW87-050119	05/01/2019	--	110 (1)	300 U	110	--	--	--	--
Bulk Terminal	Shallow	01MW88	01MW88-050119	05/01/2019	--	140 (1)	500 U	140	--	--	--	--
Bulk Terminal	Shallow	01MW88	01MW88-050319	05/03/2019	--	56 (1)	250 U	56	--	--	--	--
Bulk Terminal	Shallow	01MW90	01MW90-050119	05/01/2019	--	--	--	--	0.35 U	1 U	1 U	2 U
Bulk Terminal	Shallow	01MW99	01MW99-050119	05/01/2019	--	570 (1)	250 U	**570**	--	--	--	--
Bulk Terminal	Shallow	01MW100	01MW100-050119	05/01/2019	--	50 U	250 U	250 U	--	--	--	--
Bulk Terminal-W. Commodore Way	Shallow	01MW101	01MW101-050619	05/06/2019	100 U	410 (1)	250 U	410	--	--	--	--
Bulk Terminal-W. Commodore Way	Shallow	01MW102	01MW102-050619	05/06/2019	100 U	70 U	350 U	350 U	--	--	--	--
Bulk Terminal	Shallow	01MW105	01MW105-050619	05/06/2019	140	9,400 (1)	1,900 (1)	**11,000**	0.35 UJ	1 U	1 U	4.8
Bulk Terminal	Shallow	01MW105	01MW105-050619-D	05/06/2019	130	6,700 (1)	1,500 (1)	**8,200**	0.35 UJ	1 U	1 U	3.9
Bulk Terminal	Shallow	01MW105	01MW105-072519	7/25/19	100 U	120 (1)(2)	250 U	120	0.35 UJ	1 U	1 U	1 U
Bulk Terminal	Shallow	01MW105	01MW105-082919	8/29/19	--	100 (2)	250 U(2)	100				
Bulk Terminal	Shallow	01MW110	01MW110-072519	7/25/19	100 U	50 (1)(2)	250 U	50	0.35 UJ	1 U	1 U	1 U
Bulk Terminal	Shallow	01MW110	01MW110-082919	8/29/19	--	50 U(2)	250 U(2)	250 U				
Bulk Terminal-W. Commodore Way	Shallow & Intermediate	01MW11	01MW11-050119	05/01/2019	--	360 (1)	250 U	360	--	--	--	--
Bulk Terminal	Shallow & Intermediate	01MW37	01MW37-043019	04/30/2019	--	600 J (1)	250 U	**600**	--	--	--	--
Bulk Terminal	Shallow & Intermediate	01MW38	01MW38-043019	04/30/2019	--	930 (1)	300 U	**930**	**0.62**	3.3	1 U	3 U

Table 5.4
RI Analytical Results: TPH and BTEX in Groundwater

			Chemical of Interest	Gasoline-Range Organics	Diesel-Range Organics	Oil-Range Organics	Total DRO & ORO	Benzene	Ethylbenzene	Toluene	Xylene (total)
			CAS No.	GRO	DRO	ORO	DRO+ORO	71-43-2	100-41-4	108-88-3	1330-20-7
			PCUL	800	NA	NA	500	0.44	NA	NA	NA
			Units	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
Parcel	**Water-Bearing Zone**	**Location**	**Sample ID**	**Sample Date**							
Bulk Terminal-W. Commodore Way	Intermediate	01MW48	01MW48-050119	05/01/2019	100 U	660 (1)	250 U	**660**	0.35 UJ	1 U	1 U	3 U
Bulk Terminal-W. Commodore Way	Intermediate	01MW104	01MW104-050319	05/03/2019	100 U	120	250 U	120	0.35 UJ	1 U	1 U	3 U
Bulk Terminal-W. Commodore Way	Intermediate	01MW111	01MW111-072519	7/25/19	100 U	380 (1)(2)	1,500	**1,900**	0.35 UJ	1 U	1 U	1 U
Bulk Terminal-W. Commodore Way	Intermediate	01MW111	01MW111-082919	8/29/19	--	50 U(2)	250 U(2)	250 U				
Bulk Terminal-W. Commodore Way	Intermediate	01MW111	01MW111-082919-D	8/29/19	--	50 U(2)	250 U(2)	250 U				
ASKO	Perched	01MW70	01MW70-050219	05/02/2019	160	1,100 (1)	850 (1)	**2,000**	--	--	--	--
ASKO	Perched	01MW71	01MW71-050219	05/02/2019	--	--	--	--	0.35 U	1 U	1 U	2 U
ASKO	Perched	01MW79	01MW79-050219	05/02/2019	100 U	1,100 (1)	650 (1)	**1,800**	--	--	--	--
ASKO- BNSF	Perched	01MW92	01MW92-051419	05/14/2019	**1,500**	4,600	1,300 (1)	**5,900**	***70 U***	200 U	200 U	400 U
ASKO- BNSF	Perched	01MW96	01MW96-051419	05/14/2019	--	2,100	450 (1)	**2,600**	**1.3**	1 U	1 U	2 U
ASKO- BNSF	Perched	01MW97	01MW97-051419	05/14/2019	--	65 J	250 UJ	65 J	--	--	--	--
ASKO- BNSF	Perched	01MW98	01MW98-051419	05/14/2019	370	3,600	1,300 (1)	**4,900**	--	--	--	--
ASKO	Perched	MW03	MW03-050319	05/03/2019	--	--	--	--	**2.1**	1 U	1 U	2 U
ASKO	Shallow	01MW07	01MW07-050219	05/02/2019	--	820 (1)	250 U	**820**	0.35 U	1 U	1 U	2 U
ASKO	Shallow	01MW15	01MW15-050219	05/02/2019	100 U	220 (1)	250 U	220	0.41	1 U	1 U	2 U
ASKO	Shallow	01MW44	01MW44-050219	05/02/2019	470	290 (1)	250 U	290	**13**	1 U	1 U	2 U
ASKO	Shallow	01MW45	01MW45-050219	05/02/2019	170	850 (1)	250 U	**850**	**1.6**	1 U	1 U	2 U
ASKO	Shallow	01MW46	01MW46-050219	05/02/2019	--	280 (1)	250 U	280	**14**	1 U	1 U	2 U
ASKO-W. Commodore Way	Shallow	01MW53	01MW53-050219	05/02/2019	--	94 (1)	250 U	94	0.35 U	1 U	1 U	2 U
ASKO	Shallow	01MW55	01MW55-050219	05/02/2019	**940**	540 (1)	380 (1)	**920**	**1.3**	1 U	1 U	2 U
ASKO	Shallow	01MW56	01MW56-050219	05/02/2019	--	1,000 (1)	250 U	**1,000**	0.35 U	1 U	1 U	2 U
ASKO	Shallow	01MW56	01MW56-050219-D	05/02/2019	--	920 (1)	250 U	**920**	0.35 U	1 U	1 U	2 U
ASKO	Shallow	01MW58	01MW58-050219	05/02/2019	--	100 (1)	250 U	100	--	--	--	--
ASKO	Shallow	01MW60	01MW60-050219	05/02/2019	--	50 U	250 U	250 U	--	--	--	--
ASKO	Shallow	01MW62	01MW62-050219	05/02/2019	460	100 (1)	250 U	100	0.35	1 U	1 U	2 U
ASKO	Shallow	01MW63	01MW63-050219	05/02/2019	**2,100**	830 (1)	340 (1)	**1,200**	**4.3**	1 U	1 U	2 U
ASKO	Shallow	01MW64	01MW64-050219	05/02/2019	--	100 (1)	250 U	100	--	--	--	--
ASKO	Shallow	01MW80	01MW80-050219	05/02/2019	--	380 (1)	250 U	380	**16**	1 U	1 U	2 U
ASKO-W. Commodore Way	Shallow	01MW85	01MW85-050319	05/03/2019	--	450 (1)	250 U	450	--	--	--	--
ASKO-W. Commodore Way	Shallow	01MW89	01MW89-050219	05/02/2019	--	200 (1)	250 U	200	--	--	--	--
ASKO- BNSF	Shallow	01MW93	01MW93-051419	05/14/2019	100 U	54	250 U	54	--	--	--	--
ASKO- BNSF	Shallow	01MW94	01MW94-051419	05/14/2019	--	50 U	250 U	250 U	--	--	--	--
ASKO	Shallow	MW04	MW04-050319	05/03/2019	--	--	--	--	**1.1**	1 U	1 U	2 U
ASKO	Shallow	MW05	MW05-050319	05/03/2019	140	310 (1)	250 U	310	**1**	1 U	1 U	2 U
ASKO	Shallow	MW06	MW06-050319	05/03/2019	--	370 (1)	260 U	370	**2.6**	1 U	1 U	2 U
ASKO	Intermediate	01MW76	01MW76-050319	05/03/2019	--	150 (1)	250 U	150	--	--	--	--
East Waterfront	Shallow	02MW03	02MW03-050319	05/03/2019	100 U	240 (1)	250 U	240	0.35 UJ	1 U	1 U	3 U
East Waterfront	Shallow	02MW04	02MW04-050319	05/03/2019	**8,500 (3)**	--	--		**3.7**	44	1 U	11
East Waterfront	Shallow	02MW06	02MW06-050319	05/03/2019	--	110 (1)	250 U	110	--	--	--	--
East Waterfront	Shallow	02MW08	02MW08-050319	05/03/2019	--	110 (1)	300 U	110	--	--	--	--
East Waterfront	Shallow	02MW16	02MW16-050319	05/03/2019	--	200 (1)	250 U	200	--	--	--	--

Table 5.4
RI Analytical Results: TPH and BTEX in Groundwater

			Chemical of Interest	Gasoline-Range Organics	Diesel-Range Organics	Oil-Range Organics	Total DRO & ORO	Benzene	Ethylbenzene	Toluene	Xylene (total)
			CAS No.	GRO	DRO	ORO	DRO+ORO	71-43-2	100-41-4	108-88-3	1330-20-7
			PCUL	800	NA	NA	500	0.44	NA	NA	NA
			Units	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
Parcel	**Water-Bearing Zone**	**Location**	**Sample ID**	**Sample Date**							
East Waterfront-Shoreline	Shallow	02MW07	02MW07-050319	05/03/2019	--	220 (1)	450 (1)	**670**	--	--	--	--
East Waterfront-Shoreline	Shallow	02MW17	02MW17-050619	05/06/2019	100 U	220 (1)	250 U	220	0.35 UJ	1 U	1 U	3 U
East Waterfront-Shoreline	Shallow	02MW18	02MW18-050619	05/06/2019	100 U	190 (1)	250 U	190	--	--	--	--
East Waterfront-Shoreline	Shallow	02MW19	02MW19-050619	05/06/2019	100 U	380 (1)	300 U	380	--	--	--	--
East Waterfront-Shoreline	Shallow	02MW20	02MW20-050619	05/06/2019	100 U	210 (1)	250 U	210	0.35 UJ	1 U	1 U	3 U
East Waterfront	Intermediate	02MW05	02MW05-050319	05/03/2019	100 U	86 (1)	250 U	86	0.35 UJ	1 U	1 U	3 U
East Waterfront-Shoreline	Intermediate	02MW21	02MW21-050619	05/06/2019	100 U	75 (1)	250 U	75	0.35 UJ	1 U	1 U	3 U
East Waterfront-Shoreline	Intermediate	02MW22	02MW22-050619	05/06/2019	100 U	80 (1)	250 U	80	0.35 UJ	1 U	1 U	3 U

Notes:

-- Not analyzed.

Italics Reporting limit exceeds criteria.

RED/BOLD Detected exceedance of PCUL.

1 The laboratory noted that the sample chromatographic pattern does not resemble the fuel standard used for quantitation.

2 Analyzed after performing silica gel cleanup to remove polar organics.

3 Equivalent GRO concentration obtained by summing detected volatile petroleum hydrocarbon fractions.

Abbreviations:

BTEX Benzene, toluene, ethylbenzene, and xylenes

CAS Chemical Abstracts Service

DRO Diesel-range organics

GRO Gasoline-range organics

µg/L Micrograms per liter

NA Not applicable

ORO Oil-range organics

PCUL Preliminary cleanup level

RI Remedial Investigation

TPH Total petroleum hydrocarbons

Qualifiers:

J Analyte was detected; concentration is considered to be an estimate.

U Analyte was not detected at the given reporting limit.

UJ Analyte was not detected at the given reporting limit, which is considered to be an estimate.

Table 5.5
RI Analytical Results: EPH/VPH in Groundwater

				Location	01MW19	01MW47	01MW69	01MW90	01MW71	MW03	02MW04
				Parcel	Bulk Terminal	Bulk Terminal-W. Commodore Way	Bulk Terminal	Bulk Terminal	ASKO	ASKO	East Waterfront
				Water-Bearing Zone	Shallow	Shallow	Shallow	Shallow	Perched	Perched	Shallow
				Sample ID	01MW19-043019	01MW47-050119	01MW69-043019	01MW90-050119	01MW71-050219	MW03-050319	02MW04-050319
				Sample Date	04/30/2019	05/01/2019	04/30/2019	05/01/2019	05/02/2019	05/03/2019	05/03/2019
Analyte	**CAS No.**	**Units**	**PCUL**								
Extractable Petroleum Hydrocarbons											
C8-C10 Aliphatics	NA	µg/L	NA		60 J	42 J	41 UJ	45 UJ	41 UJ	40 UJ	40 UJ
C10-C12 Aliphatics	NA	µg/L	NA		21 UJ	310 J	20 UJ	22 UJ	21 UJ	20 UJ	20 UJ
C12-C16 Aliphatics	NA	µg/L	NA		48	330	20 U	73	21 U	20 U	20 U
C16-C21 Aliphatics	NA	µg/L	NA		34	64	20 U	22 U	21 U	20 U	20 U
C21-C34 Aliphatics	NA	µg/L	NA		21 U	21 U	20 U	22 U	21 U	20 U	20 U
C8-C10 Aromatics	NA	µg/L	NA		570 J	200 J	20 UJ	22 UJ	21 UJ	20 U	20 UJ
C10-C12 Aromatics	NA	µg/L	NA		390	320	65	22 U	21 U	20 U	27
C12-C16 Aromatics	NA	µg/L	NA		520	1,100	74	55	21 U	23 J	20 U
C16-C21 Aromatics	NA	µg/L	NA		350	440	120	22 U	21 U	20 U	20 U
C21-C34 Aromatics	NA	µg/L	NA		500	550	91	22 U	21 U	20 UJ	20 U
Volatile Petroleum Hydrocarbons											
C5-C6 Aliphatics	NA	µg/L	NA		1,700	690	40 U	40 U	89	40 U	5,600
C6-C8 Aliphatics	NA	µg/L	NA		640	720	65	20 U	20 U	38	2,300
C8-C10 Aliphatics	NA	µg/L	NA		20 U	190	52	20 U	20 U	62	88
C10-C12 Aliphatics	NA	µg/L	NA		370	360	20 U	20 U	20 U	93	73
C8-C10 Aromatics	NA	µg/L	NA		1,800	410	100	50 U	50 U	66	180
C10-C12 Aromatics	NA	µg/L	NA		800	890	200	20 U	20 U	190	270
C12-C13 Aromatics	NA	µg/L	NA		1,000	1,600	310	20 U	20 U	65	27
Volatile Organic Compounds											
1,2-Dibromoethane	106-93-4	µg/L	1		1 U	1 U	1 U	1 U	1 U	1 U	1 U
1,2-Dichloroethane	107-06-2	µg/L	4.8		1 U	1 U	1 U	1 U	1 U	1 U	1 U
Methyl tert-butyl ether	1634-04-4	µg/L	24		1 U	1 U	1 U	1 U	1 U	1 U	1 U
n-Hexane	110-54-3	µg/L	NA		59	--	1 U	--	1 U	1 U	160
Polycyclic Aromatic Hydrocarbons											
1-Methylnaphthalene	90-12-0	µg/L	NA		67	150	1.8	0.4 U	0.4 U	--	0.42
2-Methylnaphthalene	91-57-6	µg/L	NA		91	230	0.69	0.4 U	0.4 U	--	0.46
Naphthalene	91-20-3	µg/L	NA		96	77	4.2	0.4 U	0.4 U	0.4 UJ	1.2

Note:

-- Not analyzed.

Abbreviations:

CAS Chemical Abstracts Service
EPH Extractable petroleum hydrocarbons
µg/L Micrograms per liter
NA Not applicable
PCUL Preliminary cleanup level
RI Remedial Investigation
VPH Volatile petroleum hydrocarbons

Qualifiers:

J Analyte was detected; concentration is considered to be an estimate.
U Analyte was not detected at the given reporting limit.
UJ Analyte was not detected at the given reporting limit, which is considered to be an estimate.

Table 5.6
RI Analytical Results: cVOCs in Groundwater

			Chemical of Interest	Tetrachloroethene	Trichloroethene	cis-1,2-Dichloroethene	trans-1,2-Dichloroethene	1,1-Dichloroethene	1,2-Dichloroethane	Vinyl chloride
			CAS No.	127-18-4	79-01-6	156-59-2	156-60-5	75-35-4	107-06-2	75-01-4
			PCUL	2.4	0.5	16	100	7	4.8	0.2
			Units	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
Parcel	**Water-Bearing Zone**	**Location**	**Sample ID**	**Sample Date**						
Bulk Terminal	Shallow	01MW19	01MW19-043019	04/30/2019	1 U	0.5 U	1 U	1 U	1 U	1 U	0.2 U
ASKO	Perched	01MW70	01MW70-050219	05/02/2019	1 U	**310**	**52**	71	1 U	1 U	**0.69**
ASKO	Perched	01MW71	01MW71-050219	05/02/2019	1 U	**2,800**	**120**	17	**13**	1 U	**7.9**
ASKO	Perched	01MW79	01MW79-050219	05/02/2019	1 U	**61**	**28**	1.5	1 U	1 U	**3.8**
ASKO-BNSF	Perched	01MW92	01MW92-051419	05/14/2019	200 U	**5,200**	**570**	200 U	200 U	200 U	40 U
ASKO-BNSF	Perched	01MW96	01MW96-051419	05/14/2019	1 U	**1.5**	3.1	1 U	1 U	1 U	**6**
ASKO-BNSF	Perched	01MW97	01MW197-051419	05/14/2019	1 U	**54**	**19**	1 U	1 U	1 U	0.2 U
ASKO-BNSF	Perched	01MW97	01MW97-051419	05/14/2019	1 U	**56**	**20**	1 U	1 U	1 U	0.2 U
ASKO-BNSF	Perched	01MW98	01MW98-051419	05/14/2019	10 U	**810**	**57**	10 U	10 U	10 U	***2 U***
ASKO	Perched	MW03	MW03-050319	05/03/2019	1 U	0.5 U	8.6	1 U	1 U	1 U	**0.72**
ASKO	Shallow	01MW07	01MW07-050219	05/02/2019	1 U	**3.3**	1.2	1 U	1 U	1 U	**1.3**
ASKO	Shallow	01MW15	01MW15-050219	05/02/2019	1 U	0.5 U	1.7	1 U	1 U	1 U	**7.2**
ASKO	Shallow	01MW44	01MW44-050219	05/02/2019	1 U	**800**	**87**	2	1.1	4.8	**12**
ASKO	Shallow	01MW45	01MW45-050219	05/02/2019	1 U	**330**	**200**	1 U	1	1 U	**12**
ASKO	Shallow	01MW46	01MW46-050219	05/02/2019	1 U	**880**	**220**	1 U	3.4	2.2	**11**
ASKO	Shallow	01MW53	01MW53-050219	05/02/2019	1 U	0.5 U	4.4	1 U	1 U	1 U	**0.26**
ASKO	Shallow	01MW55	01MW55-050219	05/02/2019	**3.1**	**2,200**	1,000 U	7.4	3.5	1 U	**1.9**
ASKO	Shallow	01MW56	01MW56-050219	05/02/2019	1 U	0.5 U	1 U	1 U	1 U	1 U	**0.61**
ASKO	Shallow	01MW56	01MW56-050219-D	05/02/2019	1 U	0.5 U	1 U	1 U	1 U	1 U	**0.6**
ASKO	Shallow	01MW58	01MW58-050219	05/02/2019	1 U	**42**	1.6	1 U	1 U	1 U	**0.3**
ASKO	Shallow	01MW60	01MW60-050219	05/02/2019	1 U	**15**	1 U	1 U	1 U	1 U	0.2 U
ASKO	Shallow	01MW62	01MW62-050219	05/02/2019	1 U	**850**	15	1 U	1 U	1 U	0.2 U
ASKO	Shallow	01MW63	01MW63-050219	05/02/2019	1 U	**5,900**	***1,000 U***	6.1	6.5	1.7	**39**
ASKO	Shallow	01MW80	01MW80-050219	05/02/2019	1 U	**710**	**250**	1 U	2.8	1.3	**10**
ASKO-W. Commodore Way	Shallow	01MW85	01MW85-050319	05/03/2019	1 U	0.5 U	2.4	1 U	1 U	1 U	**7.9**
ASKO-BNSF	Shallow	01MW93	01MW93-051419	05/14/2019	1 U	0.5 U	1 U	1 U	1 U	1 U	0.2 U
ASKO-BNSF	Shallow	01MW94	01MW94-051419	05/14/2019	1 U	0.5 U	1 U	1 U	1 U	1 U	0.2 U
ASKO-BNSF	Shallow	01MW95	01MW95-051419	05/14/2019	1 U	0.5 U	1 U	1 U	1 U	1 U	0.2 U
ASKO-W. Commodore Way	Shallow	01MW106	01MW106-050319	05/03/2019	1 U	0.5 U	1 U	1 U	1 U	1 U	0.2 U
ASKO-W. Commodore Way	Shallow	01MW107	01MW107-050619	05/06/2019	1 U	0.5 U	1 U	1 U	1 U	1 U	0.2 U
ASKO	Shallow	MW01	MW01-050319	05/03/2019	1 U	0.5 U	1 U	1 U	1 U	1 U	0.2 U
ASKO	Shallow	MW02	MW02-050319	05/03/2019	1 U	0.5 U	1 U	1 U	1 U	1 U	0.2 U
ASKO	Shallow	MW02	MW02-050319-D	05/03/2019	1 U	0.5 U	1 U	1 U	1 U	1 U	0.2 U
ASKO	Shallow	MW04	MW04-050319	05/03/2019	1 U	**970**	**20**	1 U	1 U	1 U	**2.5**
ASKO	Shallow	MW05	MW05-050319	05/03/2019	1 U	**240**	**120**	2.4	1 U	1 U	**27**
ASKO	Shallow	MW06	MW06-050319	05/03/2019	1 U	**330**	**31**	1 U	1.1	1 U	**2.8**
ASKO	Intermediate	01MW54	01MW54-050319	05/03/2019	1 U	0.5 U	1 U	1 U	1 U	1 U	0.2 U
ASKO	Intermediate	01MW76	01MW76-050319	05/03/2019	1 U	0.5 U	1 U	1 U	1 U	1 U	0.2 U
ASKO	Intermediate	01MW77	01MW77-050319	05/03/2019	1 U	0.5 U	1 U	1 U	1 U	1 U	0.2 U
ASKO	Intermediate	01MW78	01MW78-050219	05/02/2019	1 U	**1.2**	5.5	1 U	1 U	1 U	0.2 U
ASKO	Intermediate	01MW108	01MW108-050319	05/03/2019	1 U	0.5 U	1 U	1 U	1 U	1 U	**0.33**
ASKO	Deep	01MW65	01MW65-050319	05/03/2019	1 U	0.5 U	1 U	1 U	1 U	1 U	0.2 U

Notes:

Italics Reporting limit exceeds criteria.

RED/BOLD Detected exceedance of PCUL.

Abbreviations:

CAS Chemical Abstracts Service

cVOC Chlorinated volatile organic compound

µg/L Micrograms per liter

PCUL Preliminary cleanup level

RI Remedial Investigation

Qualifier:

U Analyte was not detected at the given reporting limit.

Table 5.7
RI Analytical Results: SVOCs in Groundwater

			Location	01MW01	01MW19	01MW27	01MW47	01MW48	01MW66	01MW67	01MW69	01MW84
			Parcel	Bulk Terminal	Bulk Terminal	Bulk Terminal	Bulk Terminal	Bulk Terminal-W. Commodore Way	Bulk Terminal	Bulk Terminal	Bulk Terminal	Bulk Terminal-W. Commodore Way
			Water-Bearing Zone	Shallow	Shallow	Shallow	Shallow	Intermediate	Shallow	Shallow	Shallow	Shallow
			Sample ID	01MW01-043019	01MW19-043019	01MW27-043019	01MW47-050119	01MW48-050119	01MW66-043019	01MW67-043019	01MW69-043019	01MW84-050119
			Sample Date	04/30/2019	04/30/2019	04/30/2019	05/01/2019	05/01/2019	04/30/2019	04/30/2019	04/30/2019	05/01/2019
Chemical of Interest	**CAS No.**	**Units**	**PCUL**									
Acenaphthene	83-32-9	µg/L	NA	--	2	--	5.3	--	--	--	0.14	3.4
Acenaphthylene	208-96-8	µg/L	NA	--	0.02 U	--	0.04 U	--	--	--	0.02 U	0.04 U
Anthracene	120-12-7	µg/L	NA	--	0.085	--	0.49	--	--	--	0.02 U	0.44
Benz(a)anthracene	56-55-3	µg/L	0.06	--	0.02 U	--	0.04 U	--	--	--	0.02 U	0.04 U
Benzo(b)fluoranthene	205-99-2	µg/L	0.06	--	0.02 U	--	0.04 U	--	--	--	0.02 U	0.04 U
Benzo(k)fluoranthene	207-08-9	µg/L	0.06	--	0.02 U	--	0.04 U	--	--	--	0.02 U	0.04 U
Benzo(a)pyrene	50-32-8	µg/L	0.06	--	0.02 U	--	0.04 U	--	--	--	0.02 U	0.04 U
Chrysene	218-01-9	µg/L	0.06	--	0.02 U	--	0.04 U	--	--	--	0.02 U	0.04 U
Dibenz(a,h)anthracene	53-70-3	µg/L	0.06	--	0.02 U	--	0.04 U	--	--	--	0.02 U	0.04 U
Indeno(1,2,3-c,d)pyrene	193-39-5	µg/L	0.06	--	0.02 U	--	0.04 U	--	--	--	0.02 U	0.04 U
cPAH TEQ	CPAHTEQ	µg/L	0.06	--	0.015 U	--	0.03 U	--	--	--	0.015 U	0.03 U
Benzo(g,h,i)perylene	191-24-2	µg/L	NA	--	0.02 U	--	0.04 U	--	--	--	0.02 U	0.04 U
Fluoranthene	206-44-0	µg/L	NA	--	0.02 U	--	0.04 U	--	--	--	0.02 U	0.25
Fluorene	86-73-7	µg/L	NA	--	1.8	--	6.2	--	--	--	0.4	3.1
1-Methylnaphthalene	90-12-0	µg/L	NA	--	67	--	150	--	--	--	1.8	76
2-Methylnaphthalene	91-57-6	µg/L	NA	--	91	--	230	--	--	--	0.69	130
Naphthalene	91-20-3	µg/L	NA	--	96	--	77	--	--	--	4.2	190
Phenanthrene	85-01-8	µg/L	NA	--	0.96	--	6	--	--	--	0.079	4.2
Pyrene	129-00-0	µg/L	NA	--	0.02 U	--	0.048	--	--	--	0.02 U	0.12
Total PAHs	TPAH	µg/L	NA	--	260	--	480	--	--	--	7.3	410
Pentachlorophenol	87-86-5	µg/L	0.2	**2.1**	--	0.2 U	--	0.2 U	**3.6**	0.2	0.2 U	--

Notes:

-- Not analyzed.

RED/BOLD Detected exceedance of PCUL.

Abbreviations:

CAS Chemical Abstracts Service
cPAH Carcinogenic polycyclic aromatic hydrocarbon
µg/L Micrograms per liter
NA Not applicable
PAH Polycyclic aromatic hydrocarbon
PCUL Preliminary cleanup level
RI Remedial Investigation
SVOC Semivolatile organic compound
TEQ Toxic equivalent

Qualifiers:

U Analyte was not detected at the given reporting limit.
UJ Analyte was not detected at the given reporting limit, which is considered to be an estimate.

Table 5.7
RI Analytical Results: SVOCs in Groundwater

			Location	01MW88	01MW90	01MW101	01MW102	01MW104	01MW71	MW03	02MW04	02MW07
			Parcel	Bulk Terminal-W. Commodore Way	Bulk Terminal	Bulk Terminal-W. Commodore Way	Bulk Terminal-W. Commodore Way	Bulk Terminal-W. Commodore Way	ASKO	ASKO	East Waterfront	East Waterfront-Shoreline
			Water-Bearing Zone	Shallow	Shallow	Shallow	Shallow	Intermediate	Perched	Perched	Shallow	Shallow
			Sample ID	01MW88-050119	01MW90-050119	01MW101-050619	01MW102-050619	01MW104-050319	01MW71-050219	MW03-050319	02MW04-050319	02MW07-050319
			Sample Date	05/01/2019	05/01/2019	05/06/2019	05/06/2019	05/03/2019	05/02/2019	05/03/2019	05/03/2019	05/03/2019
Chemical of Interest	**CAS No.**	**Units**	**PCUL**									
Acenaphthene	83-32-9	µg/L	NA	0.04 U	0.04 U	0.04 U	0.04 U	--	0.04 U	0.04 UJ	0.04 U	0.04 U
Acenaphthylene	208-96-8	µg/L	NA	0.04 U	0.04 U	0.04 U	0.04 U	--	0.04 U	0.04 UJ	0.04 U	0.04 U
Anthracene	120-12-7	µg/L	NA	0.04 U	0.04 U	0.04 U	0.04 U	--	0.04 U	0.04 UJ	0.04 U	0.04 U
Benz(a)anthracene	56-55-3	µg/L	0.06	0.04 U	0.04 U	0.04 U	0.04 U	--	0.04 U	0.04 UJ	0.04 U	0.04 U
Benzo(b)fluoranthene	205-99-2	µg/L	0.06	0.04 U	0.04 U	0.04 U	0.04 U	--	0.04 U	0.04 UJ	0.04 U	0.04 U
Benzo(k)fluoranthene	207-08-9	µg/L	0.06	0.04 U	0.04 U	0.04 U	0.04 U	--	0.04 U	0.04 UJ	0.04 U	0.04 U
Benzo(a)pyrene	50-32-8	µg/L	0.06	0.04 U	0.04 U	0.04 U	0.04 U	--	0.04 U	0.04 UJ	0.04 U	0.04 U
Chrysene	218-01-9	µg/L	0.06	0.04 U	0.04 U	0.04 U	0.04 U	--	0.04 U	0.04 UJ	0.04 U	0.04 U
Dibenz(a,h)anthracene	53-70-3	µg/L	0.06	0.04 U	0.04 U	0.04 U	0.04 U	--	0.04 U	0.04 UJ	0.04 U	0.04 U
Indeno(1,2,3-c,d)pyrene	193-39-5	µg/L	0.06	0.04 U	0.04 U	0.04 U	0.04 U	--	0.04 U	0.04 UJ	0.04 U	0.04 U
cPAH TEQ	CPAHTEQ	µg/L	0.06	0.03 U	0.03 U	0.03 U	0.03 U	--	0.03 U	0.03 UJ	0.03 U	0.03 U
Benzo(g,h,i)perylene	191-24-2	µg/L	NA	0.04 U	0.04 U	0.04 U	0.04 U	--	0.04 U	0.04 UJ	0.04 U	0.04 U
Fluoranthene	206-44-0	µg/L	NA	0.04 U	0.04 U	0.04 U	0.04 U	--	0.04 U	0.04 UJ	0.04 U	0.04 U
Fluorene	86-73-7	µg/L	NA	0.04 U	0.04 U	0.04 U	0.04 U	--	0.04 U	0.04 UJ	0.04 U	0.04 U
1-Methylnaphthalene	90-12-0	µg/L	NA	0.4 U	0.4 U	0.4 U	0.4 U	--	0.4 U	--	0.42	0.4 U
2-Methylnaphthalene	91-57-6	µg/L	NA	0.4 U	0.4 U	0.4 U	0.4 U	--	0.4 U	--	0.46	0.4 U
Naphthalene	91-20-3	µg/L	NA	0.4 U	0.4 U	0.4 U	0.4 U	--	0.4 U	0.4 UJ	1.2	0.4 U
Phenanthrene	85-01-8	µg/L	NA	0.04 U	0.04 U	0.04 U	0.04 U	--	0.04 U	0.04 UJ	0.04 U	0.04 U
Pyrene	129-00-0	µg/L	NA	0.04 U	0.04 U	0.04 U	0.04 U	--	0.04 U	0.04 UJ	0.04 U	0.04 U
Total PAHs	TPAH	µg/L	NA	0.4 U	0.4 U	0.4 U	0.4 U	--	0.4 U	0.4 UJ	2.1	0.4 U
Pentachlorophenol	87-86-5	µg/L	0.2	--	--	0.2 U	--	0.2 U	--	--	--	--

Notes:

-- Not analyzed.

RED/BOLD Detected exceedance of PCUL.

Abbreviations:

CAS Chemical Abstracts Service
cPAH Carcinogenic polycyclic aromatic hydrocarbon
µg/L Micrograms per liter
NA Not applicable
PAH Polycyclic aromatic hydrocarbon
PCUL Preliminary cleanup level
RI Remedial Investigation
SVOC Semivolatile organic compound
TEQ Toxic equivalent

Qualifiers:

U Analyte was not detected at the given reporting limit.
UJ Analyte was not detected at the given reporting limit, which is considered to be an estimate.

Table 5.7
RI Analytical Results: SVOCs in Groundwater

			Location	02MW17	02MW18	02MW19	02MW20
			Parcel	East Waterfront-Shoreline	East Waterfront-Shoreline	East Waterfront-Shoreline	East Waterfront-Shoreline
			Water-Bearing Zone	Shallow	Shallow	Shallow	Shallow
			Sample ID	02MW17-050619	02MW18-050619	02MW19-050619	02MW20-050619
			Sample Date	05/06/2019	05/06/2019	05/06/2019	05/06/2019
Chemical of Interest	**CAS No.**	**Units**	**PCUL**				
Acenaphthene	83-32-9	µg/L	NA	0.04 U	0.04 U	0.04 U	0.04 U
Acenaphthylene	208-96-8	µg/L	NA	0.04 U	0.04 U	0.04 U	0.04 U
Anthracene	120-12-7	µg/L	NA	0.04 U	0.04 U	0.04 U	0.04 U
Benz(a)anthracene	56-55-3	µg/L	0.06	0.04 U	0.04 U	0.04 U	0.04 U
Benzo(b)fluoranthene	205-99-2	µg/L	0.06	0.04 U	0.04 U	0.04 U	0.04 U
Benzo(k)fluoranthene	207-08-9	µg/L	0.06	0.04 U	0.04 U	0.04 U	0.04 U
Benzo(a)pyrene	50-32-8	µg/L	0.06	0.04 U	0.04 U	0.04 U	0.04 U
Chrysene	218-01-9	µg/L	0.06	0.04 U	0.04 U	0.04 U	0.04 U
Dibenz(a,h)anthracene	53-70-3	µg/L	0.06	0.04 U	0.04 U	0.04 U	0.04 U
Indeno(1,2,3-c,d)pyrene	193-39-5	µg/L	0.06	0.04 U	0.04 U	0.04 U	0.04 U
cPAH TEQ	CPAHTEQ	µg/L	0.06	0.03 U	0.03 U	0.03 U	0.03 U
Benzo(g,h,i)perylene	191-24-2	µg/L	NA	0.04 U	0.04 U	0.04 U	0.04 U
Fluoranthene	206-44-0	µg/L	NA	0.04 U	0.04 U	0.04 U	0.04 U
Fluorene	86-73-7	µg/L	NA	0.04 U	0.04 U	0.04 U	0.04 U
1-Methylnaphthalene	90-12-0	µg/L	NA	0.4 U	0.4 U	0.4 U	0.4 U
2-Methylnaphthalene	91-57-6	µg/L	NA	0.4 U	0.4 U	0.4 U	0.4 U
Naphthalene	91-20-3	µg/L	NA	0.4 U	0.4 U	0.4 U	0.4 U
Phenanthrene	85-01-8	µg/L	NA	0.04 U	0.04 U	0.04 U	0.04 U
Pyrene	129-00-0	µg/L	NA	0.04 U	0.04 U	0.04 U	0.04 U
Total PAHs	TPAH	µg/L	NA	0.4 U	0.4 U	0.4 U	0.4 U
Pentachlorophenol	87-86-5	µg/L	0.2	--	--	--	--

Notes:

-- Not analyzed.

RED/BOLD Detected exceedance of PCUL.

Abbreviations:

CAS Chemical Abstracts Service
cPAH Carcinogenic polycyclic aromatic hydrocarbon
µg/L Micrograms per liter
NA Not applicable
PAH Polycyclic aromatic hydrocarbon
PCUL Preliminary cleanup level
RI Remedial Investigation
SVOC Semivolatile organic compound
TEQ Toxic equivalent

Qualifiers:

U Analyte was not detected at the given reporting limit.
UJ Analyte was not detected at the given reporting limit, which is considered to be an estimate.

Table 5.8
RI Analytical Results: Soil

				Location	02MW20	02MW22		SS-01	SS-02	SS-03
				Sample ID	02MW20-1.5-2	02MW22-1.5-2	02MW22-3.5-4	SS-01-0-0.4	SS-02-0-0.5	SS-03-0.25-0.75
				Sample Date	04/25/2019	04/25/2019	04/25/2019	04/26/2019	04/26/2019	04/26/2019
				Depth Range (feet bgs)	1.5–2	1.5–2	3.5–4	0–0.4	0–0.5	0.25–0.75
Analyte	**CAS No.**	**Units**	**PCUL**							
Conventionals										
Total organic carbon	NA	%	NA	--	0.9 (1)	--	--	--	--	
Metals										
Arsenic	7440-38-2	mg/kg	7.3	--	1.5	--	3.2	**30**	**26**	
Barium	7440-39-3	mg/kg	4.1	--	**84**	--	**36**	**69**	**49**	
Cadmium	7440-43-9	mg/kg	0.77	--	0.50 U	--	0.50 U	**46**	**1.9**	
Chromium (Total)	7440-47-3	mg/kg	48	--	18	--	20	43	28	
Lead	7439-92-1	mg/kg	24	--	10	--	17	**84**	**100**	
Mercury	7439-97-6	mg/kg	0.070	--	***0.25 U***	--	***0.25 U***	***0.25 U***	***0.25 U***	
Selenium	7782-49-2	mg/kg	0.5	--	0.50 U	--	0.50 U	0.50 U	0.5 U	
Silver	7440-22-4	mg/kg	0.1	--	0.10 UJ	--	0.10 UJ	**2.4**	**0.14 J**	
Total Petroleum Hydrocarbons										
Gasoline-range organics	GRO	mg/kg	30	**440**	**340**	5 U	--	--	--	
Diesel-range organics	DRO	mg/kg	6,000	1,400 (2)	50 U	50 U	--	--	--	
Oil-range organics	ORO	mg/kg	NA	2,000	250 U	250 U	--	--	--	
Diesel- and oil-range organics	DRO+ORO	mg/kg	2,000	**3,400**	250 U	250 U	--	--	--	
Extractable Petroleum Hydrocarbons										
C8-C10 Aliphatics	NA	mg/kg	NA	--	11 U	--	--	--	--	
C10-C12 Aliphatics	NA	mg/kg	NA	--	16	--	--	--	--	
C12-C16 Aliphatics	NA	mg/kg	NA	--	11 U	--	--	--	--	
C16-C21 Aliphatics	NA	mg/kg	NA	--	11 U	--	--	--	--	
C21-C34 Aliphatics	NA	mg/kg	NA	--	11 U	--	--	--	--	
C8-C10 Aromatics	NA	mg/kg	NA	--	30	--	--	--	--	
C10-C12 Aromatics	NA	mg/kg	NA	--	11 U	--	--	--	--	
C12-C16 Aromatics	NA	mg/kg	NA	--	11 U	--	--	--	--	
C16-C21 Aromatics	NA	mg/kg	NA	--	11 U	--	--	--	--	
C21-C34 Aromatics	NA	mg/kg	NA	--	11 U	--	--	--	--	
Volatile Petroleum Hydrocarbons										
C5-C6 Aliphatics	NA	mg/kg	NA	--	1.4 U	--	--	--	--	
C6-C8 Aliphatics	NA	mg/kg	NA	--	8.3	--	--	--	--	
C8-C10 Aliphatics	NA	mg/kg	NA	--	34 J	--	--	--	--	
C10-C12 Aliphatics	NA	mg/kg	NA	--	25 J	--	--	--	--	
C8-C10 Aromatics	NA	mg/kg	NA	--	41	--	--	--	--	
C10-C12 Aromatics	NA	mg/kg	NA	--	21	--	--	--	--	
C12-C13 Aromatics	NA	mg/kg	NA	--	16	--	--	--	--	
Volatile Organic Compounds										
Benzene	71-43-2	mg/kg	0.02	***0.4 U***	***0.03 U***	0.02 U	--	--	--	
1,2-Dibromoethane	106-93-4	mg/kg	0.05	--	0.05 U	--	--	--	--	
1,2-Dichloroethane	107-06-2	mg/kg	0.02	--	***0.05 U***	--	--	--	--	
Ethylbenzene	100-41-4	mg/kg	NA	1.3	0.05 U	0.02 U	--	--	--	
n-Hexane	110-54-3	mg/kg	NA		0.25 U					
Methyl tert-butyl ether	1634-04-4	mg/kg	0.05	--	0.05 U	--	--	--	--	
Toluene	108-88-3	mg/kg	NA	1.4	0.05 U	0.02 U	--	--	--	
Total xylenes	1330-20-7	mg/kg	NA	1.8	0.1 U	0.06 U	--	--	--	
Semivolatile Organic Compounds—PAHs										
Benzo(a)anthracene	56-55-3	mg/kg	0.01	--	0.01 U	--	--	--	--	
Benzo(b)fluoranthene	205-99-2	mg/kg	0.01	--	0.01 U	--	--	--	--	
Benzo(k)fluoranthene	207-08-9	mg/kg	0.01	--	0.01 U	--	--	--	--	
Benzo(a)pyrene	50-32-8	mg/kg	0.01	--	0.01 U	--	--	--	--	
Chrysene	218-01-9	mg/kg	0.01	--	0.01 U	--	--	--	--	
Dibenz(a,h)anthracene	53-70-3	mg/kg	0.01	--	0.01 U	--	--	--	--	
Indeno(1,2,3-c,d)pyrene	193-39-5	mg/kg	0.01	--	0.01 U	--	--	--	--	
cPAH TEQ	CPAHTEQ	mg/kg	0.01	--	0.0076 U	--	--	--	--	
1-Methylnaphthalene	90-12-0	mg/kg	NA	--	--	--	--	--	--	
2-Methylnaphthalene	91-57-6	mg/kg	NA	--	--	--	--	--	--	
Naphthalene	91-20-3	mg/kg	NA	--	0.01 U	--	--	--	--	

Notes:

-- Not analyzed.

Italics Reporting limit exceeds the PCUL.

RED/BOLD Detected result exceeds the PCUL.

1 Average fraction organic carbon at Site obtained for Treatability Study in Section 10.3.

2 The sample chromatographic pattern does not resemble the fuel standard used for quantitation.

Abbreviations:

bgs Below ground surface

CAS Chemical Abstracts Service

cPAH Carcinogenic polycyclic aromatic hydrocarbon

mg/kg Milligrams per kilogram

NA Not applicable

PAH Polycyclic aromatic hydrocarbon

PCUL Preliminary cleanup level

TEQ Toxic equivalent

Qualifiers:

J Analyte was detected; concentration is considered to be an estimate.

U Analyte was not detected at the given reporting limit.

UJ Analyte was not detected at the given reporting limit, which is considered to be an estimate.

Table 6.1

Groundwater Frequency of Exceedance [1]

Chemical of Interest	CAS No.	Unit	Preliminary Cleanup Level	Number of Results	Number of Detections	Number of Detected Results Exceeding PCUL	Percentage of Detected Results Exceeding PCUL	Maximum Detected Value	Location of Maximum Detected Value	Exceedance Factor [2]	Retained As a PIHS?	Comment	Proposed IHS Based on Other Considerations?	Comment
Dissolved Metals														
Arsenic	7440-38-2	µg/L	5	4	4	2	50%	2.4	01MW99	2.8	Yes	Meets PIHS selection criteria.	Yes	Exceeds PCUL and selected as an IHS in soil.
Barium [3]	7440-39-3	µg/L	1,000	4	4	None	None	18	01MW99	None	No	No PCUL exceedances.	No	
Cadmium	7440-43-9	µg/L	0.2	4	None	None	None	None	None	None	No	No PCUL exceedances.	No	
Chromium, Total	7440-47-3	µg/L	1	4	None	None	None	None	None	None	No	No PCUL exceedances.	No	
Lead	7439-92-1	µg/L	0.5	4	None	None	None	None	None	None	No	No PCUL exceedances.	No	
Mercury	7439-97-6	µg/L	0.1	4	None	None	None	None	None	None	No	No PCUL exceedances.	No	
Selenium [3]	7782-49-2	µg/L	5	4	None	None	None	None	None	None	No	No PCUL exceedances.	No	
Silver [3]	7440-22-4	µg/L	0.91	4	None	None	None	None	None	None	No	No PCUL exceedances.	No	
Total Metals														
Arsenic [4]	7440-38-2	µg/L	5	10	10	5	50%	66	MW03	13	Yes	Meets PIHS selection criteria.	Yes	Exceeds PCUL and selected as an IHS in soil.
Barium	7440-39-3	µg/L	1,000	9	9	None	None	71	02MW19	None	No	No PCUL exceedances.	No	
Cadmium [4]	7440-43-9	µg/L	0.2	9	None	None	None	None	None	None	No	No PCUL exceedances.	No	
Chromium, Total [4]	7440-47-3	µg/L	1	9	3	3	33%	2.4	02MW19	2.4	No	Criterion is based on dissolved fraction; no PCUL exceedances of	No	
Lead [4]	7439-92-1	µg/L	0.5	9	2	2	22%	6	02MW07	12	No	Criterion is based on dissolved fraction; no PCUL exceedances of	No	
Mercury [4]	7439-97-6	µg/L	0.012	9	None	None	None	None	None	None	No	No PCUL exceedances.	No	
Selenium	7782-49-2	µg/L	5	9	None	None	None	None	None	None	No	No PCUL exceedances.	No	
Silver	7440-22-4	µg/L	0.91	9	None	None	None	None	None	None	No	No PCUL exceedances.	No	
Total Petroleum Hydrocarbons														
Gasoline-range organics	GRO	µg/L	800	112	28	17	15%	10,000	01MW19	13	Yes	Meets PIHS selection criteria.	Yes	Site-wide contaminant with elevated concentrations and presence of LNAPL.
Diesel- and oil-range organics	DRO+ORO	µg/L	500	115	94	42	37%	11,000	01MW105	22	Yes	Meets PIHS selection criteria.	Yes	Site-wide contaminant with elevated concentrations and presence of LNAPL.
Volatile Organic Compounds														
Benzene	71-43-2	µg/L	0.44	108	30	28	26%	2,600	01MW19	5900	Yes	Meets PIHS selection criteria.	Yes	Contaminant present at elevated concentrations on both the Bulk Terminal and ASKO Properties. Benzene has greater mobility and toxicity than gasoline-range organics and is therefore retained separately as an IHS.
1,2-Dibromoethane	106-93-4	µg/L	1	7	None	None	None	None	None	None	No	No PCUL exceedances.	No	
1,2-Dichloroethane	107-06-2	µg/L	4.8	53	4	None	None	4.8	01MW44	None	No	No PCUL exceedances.	No	
1,1-Dichloroethene	75-35-4	µg/L	7	49	8	1	2.0%	13	01MW71	1.9	No	Does not meet PIHS selection criteria.	No	

Table 6.1

Groundwater Frequency of Exceedance [1]

Chemical of Interest	CAS No.	Unit	Preliminary Cleanup Level	Number of Results	Number of Detections	Number of Detected Results Exceeding PCUL	Percentage of Detected Results Exceeding PCUL	Maximum Detected Value	Location of Maximum Detected Value	Exceedance Factor [2]	Retained As a PIHS?	Comment	Proposed IHS Based on Other Considerations?	Comment
Volatile Organic Compounds (cont.)														
cis-1,2-Dichloroethene	156-59-2	µg/L	16	49	22	13	27%	570	01MW92	36	Yes	Meets PIHS selection criteria.	No	Exceedances fall within the ASKO Property TCE plume and the potential risk as represented by the exceedance factor is less than that posed by TCE. cis-1,2-DCE is a breakdown product of TCE and, therefore, not considered a separate "release." Additionally, cis-1,2-DCE is less mobile, volatile, and toxic than vinyl chloride, which is retained separately as an IHS. Therefore, cis-1,2-DCE is not retained separately from TCE and vinyl chloride as an IHS.
trans-1,2-Dichloroethene	156-60-5	µg/L	100	49	7	None	None	71	01MW70	None	No	No PCUL exceedances.	No	
Methyl ethyl ketone	78-93-3	µg/L	4,800	1	None	None	None	None	None	None	No	No PCUL exceedances.	No	
Methyl tert-butyl ether	1634-04-4	µg/L	24	6	None	None	None	None	None	None	No	No PCUL exceedances.	No	
Tetrachloroethene	127-18-4	µg/L	2.4	49	1	1	2.0%	3.1	01MW55	1.3	No	Does not meet PIHS selection criteria.	No	
Trichloroethene	79-01-6	µg/L	0.5	49	21	21	43%	5,900	01MW63	12,000	Yes	Meets PIHS selection criteria.	Yes	Large plume present on the ASKO Property with elevated concentrations, up to 12,000 times the PCUL. Additionally, contamination is present on the upgradient BNSF parcel.
Vinyl chloride	75-01-4	µg/L	0.2	49	21	21	43%	39	01MW63	200	Yes	Meets PIHS selection criteria.	Yes	Exceedances fall within the ASKO Property TCE plume and the potential risk as represented by the exceedance factor is less than that posed by TCE. Additionally, vinyl chloride is a breakdown product of TCE and, therefore, not considered a separate "release." However, vinyl chloride is the most mobile and volatile cVOC present on site at elevated concentrations and, therefore, is retained.

Table 6.1

Groundwater Frequency of Exceedance [1]

Chemical of Interest	CAS No.	Unit	Preliminary Cleanup Level	Number of Results	Number of Detections	Number of Detected Results Exceeding PCUL	Percentage of Detected Results Exceeding PCUL	Maximum Detected Value	Location of Maximum Detected Value	Exceedance Factor [2]	Retained As a PIHS?	Comment	Proposed IHS Based on Other Considerations?	Comment
Semivolatile Organic Compounds—PAHs														
Benz(a)anthracene	56-55-3	µg/L	0.06	16	None	None	None	None	None	None	No	No PCUL exceedances.	No	
Benzo(b)fluoranthene	205-99-2	µg/L	0.06	16	None	None	None	None	None	None	No	No PCUL exceedances.	No	
Benzo(k)fluoranthene	207-08-9	µg/L	0.06	16	None	None	None	None	None	None	No	No PCUL exceedances.	No	
Benzo(a)pyrene	50-32-8	µg/L	0.06	16	None	None	None	None	None	None	No	No PCUL exceedances.	No	
Chrysene	218-01-9	µg/L	0.06	16	None	None	None	None	None	None	No	No PCUL exceedances.	No	
Dibenz(a,h)anthracene	53-70-3	µg/L	0.06	16	None	None	None	None	None	None	No	No PCUL exceedances.	No	
Indeno(1,2,3-c,d)pyrene	193-39-5	µg/L	0.06	16	None	None	None	None	None	None	No	No PCUL exceedances.	No	
cPAH TEQ	CPAHTEQ	µg/L	0.06	16	None	None	None	None	None	None	No	No PCUL exceedances.	No	
Semivolatile Organic Compounds—Other														
Pentachlorophenol	87-86-5	µg/L	0.2	14	2	2	14%	3.6	01MW66	18	Yes	Meets PIHS selection criteria.	Yes	Exceedances are not collocated with other IHSs and are located immediately adjacent to the former source area, which was previously remediated in 2011-2012.

Notes:

Proposed Indicator Hazardous Substance.

Meets criteria for Preliminary Indicator Hazardous Substance selection.

1 For each location, the most recent Remedial Investigation data have been included. If Remedial Investigation data was not available, the next most recent sample result is included.

2 Exceedance factor has been rounded to two significant figures.

3 Criteria is for the total fraction.

4 Crtieria is for the dissolved fraction.

Abbreviations:

ASKO Property	ASKO Hydraulic Property	µg/L	Micrograms per liter
CAS	Chemical Abstracts Service	PAH	Polycyclic aromatic hydrocarbon
cPAH	Carcinogenic polycyclic aromatic hydrocarbon	PCUL	Preliminary cleanup level
cVOC	Chlorinated volatile organic compound	PIHS	Preliminary Indicator Hazardous Substance
DCE	Dichloroethene	TCE	Trichloroethene
IHS	Indicator Hazardous Substance	TEQ	Toxic equivalent
LNAPL	Light non-aqueous-phase liquid		

Table 6.2

Soil Frequency of Exceedance [1]

Chemical of Interest	CAS No.	Unit	Preliminary Cleanup Level	Number of Results	Number of Detections	Number of Detected Results Exceeding PCUL	Percentage of Detected Results Exceeding PCUL	Maximum Detected Value	Location of Maximum Detected Value	Depth of Maximum Detected Value	Maximum Exceedance Factor [2]	Meets Initial PIHS Selection Criteria?	Exceeds PCUL in Groundwater?	Retained As a PIHS?	Comment	Proposed IHS Based on Other Considerations?	Comment
Metals																	
Arsenic	7440-38-2	mg/kg	7.3	64	63	6	9.4%	30	SS-02	0 - 0.5 ft	4.1	Yes	Yes	Yes	Meets PIHS selection criteria.	Yes	Exceedances observed Site-wide with the greatest exceedance factor of the metals. Retained as an IHS in groundwater. Sand blasting known to have occurred on the East Waterfront Property, which may be an arsenic source.
Barium	7440-39-3	mg/kg	41	35	35	34	97%	220	MW05	1.5 ft	5.4	Yes	No	Yes	Although not of concern for the leaching pathway, maximum result is greater than 2 times the TEE criterion of 100 mg/kg and greater than 10% of samples exceed the TEE criterion.	No	The sample locations that exceeded the TEE criterion were further evaluated. Nine exceedances total are observed; four are collocated with gasoline-range TPH and/or arsenic exceedances on the Bulk Terminal Property (at MW03, MW05, GP04, and GP08) and will, therefore, be addressed as part of the cleanup action. The remainder of exceedances are scattered throughout the Bulk Terminal and ASKO Properties and are low-level (EFs of 1.1 to 1.4).
Cadmium	7440-43-9	mg/kg	0.77	64	15	9	14%	46	SS-02	0 - 0.5 ft	60	Yes	No	Yes	Although not of concern for the leaching pathway, maximum result is greater than 2 times the TEE criterion of 14 mg/kg.	No	The sample location that exceeded the TEE criterion was further evaluated. Only one location, SS-02 on the East Waterfront Property, exceeds TEE criterion. This location is collocated with arsenic contamination.
Chromium (total)	7440-47-3	mg/kg	48	64	64	13	20%	87	SB-50	10 ft	1.8	Yes	No	No	Does not exceed PCUL in groundwater; therefore, leaching pathway is not of concern. Exceeds TEE criterion of 67 mg/kg, but EF is less than 2 and exceeds at a frequency of less than 10%.	No	

Table 6.2

Soil Frequency of Exceedance [1]

Chemical of Interest	CAS No.	Unit	Preliminary Cleanup Level	Number of Results	Number of Detections	Number of Detected Results Exceeding PCUL	Percentage of Detected Results Exceeding PCUL	Maximum Detected Value	Location of Maximum Detected Value	Depth of Maximum Detected Value	Maximum Exceedance Factor [2]	Meets Initial PIHS Selection Criteria?	Exceeds PCUL in Groundwater?	Retained As a PIHS?	Comment	Proposed IHS Based on Other Considerations?	Comment
Metals (cont.)																	
Lead	7439-92-1	mg/kg	24	179	179	8	4.5%	280	01MW26	15 ft	12	Yes	No	Yes	Although not of concern for the leaching pathway, maximum result is greater than 2 times the TEE criterion of 120 mg/kg.	No	The sample locations that exceeded the TEE criterion were further evaluated. Two exceedances total are observed. One is collocated with gasoline-range TPH on the Bulk Terminal Property (at 01MW26) and will, therefore, be addressed as part of the cleanup action. The remaining exceedance located on the Bulk Terminal Property was low-level (EF of 1.2).
Mercury	7439-97-6	mg/kg	0.07	64	2	2	3.1%	0.12	SB-50	2 ft	1.7	No	No	No	Does not exceed PCUL in groundwater; therefore, leaching pathway is not of concern. EF is less than 2 and exceeds at a frequency of less than 10%.	No	
Selenium	7782-49-2	mg/kg	0.5	64	7	3	4.7%	1.4	SB-50	10 ft	2.8	Yes	No	Yes	Although not of concern for the leaching pathway, the TEE criterion of 0.3 mg/kg is less than the PQL-based PCUL.	No	The sample locations that exceeded the TEE criterion were further evaluated. Three exceedances total are observed, all of which are located in the ASKO Property TCE plume area. Therefore, these exceedances will be addressed as part of cleanup action to address TCE.
Silver	7440-22-4	mg/kg	0.1	64	3	3	4.7%	3.3	MW04	1 ft	33	Yes	No	No	Does not exceed PCUL in groundwater; therefore, leaching pathway is not of concern. Exceeds TEE criterion of 2 mg/kg, but EF is less than 2 and exceeds at a frequency of less than 10%.	No	
Total Petroleum Hydrocarbons																	
Gasoline-range organics	ORO	mg/kg	30	697	258	168	24%	760,000	01SB09	12.5 ft	25,000	Yes	Yes	Yes	Meets PIHS selection criteria.	Yes	Site-wide contaminant with very elevated concentrations and presence of LNAPL, and retained as an IHS in groundwater. Concentrations are present at up to 25,000 times the PCUL.
Diesel- and oil-range organics	DRO+ORO	mg/kg	2,000	698	221	118	17%	35,000	B336	7 ft	18	Yes	Yes	Yes	Meets PIHS selection criteria.	Yes	Site-wide contaminant with elevated concentrations and presence of LNAPL, and retained as an IHS in groundwater.

Table 6.2

Soil Frequency of Exceedance [1]

Chemical of Interest	CAS No.	Unit	Preliminary Cleanup Level	Number of Results	Number of Detections	Number of Detected Results Exceeding PCUL	Percentage of Detected Results Exceeding PCUL	Maximum Detected Value	Location of Maximum Detected Value	Depth of Maximum Detected Value	Maximum Exceedance Factor [2]	Meets Initial PIHS Selection Criteria?	Exceeds PCUL in Groundwater?	Retained As a PIHS?	Comment	Proposed IHS Based on Other Considerations?	Comment
Volatile Organic Compounds																	
Benzene	71-43-2	mg/kg	0.02	729	113	101	14%	5,600	01SB09	12.5 ft	280,000	Yes	Yes	Yes	Meets PIHS selection criteria.	Yes	Site-wide contaminant with very elevated concentrations, and retained as an IHS in groundwater. Concentrations are present at up to 280,000 times the PCUL.
1,2-Dibromoethane	106-93-4	mg/kg	0.05	162	None	None	None	None	None	None	None	No	No	No	No PCUL exceedances.	No	
1,2-Dichloroethane	107-06-2	mg/kg	0.02	331	6	1	0.30%	0.058	01MW41	12.5 ft	2.9	Yes	No	No	Does not exceed PCUL in groundwater; therefore, leaching pathway is not of concern. Does not exceed direct contact criterion.	No	
1,1-Dichloroethene	75-35-4	mg/kg	0.02	298	None	None	None	None	None	None	None	No	No	No	No PCUL exceedances.	No	
cis-1,2-Dichloroethene	156-59-2	mg/kg	0.02	298	65	64	21%	1.7	01MW54	10 ft	85	Yes	Yes	Yes	Meets PIHS selection criteria.	No	Exceedances fall within the TCE exceedance footprint, and the potential risk, as respresented by the EF, is less than that posed by TCE.
trans-1,2-Dichloroethene	156-60-5	mg/kg	0.063	298	1	1	0.34%	0.15	01MW70	10.5 ft	2.4	Yes	No	No	Does not exceed PCUL in groundwater; therefore, leaching pathway is not of concern. Does not exceed direct contact criterion.	No	
Methyl ethyl ketone	78-93-3	mg/kg	2,100,000	101	8	None	None	2.1	GP10	7 ft	None	No	No	No	No PCUL exceedances.	No	
Methyl tert-butyl ether	1634-04-4	mg/kg	0.05	139	1	None	None	0.00076	GP10	15 ft	None	No	No	No	No PCUL exceedances.	No	
Tetrachloroethene	127-18-4	mg/kg	0.025	298	4	4	1.3%	0.24	01MW54	10 ft	9.6	Yes	No	No	Does not exceed PCUL in groundwater; therefore, leaching pathway is not of concern. Does not exceed direct contact criterion.	No	
Trichloroethene	79-01-6	mg/kg	0.02	310	106	105	34%	120	01MW71	20 ft	6000	Yes	Yes	Yes	Meets PIHS selection criteria.	Yes	Site-wide contaminant with elevated concentrations, and retained as an IHS in groundwater.
Vinyl chloride	75-01-4	mg/kg	0.025	298	3	2	0.67%	0.13	B106	20 ft	5.2	Yes	Yes	Yes	Meets PIHS selection criteria.	No	Exceedances fall within the TCE exceedance footprint, and the potential risk, as respresented by the EF, is less than that posed by TCE.

Table 6.2

Soil Frequency of Exceedance [1]

Chemical of Interest	CAS No.	Unit	Preliminary Cleanup Level	Number of Results	Number of Detections	Number of Detected Results Exceeding PCUL	Percentage of Detected Results Exceeding PCUL	Maximum Detected Value	Location of Maximum Detected Value	Depth of Maximum Detected Value	Maximum Exceedance Factor [2]	Meets Initial PIHS Selection Criteria?	Exceeds PCUL in Groundwater?	Retained As a PIHS?	Comment	Proposed IHS Based on Other Considerations?	Comment
Semivolatile Organic Compounds—PAHs																	
Benzo(a)anthracene	56-55-3	mg/kg	0.01	43	4	4	9.3%	0.22	01MW15	2 ft	22	Yes	No	No	Does not exceed PCUL in groundwater; therefore, leaching pathway is not of concern. Does not exceed direct contact criterion.	No	
Benzo(b)fluoranthene	205-99-2	mg/kg	0.01	43	3	3	7.0%	0.03	01MW17	2 ft	3	Yes	No	No		No	
Benzo(k)fluoranthene	207-08-9	mg/kg	0.01	43	1	1	2.3%	0.034	B314	12.5 ft	3.4	Yes	No	No		No	
Benzo(a)pyrene	50-32-8	mg/kg	0.01	43	3	3	7.0%	0.11	SB-59	10 ft	11	Yes	No	No		No	
Chrysene	218-01-9	mg/kg	0.01	43	5	5	12%	0.12	01MW15	2 ft	12	Yes	No	No		No	
Dibenz(a,h)anthracene	53-70-3	mg/kg	0.01	43	None	None	None	None	None	None	None	No	No	No	No PCUL exceedances.	No	
Indeno(1,2,3-c,d)pyrene	193-39-5	mg/kg	0.01	43	2	2	4.7%	0.046	01MW17	2 ft	4.6	Yes	No	No	Does not exceed PCUL in groundwater; therefore, leaching pathway is not of concern. Does not exceed direct contact criterion.	No	
cPAH TEQ	CPAHTEQ	mg/kg	0.01	43	8	5	12%	0.23	01MW15	2 ft	23	Yes	No	No		No	
Semivolatile Organic Compounds—Other																	
Pentachlorophenol	87-86-5	mg/kg	0.05	189	35	34	18%	0.33	B339 B341	9 ft 9 ft	6.6	Yes	Yes	Yes	Meets PIHS selection criteria.	Yes	Primarily present on the Bulk Terminal Property, near the known source area for which interim actions were completed in 2011-2012, at concentrations less than the remediation level of 2.5 mg/kg. However, samples not fully collocated with other IHSs and, therefore, retained as an IHS in soil. Additionally, pentachlorophenol was retained as an IHS in groundwater sitewide.
Dioxins/Furans																	
Chlorinated dibenzo-p-dioxins	DIOX	ng/kg	2.0	21	21	17	81%	23.5	B342	9 ft	12	Yes	NA	Yes	Meets PIHS selection criteria.	No	17 exceedances total are observed on the Bulk Terminal Property; 16 are collocated with pentachlorophenol and/or benzene exceedances and will, therefore, be addressed as part of the cleanup action. The remaining exceedance is low-level (EF of 2.1) and present at a depth of 9 feet bgs, within the TPH groundwater plume.
Chlorinated dibenzofurans	FUR	ng/kg	2.0	21	19	1	4.8%	3.37	B342	9 ft	1.7	No	NA	No	Does not meet PIHS selection criteria.	No	
Dioxin/furan TEQ	DFTEQ	ng/kg	1,700	21	21	None	None	26.9	B342	9 ft	None	No	NA	No	No PCUL exceedances.	No	

Notes:

Proposed Indicator Hazardous Substance.

Meets criteria for Preliminary Indicator Hazardous Substance selection.

1 All in-situ soil results are included.

2 EF has been rounded to two significant figures.

Abbreviations:

ASKO Property ASKO Hydraulic Property
bgs Below ground surface
CAS Chemical Abstracts Service
cPAH Carcinogenic polycyclic aromatic hydrocarbon
EF Exceedance factor
ft Feet
IHS Indicator Hazardous Substance
LNAPL Light non-aqueous phase liquid
mg/kg Milligrams per kilogram
NA Not data available
ng/kg Nanograms per kilogram
PAH Polycyclic aromatic hydrocarbon
PCUL Preliminary cleanup level
PIHS Preliminary Indicator Hazardous Substance
PQL Practical quantitation limit
TCE Trichloroethene
TEE Terrestrial Ecological Evaluation
TEQ Toxic equivalent
TPH Total petroleum hydrocarbons

Table 7.1
Chemical-Specific Properties for Indicator Hazardous Substances

Indicator Hazardous Substance	CAS No.	Boiling Point (°C)	Form at 20 °C	Vapor Pressure (atm)	Volatile	Solubility at 20 °C (mg/L)	Henry's Law at 13 °C (atm-m^3/mol)	Partitioning Coefficient (K_{oc}) (cm^3/g)	Mobility in Water
Metals									
Arsenic	7440-38-2	Sublimes [1]	solid	0 [1]	no	NA [2]	0 [2]	NA [2]	high
Total Petroleum Hydrocarbons									
Gasoline-range organics	GRO	50–200 [3]	liquid	0.4–0.9 [3]	moderate	Insoluble [4]	0.00033–0.00048 at 20 °C [4]	Log 1.8-4.6 [4]	high
Diesel-range organics	DRO	282–338 [5]	liquid	0.003–0.035 [5]	moderate	5 [5]	0.000059–0.000074 at 20 °C [5]	Log 3.0-6.7 [5]	moderate
Oil-range organics	ORO	101–588 [5]	liquid	0.003–0.035 [5]	moderate	5 [5]	0.000059–0.000074 at 20 °C [5]	Log 3.0-6.7 [5]	low
Volatile Organic Compounds									
Benzene	71-43-2	80 [1]	liquid	0.1 [1]	moderate	1,750 [2]	0.133 [2]	62 [2]	high
Trichloroethene	79-01-6	87 [1]	liquid	0.08 [1]	moderate	1,100 [2]	0.239 [2]	94 [2]	high
Vinyl chloride	75-01-4	-14 [1]	gas	3.3 [1]	very high	2,760 [2]	0.807 [2]	18.6 [2]	very high
Semivolatile Organic Compounds									
Pentachlorophenol	87-86-5	309 [1]	solid	0.00000013 [1]	no	1,950 [2]	0.00000021 [2]	590 [2]	low

Notes:

1 From NIOSH pocket guide to Chemical Hazards, distributed and published by Center for Diseases Control and Prevention, DHHS (NIOSH) Publication No. 97-140.

2 From Washington State Department of Ecology Cleanup Levels and Risk Calculation (CLARC) (https://ecology.wa.gov/Regulations-Permits/Guidance-technical-assistance/Contamination-clean-up-tools/CLARC/Data-tables).

3 Chemical and physical properties data for gasoline from the IARC Working Group on the Evaluation of Carcinogenic Risk to Humans' 1989 *IARC Monographs on the Evaluation of Carcinogenic Risks to Humans, No. 45* (https://www.ncbi.nlm.nih.gov/books/NBK5

4 From the Agency for Toxic Substances & Disease Registry's Toxic Substances Portal page for Gasoline, Automotive (https://www.atsdr.cdc.gov/substances/toxsubstance.asp?toxid=83).

5 From the Agency for Toxic Substances & Disease Registry's Toxic Substances Portal page for Fuel Oils/Kerosene (https://www.atsdr.cdc.gov/substances/toxsubstance.asp?toxid=91).

Abbreviations:

atm	Atmospheres
°C	Degrees Celsius
CAS	Chemical Abstracts Service
CLARC	Cleanup Levels and Risk Calculation
cm^3/g	Cubic centimeters per gram
DHHS	Department of Health and Human Services
K_{oc}	Soil organic carbon-water partitioning coefficient
m^3/mol	Cubic meters per mole
mg/L	Milligrams per liter
NA	Not available
NIOSH	National Institute for Occupational Safety and Health

Table 9.1
Previous Cleanup Action Alternatives Assessment

Alternative	Description	Remediation Duration (years)	Protectiveness	Permanence	Effectiveness over Long Term	Management of Short-Term Risk	Implementability	Benefit Score [1]	Cost	Cost Per Benefit [2]	Preferred Alternative	Ecology Comments
Bulk Terminal												
All Alternatives	• MNA and focused bioremediation.	--	--	--	--	--	--	--	--	--		Natural attenuation has not yet been demonstrated as occuring on the site.
Alternative 1	• Unsaturated zone excavation with offsite land disposal. • Multi-phase extraction for LNAPL. • Biosparge and air sparge/SVE for TPH in groundwater.	10	7	7	6	4	4	28	$6,029,000	$215		
Alternative 2	• Unsaturated zone excavation with offsite land disposal. • Multi-phase extraction for LNAPL and TPH in groundwater.	10	7	7	7	4	4	29	$5,796,000	$200		
Alternative 3	• Unsaturated zone and LNAPL excavation with offsite land disposal. • MNA for TPH in groundwater.	20	9	9	8	5	4	35	$4,841,000	$138		Ecology comment: "The disproportionate cost analysis graphically displayed in Chart 2 of the FS indicates that Alternative 3 achieves the most environmental benefit for the cost." Ecology did not say they preferred Alternative 3 over Alternative 4, and Chart 2 indicated that Alternative 4 is the lowest cost per benefit score.
Alternative 4	• Multi-phase extraction for unsaturated zone, LNAPL, and TPH in groundwater.	15	6	6	6	7	8	33	$3,980,000	$121	PREFFERED	Ecology would prefer a more reliable and permanent solution with a shorter remediation time frame that does not require an environmental covenant.
W. Commodore Way ROW												
All Alternatives	• MNA and focused bioremediation.	--	--	--	--	--	--	--	--	--		
Alternative 1	• Multi-phase extraction for LNAPL and TPH in groundwater.	15	6	6	6	7	8	33	$2,986,000	$90.5		
Alternative 2	• LNAPL excavation for offsite land disposal. • Muli-phase extraction for residual LNAPL. • MNA for TPH in groundwater.	10	9	9	8	5	4	35	$2,455,000	$70.1	PREFFERED	Ecology tentatively concurred with the choice of Alternative 2.
ASKO												
All Alternatives	• MNA, permeable reactive barrier adjacent to BNSF parcel, and focused bioremediation.	--	--	--	--	--	--	--	--	--		General Comments: • Arsenic in groundwater was not addressed in the FS. • The graphical representation of the DCA needs to be prepared and evaluated in accordance with WAC 173-340-360(3)(e). • No other comments were made about agreement or disagreement for any of the alternatives.
Alternative 1	• Excavation with shoring and offsite disposal for all COCs.	5	10	9	9	5	5	38	$7,622,490	$201		
Alternative 2	• Enhanced reductive dechlorination for cVOCs in groundwater. • Dual-phase extraction for cVOCs in groundwater. • SVE for GRO and cVOCs in soil. • Excavation for DRO in soil.	10	6	6	7	7	8	34	$4,660,000	$137	PREFFERED	
Alternative 3	• In situ chemical oxidation (permanganate) for cVOCs in groundwater. • Dual-phase extraction for TPH in groundwater. • SVE for GRO and cVOCs in soil. • Excavation for DRO in soil.	10	6	6	8	5	8	33	$4,917,440	$149		
Alternative 4	• Electrical resistance heating for cVOCs in groundwater. • Dual-phase extraction for TPH in groundwater. • SVE for GRO and cVOCs in soil. • Excavation for DRO in soil.	8	9	9	8	5	5	36	$6,958,190	$193		

Table 9.1
Previous Cleanup Action Alternatives Assessment

Alternative	Description	Remediation Duration (years)	Protectiveness	Permanence	Effectiveness over Long Term	Management of Short-Term Risk	Implementability	Benefit Score [1]	Cost	Cost Per Benefit [2]	Preferred Alternative	Ecology Comments
East Waterfront												
All Alternatives	• MNA.	--	--	--	--	--	--	--	--	--		
Alternative 1	• Excavation with offsite disposal for all COCs.	3	8	9	8	5	7	37	$701,000	$18.9	PREFFERED	Ecology tentatively concurred with the selection of Alternative 1 with the exception that the soil removal must be completed to below applicable MTCA Method A or Method B CULs rather than preliminary CULs. Also, groundwater concentrations need to be less than MTCA Method A or B CULs and potentially less than surface water CULs.
Alternative 2	• Air sparging with SVE for all COCs.	7	7	5	7	8	8	35	$1,181,000	$33.7		
Alternative 3	• Dual-phase extraction for all COCs.	10	7	5	7	6	8	33	$1,719,000	$52.1		

Notes:

-- Not applicable.

1 Total benefit score was created by adding together the score (1 to 10) for each category: protectiveness, performance, long-term effectiveness, short-term risk management, implementability, and public concern. A weighting factor was not used to adjust the scoring.

2 Cost in thousands.

Abbreviations:

COC Constituent of concern
CUL Cleanup level
cVOC Chlorinated volatile organic compound
DCA Disproportionate Cost Analysis
DRO Diesel-range organics
Ecology Washington State Department of Ecology
FS Feasibility Study
GRO Gasoline-range organics
LNAPL Light non-aqueous-phase liquid
MNA Monitored natural attenuation
MTCA Model Toxics Control Act
ROW Right of way
SVE Soil-vapor extraction
TPH Total petroleum hydrocarbons
WAC Washington Administrative Code

Table 9.2
Summary of Proposed Indicator Hazardous Substances, Cleanup Standards, and Remediation Levels

Proposed IHS	Proposed Cleanup Standard [1]				Proposed Remediation Level		
	CUL	Unit	Basis	Point of Compliance	Value	Unit	Basis
Groundwater							
Arsenic	5	µg/L	Natural background	*Upland AOC* : CPOC in W. Commodore Way *Shoreline AOC:* standard POC throughout the AOC	--	--	--
GRO	800	µg/L	Protection of drinking water		--	--	--
DRO and ORO	500	µg/L	Protection of drinking water		--	--	--
Benzene	0.44	µg/L	Protection of surface water		--	--	--
TCE	0.5	µg/L	Protection of surface water (PQL-based)		--	--	--
Vinyl Chloride	0.2	µg/L	Protection of surface water (PQL-based)		--	--	--
Penta	0.2	µg/L	Protection of surface water (PQL-based)		--	--	--
Soil							
Arsenic	7.3	mg/kg	Natural background	Empirical demonstration by compliance with groundwater CULs at the applicable POC	--	--	--
GRO	30	mg/kg	Protection of groundwater		5,000	mg/kg	Conservative residual saturation value for gasoline
DRO and ORO	2,000	mg/kg	Protection of groundwater		12,000	mg/kg	Conservative residual saturation value for middle distillates
Benzene	0.02	mg/kg	Protection of surface water (PQL-based)		Compliance with GRO REL	mg/kg	Benzene is present due to a release of gasoline and is collocated with GRO
TCE	0.02	mg/kg	Protection of surface water (PQL-based)		1	mg/kg	Target significant, continuous contamination contributing to TCE exceedances in groundwater
Penta	0.05	mg/kg	Protection of surface water (PQL-based)		--	--	--
LNAPL	--	--	--		No visible LNAPL	--	Field verification of visual LNAPL during remedy implementation

Notes:

-- Not proposed.

1 Cleanup standards are based on protection of all exposure pathways, with the most stringent criterion selected as the proposed CUL as directed by Ecology. Therefore, in groundwater the proposed CUL is also protective of potential exposure pathways including drinking water, discharge to surface water and sediment, and volatilization to indoor air. In soil, the proposed CUL is also protective of potential exposure pathways including direct contact (human and terrestrial receptors) and leaching to groundwater. Tables 4.1 and 4.2 present all applicable groundwater and soil criteria, respectively, considered in the selection of the proposed CULs.

Abbreviations:

AOC Area of concern
CUL Cleanup level
CPOC Conditional point of compliance
DRO Diesel-range organics
Ecology Washington State Department of Ecology
GRO Gasoline-range organics
IHS Indicator hazardous substance
LNAPL Light non-aqueous-phase liquid
µg/L Micrograms per liter
mg/kg Milligrams per kilogram
ORO Oil-range organics
penta Pentachlorophenol
POC Point of compliance
PQL Practical quantitation limit
REL Remediation level
TCE Trichloroethene

Table 11.1
Summary of Remedial Alternatives

Cleanup Action Area (CAA)	Alternative A.1	Alternative A.2	Alternative B	Alternative C	Alternative D	Alternative E
Upland AOC—Bulk Terminal (includes CAA-3)						
CAA-1.a	**Excavate to CULs** (2,800 CY, 5 ft bgs) Remove LNAPL	**Excavate to RELs** (2,200 CY, 5 ft bgs) Remove LNAPL	**Excavate to RELs** (2,200 CY, 5 ft bgs) Remove LNAPL	**Excavate to RELs** (1,300 CY, 5 ft bgs) Remove LNAPL	**Excavate to RELs** (600 CY, 5 ft bgs) Remove LNAPL	**Excavate to RELs** (600 CY, 5 ft bgs) Remove LNAPL
CAA-1.b	**Excavate to CULs** (1,900 CY, 10 ft bgs)	**Excavate to RELs** (1,600 CY, 10 ft bgs)	**Excavate to RELs** (1,600 CY, 10 ft bgs)	**Excavate to RELs** (800 CY, 10 ft bgs)	**No Action**	**No Action**
CAA-2	**Excavate to CULs** (13,400 CY, 15 ft bgs) Remove LNAPL	**Excavate to RELs** (8,800 CY, 15 ft bgs) Remove LNAPL	**ISS to RELs** in CAA-2.a (10,200 CY, 23 ft bgs) **Excavate to RELs** in CAA-2.b (2,100 CY, 15 ft bgs) and remove LNAPL	**ISS to RELs** in CAA-2.a (10,200 CY, 23 ft bgs) **Excavate to RELs** in CAA-2.b (2,100 CY, 15 ft bgs) and remove LNAPL	**Excavate to RELs** (7,900 CY, 20 ft bgs) Remove LNAPL	**ISS to RELs** in CAA-2.a (10,200 CY, 23 ft bgs) **Excavate to RELs** in CAA-2.b (2,100 CY, 15 ft bgs) and remove LNAPL
CAA-3	**Excavate to CULs** (2,600 CY, 5 ft bgs)	**Excavate to RELs** (1,700 CY, 5 ft bgs)	**Excavate to RELs** (800 CY, 5 ft bgs)	**Excavate to RELs** (800 CY, 5 ft bgs)	**No Action**	**No Action**
CAA-4.a	**Excavate to CULs** (4,000 CY, 20 ft bgs) Install PRB Wall along BNSF AOC boundary	**Excavate to CULs** (4,000 CY, 20 ft bgs) Install PRB Wall along BNSF AOC boundary	**ISS to RELs** (5,900 CY, 30 ft bgs) Install interceptor trench and PRB wall along BNSF AOC boundary	**ISS to RELs** (5,900 CY, 30 ft bgs) Install interceptor trench and PRB wall along BNSF AOC boundary	**Thermal to RELs** (4,000 CY to 20 ft bgs)	**ISS to RELs** (5,900 CY, 30 ft bgs) Install interceptor trench and PRB wall along BNSF AOC boundary
CAA-4.b	**Excavate to CULs** (14,800 CY, 28 ft bgs) Install PRB Wall along BNSF AOC boundary	**Excavate to RELs** (10,500 CY, 28 ft bgs) Install PRB Wall along BNSF AOC boundary	**ISS to RELs** (11,300 CY, 30 ft bgs) Install interceptor trench and PRB wall along BNSF AOC boundary	**ISS to RELs** (11,300 CY, 30 ft bgs) Install interceptor trench and PRB wall along BNSF AOC boundary	**Thermal to RELs** (7,500 CY to 20 ft bgs)	**ISS to RELs** (11,300 CY, 30 ft bgs) Install interceptor trench and PRB wall along BNSF AOC boundary
CAA-5	**Excavate to CULs** (1,300 CY, 5 ft bgs)	**No Action**	**Excavate to CULs** (1,300 CY, 5 ft bgs)	**Excavate to CULs** (200 CY, 5 ft bgs) **ERD Treatment (gw only)**	**No Action**	**No Action**
CAA-6	**Excavate to CULs** (1,300 CY)	**Excavate to CULs** (1,300 CY)	**Excavate to CULs** (1,300 CY)	**Excavate to CULs** (1,300 CY)	**Excavate to CULs** (1,300 CY)	**Excavate to CULs** (1,300 CY)
CAA-7	**Excavate to CULs** (60 CY)	**Excavate to CULs** (60 CY)	**Excavate to CULs** (60 CY)	**Excavate to CULs** (60 CY)	**Excavate to CULs** (60 CY)	**Excavate to CULs** (60 CY)
Upland AOC	Cap with pavement or buildings. Implement groundwater monitoring plan. Implement institutional controls that would restrict groundwater withdrawal, require maintenance of the cap, and require a Soil Management Plan.					
Restoration Timeframe	*10 years*	*15 years*	*15 years*	*15 years*	*15 years*	*15 years*
Cost	***$16,151,000***	***$12,244,000***	***$8,251,000***	***$7,821,000***	***$7,404,000***	***$6,725,000***
Total Soil Excavation or Treatment	42,160	30,160	36,760	33,960	21,360	31,460

Abbreviations:

AOC Area of Concern
bgs Below ground surface
BNSF BNSF Railway Company
CUL Cleanup level
CY Cubic yard
Ecology Washington State Department of Ecology
ERD Enhanced reductive dechlorination
ft Feet
gw Groundwater
ISS In situ solidification and stabilization
LNAPL Light non-aqueous-phase liquid
PRB Permeable reactive barrier
REL Remediation level

Table 12.1
Disproportionate Cost Analysis Summary

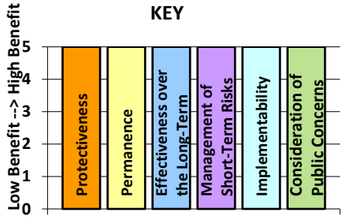
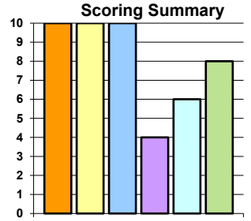
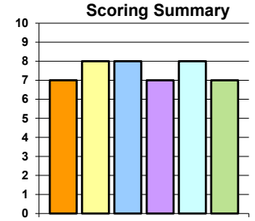
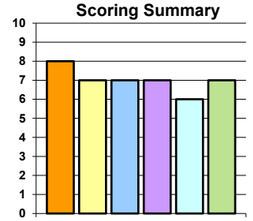
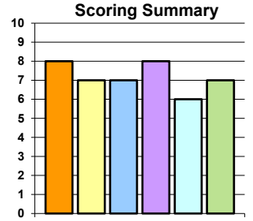
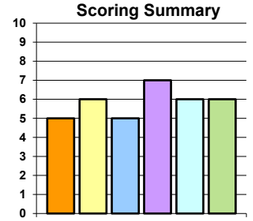
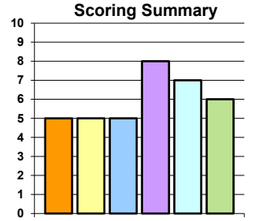
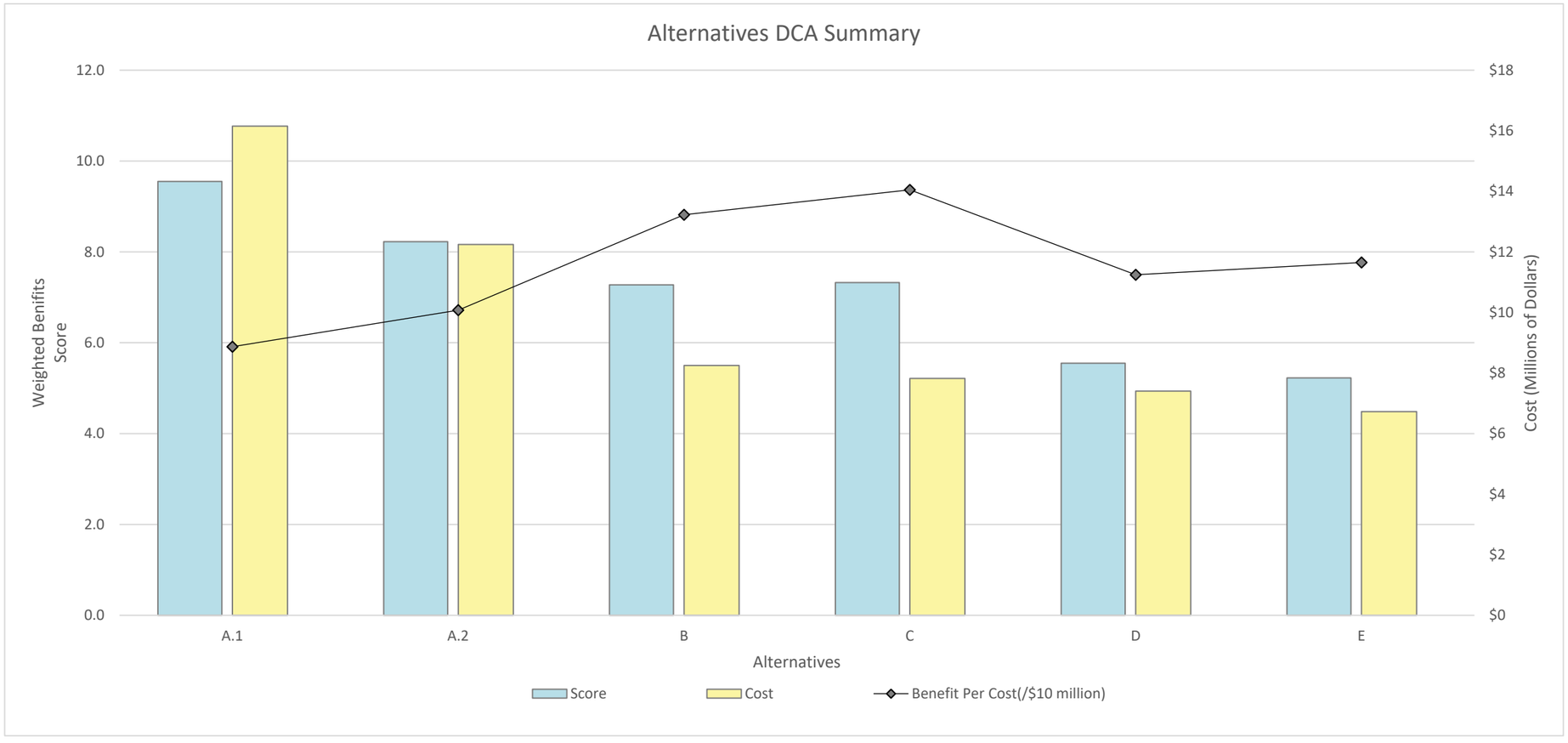
Alternative	Alternative A.1 Soil Excavation to Meet Proposed Cleanup Levels	Alternative A.2 Soil Excavation to Meet Remediation Levels	Alternative B Soil and LNAPL Excavation on BT and ROW, ISS on BT and ASKO, Excavation on EW	Alternative C Soil and LNAPL Excavation on BT and ROW, ISS on BT and ASKO, Groundwater Treatment and ERD on ASKO, Excavation on EW	Alternative D Soil and LNAPL Excavation on BT and in ROW, ERH (thermal) on ASKO, Excavation on EW	Alternative E Soil and LNAPL Excavation on BT and in ROW, ISS on BT and ASKO, Excavation on EW
Alternative Description	Alternative A.1 includes (1) excavation to CULs on the Upland and Shoreline AOCs using normally accepted engineering methods, (2) removal of LNAPL using normally accepted engineering methods, and (3) Installation of a PRB wall with ZVI between the BNSF AOC and a portion of the Upland AOC.	Alternative A.2 includes (1) excavation to RELs in CAA-1, CAA-2, CAA-3, and CAA-4, (2) removal of LNAPL using normally accepted engineering methods, (3) excavation to CULs in CAA-6 and CAA-7, and (4) installation of a PRB wall with ZVI between the BNSF AOC and a portion of the Upland AOC.	Alternative B includes (1) excavation to RELs in CAA-1, CAA-2.b, and CAA-3, (2) removal of LNAPL using normally accepted engineering methods, (3) excavation to CULs in CAA-5, CAA-6, and CAA-7, (4) ISS to RELs in CAA-2.a and CAA-4, and (5) installation of a groundwater interceptor trench and PRB with ZVI between the BNSF AOC and a portion of the Upland AOC.	Alternative C includes (1) excavation to RELs in CAA-1, CAA-2.b, and CAA-3, (2) removal of LNAPL using normally accepted engineering methods, (3) hotspot excavation in CAA-5, (4) excavation to CULs in CAA-6 and CAA-7, (5) ISS to RELs in CAA-2.a and CAA-4, (6) in situ groundwater treatment and ERD in CAA-5, and (7) installation of a groundwater interceptor trench and PRB wall with ZVI between the BNSF AOC and a portion of the Upland AOC.	Alternative D includes (1) excavation to RELs in CAA-1.a and CAA-2, (2) removal of LNAPL using normally accepted engineering methods, (3) excavation to CULs in CAA-6 and CAA-7, (4) treatment of cVOCs in soil and groundwater in CAA-4 via ERH, and (5) installation of a PRB wall with ZVI between the BNSF AOC and a portion of the Upland AOC.	Alternative C includes (1) excavation to RELs in CAA-1.a and CAA-2.b, (2) removal of LNAPL using normally accepted engineering methods, (3) excavation to CULs in CAA-6 and CAA-7, (4) ISS to RELs in CAA-2.a and CAA-4, and (5) installation of a groundwater interceptor trench and PRB wall with ZVI between the BNSF AOC and a portion of the Upland AOC.
KEY 						
Complies with MTCA Threshold Requirements	Yes	Yes	Yes	Yes	Yes	Yes
Restoration Timeframe (to achieve CULs in groundwater at CPOC)	10 Years	15 Years	15 Years	15 Years	15 Years	20 Years
Benefit Scoring (Weighted)						
Protectiveness (30%)	10	9	8	8	5	5
Permanence (40%)	10	8	7	7	6	5
Effectiveness over the Long-Term (20%)	10	8	7	7	5	5
Management of Short-Term Risks (5%)	4	7	7	8	7	8
Technical and Administrative Implementability (2.5%)	6	8	6	6	6	7
Consideration of Public Concerns (2.5%)[1]	8	7	7	7	6	6
Total Weighted Benefit Score (Relative Benefit Ranking)	**9.6**	**8.2**	**7.3**	**7.3**	**5.6**	**5.2**
Estimated Total Alternative Cost [2]	$16.2 million	$12.2 million	$8.3 million	$7.8 million	$7.4 million	$6.7 million
Benefit per Unit Cost Ratio [3]	**5.91**	**6.72**	**8.82**	**9.37**	**7.50**	**7.77**
Costs Disproportionate to Incremental Benefits	YES	YES	NO	NO	NO	NO
Overall Alternative Ranking	**6**	**5**	**2**	**1**	**4**	**3**

Table 12.1
Disproportionate Cost Analysis Summary



Notes:

1 Scores for Consideration of Public Concerns were provided by the Washington State Department of Ecology.
2 Specific cost estimate information is provided in Appendix G of the Supplemental Upland RI/FS.
3 Benefit per Unit Cost Ratio calculated by dividing the Total Weighted Benefit Score by the Estimated Total Alternative Cost (standardized by divided by $10 million). Higher value indicates the most benefit per unit cost.

Abbreviations:

AOC = Area of concern, ASKO = ASKO Hydraulic Property, BT = Bulk Terminal Property, CAA = Cleanup Action Area, CPOC = Conditional point of compliance, cVOC = Chlorinated volatile organic compound, CUL = Cleanup level, ERD = Enhanced reductive dechlorination, ERH = Electrical resistance heating, EW = East Waterfront Property, ISS = In situ solidification and stabilization, LNAPL = Light non-aqueous-phase liquid, MTCA = Model Toxics Control Act, PRB = Permeable Reactive Barrier, REL = Remediation Level, ROW = Right of way, ZVI = Zero valent iron

Table 12.2
Summary of Feasibility Study Alternatives and Disproportionate Cost Analysis

Alternative	Alternative A.1	Alternative A.2	Alternative B
Alternative Description	Alternative A.1 consists of: • Excavation of contaminated soil greater than CULs within all CAAs using normally accepted engineering methods. • Removal of LNAPL in CAA-1.a and CAA-2 using normally accepted engineering methods. Excavated soil and LNAPL would be disposed of offsite at Subtitle D and Subtitle C facilities as applicable. Excavations would be backfilled with clean import fill, and the final surface would be pavement or buildings in the Upland AOC. Alternative A.1 would support Sitewide groundwater recovery through the removal of source material. Groundwater monitoring would be implemented to evaluate groundwater compliance with CULs at the CPOC. The anticipated restoration timeframe is 10 years. Institutional controls would be required where industrial CULs are used, which is expected to be within the Upland AOC. Institutional controls would require implementation of an SMP that would protect all exposure pathways during future excavation or site redevelopment.	Alternative A.2 consists of: • Excavation to RELs in CAA-1, CAA-2, CAA-3 and CAA-4. • Removal of LNAPL in CAA-1a and CAA-2 using normally accepted engineering methods. • No action in CAA-5 (no REL exceedances within soil POC). • Installation of a PRB wall with ZVI in CAA-4 between the BNSF and Upland AOCs. • Excavation of contaminated soil greater than CULs in CAA-6 and CAA-7. Excavated soil and LNAPL would be disposed of offsite at Subtitle D and Subtitle C facilities as applicable. Excavations would be backfilled with clean import fill, and the final surface would be pavement or buildings in the Upland AOC. Alternative A.2 would support Sitewide groundwater recovery through the removal of source material. Groundwater monitoring would be implemented to evaluate groundwater compliance with CULs at the CPOC. The anticipated restoration timeframe is 15 years. Institutional controls would be required where industrial CULs are used, which is expected to be within the Upland AOC. Institutional controls would require implementation of an SMP that would protect all exposure pathways during future excavation or site redevelopment.	Alternative B consists of: • Stabilization of contaminants (including LNAPL) in soil greater than RELs using ISS in CAA-2.a and CAA-4. • Removal of LNAPL in CAA-1.a and CAA-2.b using normally accepted engineering methods. • Excavation to RELs in CAA-1, CAA-2.b, and CAA-3. • Installation of a groundwater interceptor trench and PRB wall with ZVI in CAA-4 between the BNSF and Upland AOCs. • Excavation of contaminated soil greater than CULs in CAA-5, CAA-6 and CAA-7. Excavated soil and LNAPL would be disposed of offsite at a Subtitle D facility. Excavations would be backfilled with clean import fill, and the final surface would be pavement or buildings in the Upland AOC and either pavement or gravel in the Shoreline AOC. Alternative C would support Sitewide groundwater recovery through the removal and/or stabilization of source material. Groundwater monitoring would be implemented to evaluate groundwater compliance with CULs at the CPOC. The anticipated restoration timeframe is 15 years. Institutional controls would be required to address soil left in place with contamination greater than CULs or where industrial CULs are used. Institutional controls would require an SMP that would protect all exposure pathways during future excavation or site redevelopment.
	Alternative C	**Alternative D**	**Alternative E**
	Alternative C consists of: • Stabilization of contaminants (including LNAPL) in soil greater than RELs using ISS in CAA-2.a and CAA-4. • Removal of LNAPL in CAA-1.a and CAA-2.b using normally accepted engineering methods. • Excavation to RELs and removal of soil less than RELs to address groundwater impacts in CAA-1, CAA-2.b, CAA-3, and CAA-5. • In situ groundwater treatment and ERD of TCE in CAA-5. • Installation of a groundwater interceptor trench and PRB wall with ZVI in CAA-4 between the BNSF and Upland AOCs. • Excavation to CULs in CAA-6 and CAA-7. Excavated soil and LNAPL would be disposed of offsite at a Subtitle D facility. Excavations would be backfilled with clean import fill, and the final surface would be pavement or buildings in the Upland AOC and either pavement or gravel in the Shoreline AOC. Alternative C would support Sitewide groundwater recovery through the removal or stabilization of source material. Groundwater monitoring would be implemented to evaluate groundwater compliance with CULs at the CPOC. The anticipated restoration timeframe is 15 years. Institutional controls would be required to address soil left in place with contamination greater than CULs or where industrial CULs are used. Institutional controls would require an SMP that would protect all exposure pathways during future excavation or site redevelopment.	Alternative D consists of: • Excavation of contaminated soil greater than RELs in CAA-1.a and CAA-2. • Removal of LNAPL in CAA-1.a and CAA-2 using normally accepted engineering methods. • No action in CAA-1.b, CAA-3, and CAA-5. • ERH treatment of soil to 20 feet bgs in CAA-4. • Installation of a PRB wall with ZVI in CAA-4 between the BNSF and Upland AOCs. • Excavation of contaminated soil greater than CULs in CAA-6 and CAA-7. Excavated soil and LNAPL would be disposed of offsite at a Subtitle D facility. Excavations would be backfilled with clean import fill, and the final surface would be pavement or buildings in the Upland AOC and either pavement or gravel in the Shoreline AOC. Alternative D would support Sitewide groundwater recovery through the removal of source material via excavation and treatment of soil and groundwater via ERH. Groundwater monitoring would be implemented to evaluate groundwater compliance with CULs at the CPOC. The anticipated restoration timeframe is 15 years. Institutional controls would be required to address soil left in place with contamination greater than CULs or where industrial CULs are used. Institutional controls would require implementation of an SMP that would protect all exposure pathways during future excavation or site redevelopment.	Alternative E consists of: • Stabilization of contaminants (including LNAPL) in soil greater than RELs using ISS in CAA-2.a and CAA-4. • Excavation to RELs in CAA-1.a and the CAA-2.b. • Removal of LNAPL in CAA-1.a and CAA-2.b using normally accepted engineering methods. • No action in CAA-1.b, CAA-3, and CAA-5. • Installation of a groundwater interceptor trench and PRB wall with ZVI in CAA-4 between the BNSF and Upland AOCs. • Excavation of contaminated soil greater than CULs in CAA-6 and CAA-7. Excavated soil and LNAPL would be disposed of offsite at a Subtitle D facility. Excavations would be backfilled with clean import fill, and the final surface would be pavement or buildings in the Upland AOC and either pavement or gravel in the Shoreline AOC. Alternative E would support Sitewide groundwater recovery through the removal and/or stabilization of source material. Groundwater monitoring would be implemented to evaluate groundwater compliance with CULs at the CPOC. The anticipated restoration timeframe is 15 years. Institutional controls would be required to address soil left in place with contamination greater than CULs or where industrial CULs are used. Institutional controls would require implementation of an SMP that would protect all exposure pathways during future excavation or site redevelopment.

Table 12.2
Summary of Feasibility Study Alternatives and Disproportionate Cost Analysis

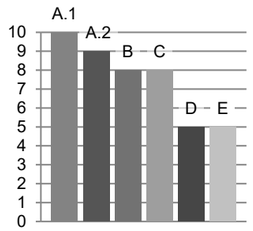
Alternative	Alternative A.1	Alternative A.2	Alternative B
Overall Protectiveness • Degree to which existing risks to human health and the environment are reduced • Time required to reduce risks and attain cleanup standards • Onsite and offsite risks resulting from alternative implementation • Improvement in overall environmental quality **Overall Protectiveness Benefit Scoring by Alternative**  	• Risks associated with contaminated soil in the Upland and Shoreline AOCs would be permanently reduced to a high degree by excavation. Excavation of contaminated soil would provide a reduction in risk associated with groundwater. • Risks associated with cVOC-contaminated groundwater on the BNSF AOC would be reduced by the installation of a PRB wall with ZVI. • The timeframe to reduce risks associated with soil would be immediately following remedy implementation. The timeframe for achievement of groundwater CULs Sitewide is anticipated to be 10 years. • Onsite risks during construction would be managed by proper H&S protocols and site security. There are no other added onsite risks. The offsite risks associated with contaminated material transport and disposal are negligible and would be managed using licensed operators and permitted disposal facilities. • Alternative A.1 achieves the highest improvement in overall environmental quality because it permanently removes the greatest mass of contamination. This alternative has a shorter anticipated restoration timeframe for groundwater compared to other alternatives due to significant source removal.	• Risks associated with contaminated soil in the remediated areas would be permanently reduced to a moderate degree by excavation. Some risk would remain from residual soil contamination greater than CULs but would be managed by a pavement cap and ICs. Removal of contaminated soil would reduce risk in groundwater. • Risks associated with cVOC-contaminated groundwater on the BNSF AOC would be reduced by the installation of a PRB wall with ZVI. • The timeframe to reduce risks associated with soil would be immediately following remedy implementation. The timeframe for achievement of groundwater CULs at the Upland CPOC is anticipated to be 15 years and at the Shoreline POC is anticipated to be 5 years. • Minimal onsite risks during construction would be managed by proper H&S protocols and site security. There are no other added onsite risks. The offsite risks associated with contaminated material transport and disposal are negligible and would be managed using licensed operators and facilities.	• Risks associated with contaminated soil in the remediated areas would be permanently reduced using excavation and ISS technologies. Some risk would remain from residual soil with contamination greater than CULs and the stabilized soil monoliths that would remain in place, but these risks would be managed by a pavement cap and ICs. Removal or treatment of contaminated soil would reduce risk in groundwater, but not as high of a reduction compared to full removal to CULs. • Risks associated with cVOC-contaminated groundwater on the BNSF AOC would be reduced by the installation of an interceptor trench and PRB wall with ZVI. • Risks associated with TPH-contamination in groundwater in CAA-5 would be addressed by removing the source material. • The timeframe to reduce risks associated with soil would be immediately following remedy implementation. The timeframe for achievement of groundwater CULs at the Upland CPOC is anticipated to be 15 years and at the Shoreline POC is anticipated to be 5 years. • Minimal onsite risks during construction would be managed by proper H&S protocols and site security. There are no other added onsite risks. The offsite risks associated with contaminated material transport and disposal are negligible and would be managed using licensed operators and facilities.
	Alternative C	**Alternative D**	**Alternative E**
	• Risks associated with contaminated soil in the remediated areas would be permanently reduced using excavation and ISS technologies. Some risk would remain from residual soil with contamination greater than CULs and the stabilized soil monoliths that would remain in place, but these risks would be managed by a pavement cap and ICs. Removal or treatment of contaminated soil would reduce risk in groundwater, but not as high of a reduction compared to full removal to CULs. • Risks associated with cVOC-contaminated groundwater on the BNSF AOC would be reduced by the installation of an interceptor trench and PRB wall with ZVI. Risks associated with cVOC-contaminated groundwater in CAA-5 would be addressed by in situ groundwater treatment and ERD. • Risks associated with TPH-contamination in groundwater in CAA-5 would be addressed by removing the source material. • The timeframe to reduce risks associated with soil would be immediately following remedy implementation. The timeframe for achievement of groundwater CULs at the Upland CPOC is anticipated to be 15 years and at the Shoreline POC is anticipated to be 5 years. • Minimal onsite risks during construction would be managed by proper H&S protocols and site security. There are no other added onsite risks. The offsite risks associated with contaminated material transport and disposal are negligible and would be managed using licensed operators and facilities.	• Risks associated with contaminated soil in remediated areas would be permanently reduced using excavation. Some risk would remain from residual soil with contamination greater than CULs, but this would be managed by a pavement cap and ICs. Removal of contaminated soil would reduce risk in groundwater, but not as high of a reduction compared to full removal to CULs. • Risks associated with contaminated soil and groundwater in the ERH treatment area in CAA-4 would be significantly reduced. Thermal treatment would also reduce risk from residual contamination outside of the treatment area due to the technology's radiating effect. • Risks associated with cVOC-contaminated groundwater on the BNSF AOC would be reduced by the installation of a PRB wall with ZVI. • The timeframe to reduce risks associated with soil would be immediately following remedy implementation. The timeframe for achievement of groundwater CULs at the Upland CPOC is anticipated to be 15 years and at the Shoreline POC is anticipated to be 5 years. • Minimal onsite risks during construction would be managed by proper H&S protocols and site security. There are no other added onsite risks. The offsite risks associated with contaminated material transport and disposal are negligible and would be managed using licensed operators and facilities.	• Risks associated with contaminated soil in the remediated areas would be permanently reduced using excavation and ISS technologies. Some risk would remain from residual soil with contamination greater than CULs and the stabilized soil monoliths that would remain in place, but these risks would be managed by a pavement cap and ICs. Removal or treatment of contaminated soil would reduce risk in groundwater, but not as high of a reduction compared to full removal to CULs. • Risks associated with cVOC-contaminated groundwater on the BNSF AOC would be reduced by the installation of an interceptor trench and PRB wall with ZVI. • The timeframe to reduce risks associated with soil would be immediately following remedy implementation. The timeframe for achievement of groundwater CULs at the Upland CPOC is anticipated to be 15 years and at the Shoreline POC is anticipated to be 5 years. • Minimal onsite risks during construction would be managed by proper H&S protocols and site security. There are no other added onsite risks. The offsite risks associated with contaminated material transport and disposal are negligible and would be managed using licensed operators and facilities.

Table 12.2
Summary of Feasibility Study Alternatives and Disproportionate Cost Analysis

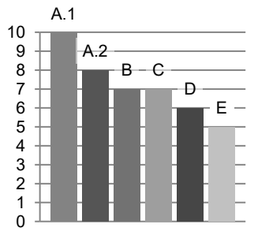
Alternative	Alternative A.1	Alternative A.2	Alternative B
Permanence • Degree of reduction of contaminant toxicity, mobility, and volume • Adequacy of destruction of hazardous substances • Reduction or elimination of substance release, and source of release • Degree of irreversibility of waste treatment processes • Volume and characteristics of generated treatment residuals	• Alternative A.1 provides the greatest reduction in contaminant volume compared to other alternatives. Excavation to CULs would fully remove contaminated soil volume within the Site, which would reduce contaminated groundwater concentration over the restoration timeframe. • Contaminated groundwater entering the Upland AOC from the BNSF AOC would be reduced by the PRB wall. • The primary sources of contamination would be removed from the Site by excavation. • Excavation and offsite disposal of contamination are irreversible. cVOC reduction in groundwater passing through the PRB wall is irreversible. • There are no treatment residuals associated with implementation of this technology.	• Alternative A.2 provides a greater reduction in contaminant volume compared to other alternatives, but less than the reduction from Alternative A.1. Excavation to RELs would remove a moderate volume of contaminated soil within the Site, which would reduce contaminated groundwater concentration over the restoration timeframe. • Contaminated groundwater entering the Upland AOC from the BNSF AOC would be reduced by the PRB wall. • The primary sources of contamination would be removed from the Site by excavation. • Excavation and offsite disposal of contamination are irreversible. cVOC reduction in groundwater passing through the PRB wall is irreversible. • There are no treatment residuals associated with implementation of this technology.	• Alternative B provides a moderate reduction of contaminant mobility in the Upland AOC. Alternative C would remove or immobilize a significant volume of contaminated soil within the Site, which would reduce contaminated groundwater concentration over the restoration timeframe. • Contaminated groundwater entering the Upland AOC from the BNSF AOC would be treated by the PRB wall. • The primary sources of groundwater contamination would be removed from the Site by excavation or immobilized by ISS. • ISS, excavation, and offsite disposal of contamination are irreversible. cVOC reduction in groundwater passing through the PRB wall is irreversible. • There are no treatment residuals associated with implementation of this technology.
	Alternative C	**Alternative D**	**Alternative E**
Overall Permanence Benefit Scoring by Alternative  	• Alternative C provides a moderate reduction of contaminant mobility in the Upland AOC. Alternative C would remove or immobilize a significant volume of contaminated soil within the Site, which would reduce contaminated groundwater concentration over the restoration timeframe. • Contaminated groundwater entering the Upland AOC from the BNSF AOC would be treated by the PRB wall. • TCE in groundwater near CAA-5 would be treated by in situ injection of a proprietary reagent mixture. • The primary sources of groundwater contamination would be removed from the Site by excavation or immobilized by ISS. • ISS, excavation, and offsite disposal of contamination are irreversible. cVOC reduction in groundwater passing through the PRB wall is irreversible. • There are no treatment residuals associated with implementation of this technology.	• Alternative D provides a low reduction in contaminant toxicity and volume compared to other alternatives using excavation and ERH treatment technologies. Alternative D would remove or treat a significant volume of contaminated soil within the Site, which would reduce contaminated groundwater concentration over the restoration timeframe. ERH treatment would also reduce the concentration of contaminated groundwater in CAA-4 and the immediately surrounding area during treatment. • Contaminated groundwater entering the Upland AOC from the BNSF AOC would be treated by the PRB wall. • The primary sources of contamination would be removed from the Site by excavation or treated and destroyed by ERH. • Thermal treatment, excavation, and offsite disposal of contamination are irreversible. cVOC reduction in groundwater passing through the PRB wall is irreversible. • There are no treatment residuals associated with implementation of this technology.	• Alternative E provides a low reduction of contaminant mobility in the Upland AOC. Alternative C would remove or immobilize a significant volume of contaminated soil within the Site, which would reduce contaminated groundwater concentration over the restoration timeframe. • Contaminated groundwater entering the Upland AOC from the BNSF AOC would be treated by the PRB wall. • The primary sources of groundwater contamination would be removed from the Site by excavation or immobilized by ISS. • ISS, excavation, and offsite disposal of contamination are irreversible. cVOC reduction in groundwater passing through the PRB wall is irreversible. • There are no treatment residuals associated with implementation of this technology.

Table 12.2
Summary of Feasibility Study Alternatives and Disproportionate Cost Analysis

Alternative	Alternative A.1	Alternative A.2	Alternative B
Effectiveness over the Long-Term • Degree of certainty of alternative success • Reliability while contaminants remain on site greater than CULs • Magnitude of residual risk • Effectiveness of controls implemented to manage residual risk **Overall Long-Term Effectiveness Benefit Scoring by Alternative** 	• Alternative A.1 provides the highest degree of effectiveness and certainty of success to meet RAOs and achieve groundwater CULs within a restoration timeframe of 10 years at the CPOC. • Excavation is an effective and common technology to implement and would fully remove contaminants in remediated areas. • Degree of certainty for success to remediate groundwater at the CPOC is high because a significant amount of source contamination would be removed. • The risk from groundwater contamination remaining on site during the restoration timeframe would be monitored by routine groundwater monitoring events until compliance with CULs was achieved. • Residual risk from soil and groundwater contamination remaining in place on the BNSF AOC is low and would be managed by PRB wall, which is a common and effective technology. There would be no other sources of residual risk.	• Alternative A.2 provides a high degree of certainty of success to meet RAOs and achieve groundwater CULs within a restoration timeframe of 15 years at the CPOC. • Excavation is an effective and common technology to implement and would fully remove contaminants in remediated areas. • Degree of certainty for success to remediate groundwater at the CPOC is moderate because a significant amount of source contamination would be removed, but not as extensively as other alternatives. • The risk from soil contamination greater than CULs remaining on site would be low and managed with ICs and a final pavement surface in the Upland AOC to block the direct contact and vadose zone leaching pathways. • The risk from groundwater contamination remaining on site during the restoration timeframe would be monitored by routine groundwater monitoring events until compliance with CULs was achieved. • Residual risk from soil and groundwater contamination remaining in place on the BNSF AOC is low and would be managed by the PRB wall, which is a common and effective technology. There would be no other sources of residual risk.	• Alternative B provides a high degree of certainty of success to meet RAOs and achieve groundwater CULs within a restoration timeframe of 15 years at the CPOC. • Degree of certainty for success to remediate groundwater at the CPOC is moderate because a significant amount of source contamination would be fully removed or stabilized. • The risk from soil contamination greater than CULs remaining on site would be low and managed with ICs and a final pavement surface on the Bulk Terminal and ASKO Properties to block the direct contact and vadose zone leaching pathways. The stabilized soil monolith within CAA-2 and CAA-4 would leave contaminants on site in an immobilized form, and, therefore, the residual risk would be very low. • The risk from groundwater contamination remaining on site during the restoration timeframe would be monitored by routine groundwater monitoring events until compliance with CULs was achieved. • Residual risk from soil and groundwater contamination remaining in place on the BNSF AOC is low and would be managed by the PRB wall, which is a common and effective technology. There would be no other sources of residual risk.
	Alternative C	**Alternative D**	**Alternative E**
	• Alternative C provides a moderate degree of certainty of success to meet RAOs and achieve groundwater CULs within a restoration timeframe of 15 years at the CPOC. • Degree of certainty for success to remediate groundwater at the CPOC is high because a significant amount of source contamination would be fully removed or stabilized and in situ groundwater treatment and ERD in CAA-5 would address TCE contamination in groundwater. • The risk from soil contamination greater than CULs remaining on site would be low and managed with ICs and a final pavement surface on the Bulk Terminal and ASKO Properties to block the direct contact and vadose zone leaching pathways. The stabilized soil monolith within CAA-2 and CAA-4 would leave contaminants on site in an immobilized form, and, therefore, the residual risk would be very low. • The risk from groundwater contamination remaining on site during the restoration timeframe would be monitored by routine groundwater monitoring events until compliance with CULs was achieved. • Residual risk from soil and groundwater contamination remaining in place on the BNSF AOC is low and would be managed by the PRB wall, which is a common and effective technology. There would be no other sources of residual risk.	• Alternative D provides a moderate degree of certainty of success to meet RAOs and achieve groundwater CULs within a restoration timeframe of 15 years at the CPOC. • Excavation and ERH treatment are effective and common technologies to implement and would significantly remove or treat contaminants in remediated areas. Geotechnical evaluations have been performed at the Site and have shown the Site conditions within the Upland AOC are favorable for ERH treatment. • Degree of certainty for success to remediate groundwater at the CPOC is high because a significant amount of source contamination would be removed or treated, and ERH treatment also reduces volatile concentrations in groundwater. • The risk from soil contamination greater than CULs remaining on site would be low and managed with ICs and a final pavement surface on the Bulk Terminal and ASKO Properties to block the direct contact and vadose zone leaching pathways. • The risk from groundwater contamination remaining on site during the restoration timeframe would be monitored by routine groundwater monitoring events until compliance with CULs was achieved. • Residual risk from soil and groundwater contamination remaining in place on the BNSF AOC is low and would be managed by the PRB wall, which is a common and effective technology. There would be no other sources of residual risk.	• Alternative E provides a moderate degree of certainty of success to meet RAOs and achieve groundwater CULs within a restoration timeframe of 15 years at the CPOC. • Degree of certainty for success to remediate groundwater at the CPOC is moderate because a significant amount of source contamination would be fully removed or stabilized, but not as extensively as other alternatives. • The risk from soil contamination greater than CULs remaining on site would be low and managed with ICs and a final pavement surface on the Bulk Terminal and ASKO Properties to block the direct contact and vadose zone leaching pathways. The stabilized soil monolith within CAA-2 and CAA-4 would leave contaminants on site in an immobilized form, and, therefore, the residual risk would be very low. • The risk from groundwater contamination remaining on site during the restoration timeframe would be monitored by routine groundwater monitoring events until compliance with CULs was achieved. • Residual risk from soil and groundwater contamination remaining in place on the BNSF AOC is low and would be managed by the PRB wall, which is a common and effective technology. There would be no other sources of residual risk.

Table 12.2
Summary of Feasibility Study Alternatives and Disproportionate Cost Analysis

Alternative	Alternative A.1	Alternative A.2	Alternative B
Short-Term Risk Management • Risk to human health and the environment associated with alternative construction • The effectiveness of controls in place to manage short-term risks **Overall Short-Term Risk Management Benefit Scoring by Alternative** 	• Alternative A.1 has the largest volume of contaminated material handling during remedy construction. • There is high short-term risk to human health and the environment during implementation due to handling contaminated material during excavation, which is a direct contact risk to construction workers and can release odors, which is a public health risk. These risks would be managed by proper H&S procedures, site security, and using an odor-suppression foam if necessary. This alternative would have the most amount of traffic, which a short-term risk due to potential for accidents, etc. • There is some risk for public exposure with this alternative due to increased traffic associated with contaminated soil transportation from the Site for disposal over public roadways; however, the excavated soil would be managed by licensed professionals at a permitted landfill. • Site activities would require appropriate PPE, BMPs, site controls to restrict site access, and appropriate training requirements for management of risk. These controls are highly effective and anticipated to adequately manage short-term risk.	• Alternative A.2 has a large volume of contaminated material handling during remedy construction compared to the other alternatives. • There is moderate short-term risk to human health and the environment during implementation due to handling contaminated material during excavation, which is a direct contact risk to construction workers and can release odors, which is a public health risk. These risks would be managed by proper H&S procedures, site security, and using an odor-suppression foam if necessary. • There is some risk for public exposure with this alternative due to increased traffic associated with contaminated soil transportation from the Site for disposal over public roadways; however, the excavated soil would be managed by licensed professionals at a permitted landfill. • Site activities would require appropriate PPE, BMPs, site controls to restrict site access, and appropriate training requirements for management of risk. These controls are highly effective and anticipated to adequately manage short-term risk.	• Alternative B has a large volume of contaminated material handling during remedy construction compared to the other alternatives. • There is moderate short-term risk to human health and the environment during implementation due to handling and in situ mixing of contaminated material. These activities are a direct contact risk to construction workers and can release odors, which is a public health risk. These risks would be managed by proper H&S procedures, site security, and using an odor-suppression foam if necessary. • There is some risk for public exposure with this alternative due to increased traffic associated with contaminated soil transportation from the Site for disposal over public roadways; however, the excavated soil would be managed by licensed professionals at a permitted landfill. • Site activities would require appropriate PPE, BMPs, site controls to restrict site access, and appropriate training requirements for management of risk. These controls are highly effective and anticipated to adequately manage short-term risk.
	Alternative C	**Alternative D**	**Alternative E**
	• Alternative C has a moderate volume of contaminated material handling during remedy construction compared to the other alternatives. • There is moderate short-term risk to human health and the environment during implementation due to handling and in situ mixing of contaminated material. These activities are a direct contact risk to construction workers and can release odors, which is a public health risk. These risks would be managed by proper H&S procedures, site security, and using an odor-suppression foam if necessary. • There is some risk for public exposure with this alternative due to increased traffic associated with contaminated soil transportation from the Site for disposal over public roadways; however, the excavated soil would be managed by licensed professionals at a permitted landfill. • Site activities would require appropriate PPE, BMPs, site controls to restrict site access, and appropriate training requirements for management of risk. These controls are highly effective and anticipated to adequately manage short-term risk.	• Alternative D has a low volume of contaminated material handling during remedy construction compared to the other alternatives. • There is moderate short-term risk to human health and the environment during implementation due to handling and in situ mixing of contaminated material. These activities are a direct contact risk to construction workers and can release odors, which is a public health risk. These risks would be managed by proper H&S procedures, site security, and using an odor-suppression foam if necessary. • There is some risk for public exposure with this alternative due to increased traffic associated with contaminated soil transportation from the Site for disposal over public roadways; however, the excavated soil would be managed by licensed professionals at a permitted landfill. • Site activities would require appropriate PPE, BMPs, site controls to restrict site access, and appropriate training requirements for management of risk. These controls are highly effective and anticipated to adequately manage short-term risk.	• Alternative E has a low volume of contaminated material handling during remedy construction compared to the other alternatives. • There is moderate short-term risk to human health and the environment during implementation due to handling contaminated material during excavation. These activities are a direct contact risk to construction workers and can release odors, which is a public health risk. These risks would be managed by proper H&S procedures, site security, and using an odor-suppression foam if necessary. • There is a low short-term risk to construction worker health from drilling and installed electrodes used by the ERH treatment system. These risks would be managed by site controls, operation training requirements, and proper H&S procedures. • There is some risk for public exposure with this alternative due to increased traffic associated with contaminated soil transportation from the Site for disposal over public roadways; however, the excavated soil would be managed by licensed professionals at a permitted landfill. • Site activities would require appropriate PPE, BMPs, site controls to restrict site access, and appropriate training requirements for management of risk. These controls are highly effective and anticipated to adequately manage short-term risk.

Table 12.2
Summary of Feasibility Study Alternatives and Disproportionate Cost Analysis

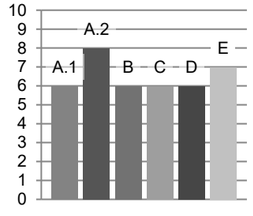
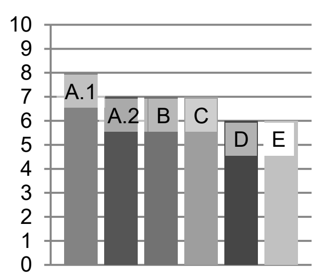
Alternative	Alternative A.1	Alternative A.2	Alternative B
Technical and Administrative Implementability *Ability of alternative to be implemented considering:* • Technical possibility • Availability of offsite facilities, services, and materials • Administrative and regulatory requirements • Schedule, size, and complexity of construction • Monitoring requirements • Site access for construction, operations, and monitoring • Integration with existing site operations or other current and potential future remedial action	• Alternative A.1 is technically challenging due to shoring and dewatering requirements for deep excavation. • All necessary offsite facilities, materials, and services are available within the region. • This alternative is large in scale. Excavation is a common technology that can be safely implemented by many contractors in the local area. This alternative can be implemented easily in 1–2 construction seasons. • Monitoring requirements include protection monitoring for workers during construction (e.g., vapor monitoring) and groundwater monitoring following implementation. • ICs would be maintained on the Upland AOC in perpetuity, and the pavement cap would be maintained and monitored in compliance with the ICs. • This alternative is intended to be completed as part of Site redevelopment and will be integrated with proposed future site uses.	• Alternative A.2 is technically possible to implement and involves common technologies. • All necessary offsite facilities, materials, and services are available within the region. • This alternative is moderate in scale. Excavation is a common technology that can be safely implemented by many contractors in the local area. This alternative can easily be implemented in 1–2 construction seasons. • Monitoring requirements include protection monitoring for workers during construction (e.g., vapor monitoring) and groundwater monitoring following implementation. • ICs would be maintained on the Upland AOC in perpetuity and the pavement cap would be maintained and monitored in compliance with the ICs. • This alternative is intended to be completed as part of Site redevelopment and will be integrated with proposed future site uses.	• Alternative B is technically possible to implement and involves common technologies. • All necessary offsite facilities, materials, and services are available within the region. • This alternative is moderate in scale. This alternative would be managed and constructed by specialty professionals familiar with ISS technology, and this alternative can be implemented in 1–2 construction seasons. • Monitoring requirements include protection monitoring for workers during construction (e.g., vapor monitoring), collection of wet ISS grout after soil mixing for moisture content testing before soil-grout mixture sets up and unconfined compressive strength and hydraulic conductivity testing post-curing of soil-grout mixture during construction, and groundwater monitoring following implementation. • ICs would be maintained on the Upland AOC in perpetuity, and the pavement cap would be maintained and monitored in compliance with the ICs. • This alternative is intended to be completed as part of Site redevelopment and will be integrated with proposed future site uses.
	Alternative C	**Alternative D**	**Alternative E**
Overall Technical and Administrative Implementability Benefit Scoring by Alternative  	• Alternative C is technically possible to implement and involves common technologies. • All necessary offsite facilities, materials, and services are available within the region. • This alternative is moderate in scale. This alternative would be managed and constructed by specialty professionals familiar with ISS technology, and this alternative can be implemented in 1–2 construction seasons. • Monitoring requirements include protection monitoring for workers during construction (e.g., vapor monitoring), collection of wet ISS grout after soil mixing for moisture content testing before soil-grout mixture sets up and unconfined compressive strength and hydraulic conductivity testing post-curing of soil-grout mixture during construction, and groundwater monitoring following implementation. • ICs would be maintained on the Upland AOC in perpetuity, and the pavement cap would be maintained and monitored in compliance with the ICs. • This alternative is intended to be completed as part of Site redevelopment and will be integrated with proposed future site uses.	• Alternative D is technically possible to implement and involves common technologies but requires specialized contractors trained to implement ERH. • All necessary offsite facilities, materials, and services are available within the region. • This alternative is moderate in scale. This alternative would be managed and constructed by specialty professionals familiar with the type of work, and this alternative would be implemented in 2 construction seasons. • Monitoring requirements include protection monitoring for workers during construction (e.g., vapor monitoring), temperature and treated permitted effluent monitoring during vapor extraction, water/condensate monitoring during construction, routine O&M of system during operation, and groundwater monitoring following implementation. • ICs would be maintained on the Upland AOC in perpetuity, and the pavement cap would be maintained and monitored in compliance with the ICs. • This alternative is intended to be completed as part of Site redevelopment and will be integrated with proposed future site uses.	• Alternative E is technically possible to implement and involves common technologies. • All necessary offsite facilities, materials, and services are available within the region. • This alternative is moderate in scale. This alternative would be managed and constructed by specialty professionals familiar ISS technology, and this alternative can be implemented in 1–2 construction seasons. • Monitoring requirements include protection monitoring for workers during construction (e.g., vapor monitoring), collection of wet ISS grout after soil mixing for moisture content testing before soil-grout mixture sets up and unconfined compressive strength and hydraulic conductivity testing post-curing of soil-grout mixture during construction, and groundwater monitoring following implementation. • ICs would be maintained on the Upland AOC in perpetuity, and the pavement cap would be maintained and monitored in compliance with the ICs. • This alternative is intended to be completed as part of Site redevelopment and will be integrated with proposed future site uses.

Table 12.2
Summary of Feasibility Study Alternatives and Disproportionate Cost Analysis

Alternative	Alternative A.1	Alternative A.2	Alternative B
Consideration of Public Concerns • Whether the community has concerns • Degree to which the alternative addresses those concerns	Public concerns will be reviewed following the public comment period and addressed in the final remedial alternative selection and design. However, most of the Site is currently vacant with a significant amount of contamination. It is anticipated that the public would have minimal concern with cleanup and redevelopment of vacant properties. Scoring for Considerations of Public Concerns was provided by Ecology.	Public concerns will be reviewed following the public comment period and addressed in the final remedial alternative selection and design. However, most of the Site is currently vacant with a significant amount of contamination. It is anticipated that the public would have minimal concern with cleanup and redevelopment of vacant properties. Scoring for Considerations of Public Concerns was provided by Ecology.	Public concerns will be reviewed following the public comment period and addressed in the final remedial alternative selection and design. However, most of the Site is currently vacant with a significant amount of contamination. It is anticipated that the public would have minimal concern with cleanup and redevelopment of vacant properties. Scoring for Considerations of Public Concerns was provided by Ecology.
Overall Consideration of Public Conerns Benefit Scoring by Alternative 	**Alternative C**	**Alternative D**	**Alternative E**
	Public concerns will be reviewed following the public comment period and addressed in the final remedial alternative selection and design. However, most of the Site is currently vacant with a significant amount of contamination. It is anticipated that the public would have minimal concern with cleanup and redevelopment of vacant properties. Scoring for Considerations of Public Concerns was provided by Ecology.	Public concerns will be reviewed following the public comment period and addressed in the final remedial alternative selection and design. However, most of the Site is currently vacant with a significant amount of contamination. It is anticipated that the public would have minimal concern with cleanup and redevelopment of vacant properties. Scoring for Considerations of Public Concerns was provided by Ecology.	Public concerns will be reviewed following the public comment period and addressed in the final remedial alternative selection and design. However, most of the Site is currently vacant with a significant amount of contamination. It is anticipated that the public would have minimal concern with cleanup and redevelopment of vacant properties. Scoring for Considerations of Public Concerns was provided by Ecology.
Cost • Cost of construction • Long-term monitoring, operations, and maintenance costs • Agency oversight costs	**Alternative A.1**	**Alternative A.2**	**Alternative B**
	Total cost: $16,151,000 • Includes construction, long-term monitoring, O&M, and agency oversight costs • Includes tax • Includes 20% contingency	Total cost: $12,244,000 • Includes construction, long-term monitoring, O&M, and agency oversight costs • Includes tax • Includes 20% contingency	Total cost: $8,251,000 • Includes construction, long-term monitoring, O&M, and agency oversight costs • Includes tax • Includes 20% contingency
	Alternative C	**Alternative D**	**Alternative E**
	Total cost: $7,821,000 • Includes construction, long-term monitoring, O&M, and agency oversight costs • Includes tax • Includes 20% contingency	Total cost: $7,404,000 • Includes construction, long-term monitoring, O&M, and agency oversight costs • Includes tax • Includes 20% contingency	Total cost: $6,727,000 • Includes construction, long-term monitoring, O&M, and agency oversight costs • Includes tax • Includes 20% contingency

Abbreviations:

AOC = Area of concern, bgs = Below ground surface, BMP = Best management practice, CAA = Cleanup Action Area, CPOC = Conditional point of compliance, cVOC = Chlorinated volatile organic compound, CUL = Cleanup level, ERD = Enhanced reductive dechlorination, ERH = Electrical resistance heating, H&S = Health and safety, IC = Institutional control, IHS = Indicator hazardous substance, ISS = In situ solidification and stabilization, LNAPL = Light non-aqueous-phase liquid, O&M = Oversight and management, PPE = Personal protective equipment, PRB = Permeable Reactive Barrier, RAO = Remedial Action Objective, REL = Remediation Level, ROW = Right of way, SMP = Soil Management Plan, TCE = Trichloroethene, TPH = Total petroleum hydrocarbons, ZVI = Zero valent iron

Table 13.1
Applicable or Relevant and Appropriate Requirements for the Preferred Remedial Alternative

Standard, Requirement, or Limitation [1]	Description
Location-Specific ARARs [2]	
State Environmental Policy Act (RCW 43.21C; WAC 197-10)	SEPA review is required for MTCA cleanup actions; Ecology will be the lead agency for this effort.
Washington Shoreline Management Act (RCW 90.58; WAC 173-14)	The Washington Shoreline Management Act, authorized under the federal Coastal Zone Management Act, establishes requirements for substantial development occurring within the waters of Washington or within 200 feet of a shoreline.
Seattle Shoreline Master Program (SMC 23.60A)	Implements the requirements imposed on the City of Seattle by the Washington Shoreline Management Act (RCW 90.58) and ensures that development under the program will not cause a net loss of ecological functions. Applies to areas with 200 feet of a waterbody regulated by the program.
Seattle Critical Areas Regulations (SMC 25.09)	This chapter establishes regulations pertaining to the development within or adjacent to critical areas, which include areas that provide a variety of biological and physical functions that benefit the City of Seattle and its residents, including water quality protection, fish and wildlife habitat, and food chain support.
Endangered Species Act (16 USC 1531 et seq.; 50 CFR 17, 225, and 402) Migratory Bird Treaty Act (16 USC 742a-j and 40 CFR 10.13)	These statutes regulate the incidental take of migratory birds (such as Canada geese) and other endangered species by facility operations and construction activities.
Native American Graves Protection and Repatriation Act (25 USC 3001 through 3013; 43 CFR 10) Washington's Indian Graves and Records Law (RCW 27.44)	These statutes prohibit the destruction or removal of Native American cultural items and require written notification of inadvertent discovery to the appropriate agencies and Native American tribe. These programs are applicable to the remedial action if cultural items are found. The activities must cease in the area of the discovery; a reasonable effort must be made to protect the items discovered; and notice must be provided.
Archaeological Resources Protection Act (16 USC 470aa et seq.; 43 CFR 7)	This program sets forth requirements that are triggered when archaeological resources are discovered. These requirements only apply if archaeological items are discovered during implementation of the selected remedy.
National Historic Preservation Act (16 USC 470 et seq.; 36 CFR parts 60, 63, and 800)	This program sets forth a national policy of historic preservation and provides a process that must be followed to ensure that impacts of actions on archaeological, historic, and other cultural resources are protected.
Action-Specific ARARs [3]	
State Environmental Policy Act (RCW 43.21C, WAC 197-11)	Establishes the state's policy for protection and preservation of the natural environment. Applies to cleanup actions conducted under MTCA.
Resource Conservation and Recovery Act (42 USC 6921-6949a; 40 CFR Part 268, Subtitles C and D)	Establishes requirements for the identification, handling, and disposal of hazardous and non-hazardous waste.
Dangerous Waste Regulations (RCW 70.105; WAC 173-303)	Establishes regulations that are the state equivalent of RCRA requirements for determining whether a solid waste is a state dangerous waste. This regulation also provides requirements for the management of dangerous wastes.
Solid Waste Disposal Act (42 USC Sec. 6901-6992; 40 CFR 257-258) Federal Land Disposal Requirements (40 CFR 268)	Protects health and the environment and promotes conservation of valuable material and energy resources. The Solid Waste Disposal Act establishes a framework for regulation of solid waste disposal. Federal land disposal requirements promulgated under the authority of the Solid Waste Disposal Act set minimum safety requirements for landfills including limitations on storage and land disposal for hazardous substances.
Department of Transportation Hazardous Materials Regulations (49 CFR 172)	Regulates the safe and secure transportation of hazardous materials, including documentation and handling requirements for shipping.
Washington Minimum Functional Standards for Solid Waste Handling (WAC 173-304)	Sets minimum functional standards for the proper handling of all solid waste materials originating from residences, commercial, agricultural, and industrial operations, as well as other sources.
Washington Solid Waste Handling Standards (RCW 70.95 and WAC 173-350)	Establishes minimum standards for handling and disposal of solid waste. Solid waste includes wastes that are likely to be generated as a result of site remediation, including contaminated soils, construction and demolition wastes, and garbage.
Washington Water Pollution Control Law (RCW 90.48; WAC 173-216, WAC 173-220) National Pollution Discharge Elimination System (CWA Part 402)	Washington has been delegated authority to issue NPDES permits. CWA Section 301, 302, and 303 require states to adopt water quality standards and implement a NPDES permitting process. The Washington Water Pollution Control Law and regulations address this requirement.
Noise Control Act of 1974 (RCW 70.107, WAC 173-60)	Establishes maximum noise levels.
Washington State Underground Injection Control Program (WAC 173-218)	Washington is authorized under CWA Sections 144 through 147 to administer a statewide Underground Injection Control program to protect groundwater by regulating the discharge of fluid from injection wells including temporary injection points.
City of Seattle Traffic Code (SMC 11.1)	The City of Seattle code regulates construction use and permitting in the right of way.

Table 13.1
Applicable or Relevant and Appropriate Requirements for the Preferred Remedial Alternative

Standard, Requirement, or Limitation [1]	Description
Action-Specific ARARs [3] (cont.)	
City of Seattle Construction Codes for Grading (SMC 22.170)	Required for the excavation or addition of material within an Environmentally Critical Area, movement of more than 500 cubic yards of material, and in-place modification of the ground (soil remediation).
Seattle of Seattle Construction Codes for Demolition (Seattle Building Code Chapter 33)	Regulates the demolition of any structures within an Environmentally Critical Area or greater than 120 square feet in size.
National Electrical Code (NFPA 70) and the Seattle Electric Code Supplement for Class 1 Division 2 Environments.	Establishes restrictions and guidelines for temporary and/or permanent electrical installations.
City of Seattle Water Utilities Code (SMC 21.04)	Establishes rules for hydrant water use.
King County Industrial Waste Program	The King County Industrial Waste Program monitors discharge of liquid waste to the wastewater (sanitary sewer) system. Any discharges during construction to the wastewater system must be approved by King County prior to discharge. The King County Industrial Waste Program monitors volume and water quality of liquid waste discharged to the system.
Federal, State, and Local Air Quality Protection Programs State Implementation of Ambient Air Quality Standards NWAPA Ambient and Emission Standards Regional Standards for Fugitive Dust Emissions Toxic Air Pollutants	Regulations promulgated under the federal Clean Air Act (42 USC 7401) and the Washington State Clean Air Act (RCW 70.94) govern the release of airborne contaminants from point and non-point sources. Local air pollution control authorities such as PSCAA have also set forth regulations for implementing these air quality requirements. These requirements may be applicable to the Site for the purposes of demolition or dust control. PSCAA requires notification prior to demolition of any building with asbestos-containing material. Both PSCAA (under Regulation III) and WAC 173-460 establish ambient source impact levels for arsenic.
Chemical-Specific ARARs [4]	
Model Toxics Control Act (WAC 173-340)	Establishes Washington administrative processes and standards to identify, investigate, and clean up facilities where hazardous substances are located.
Drinking Water Standards—State MCLs (WAC 246-290-310)	Establishes standards for contaminant levels in drinking water for water system purveyors.
Water Quality Standards for Groundwaters of the State of Washington (WAC 173-200)	Implements the Water Pollution Control Act and the Water Resources Act of 1971 (90.54 RCW).
National Recommended Water Quality Standards (40 CFR 131) Washington Maximum Contaminant Levels (WAC 246-290-310)	These water quality standards define the water quality goals of the water body by designating the use or uses to be made of the water and by setting criteria necessary to protect the uses. States adopt water quality standards from 40 CFR 131 to protect public health or welfare, enhance the quality of water, and serve the purposes of the CWA. Washington water quality standards (MCLs) are presented in WAC.

Notes:

1 Projects conducted under a consent decree are exempt from the procedural requirements of most state and local permits (RCW 70.105D.090); however, the remedial actions must still comply with the substantive requirements of the exempt permits. Therefore, for exempt permits, the statutory review timelines do not apply; actual timelines will be based on negotiations with the jurisdiction or agency, which should result in an expedited review timeline.
2 Location-specific ARARs are requirements that are applicable to the specific area where the Site is located, and can restrict the performance of activities, including cleanup actions, solely because they occur in specific locations.
3 Action-specific ARARs are requirements that are applicable to certain types of activities that occur or technologies that are used during the implementation of cleanup actions.
4 Chemical-specific ARARs are applicable to the types of contaminants present at the Site. The cleanup of contaminated media at the Site must meet the CULs developed under MTCA; these CULs are considered chemical-specific ARARs.

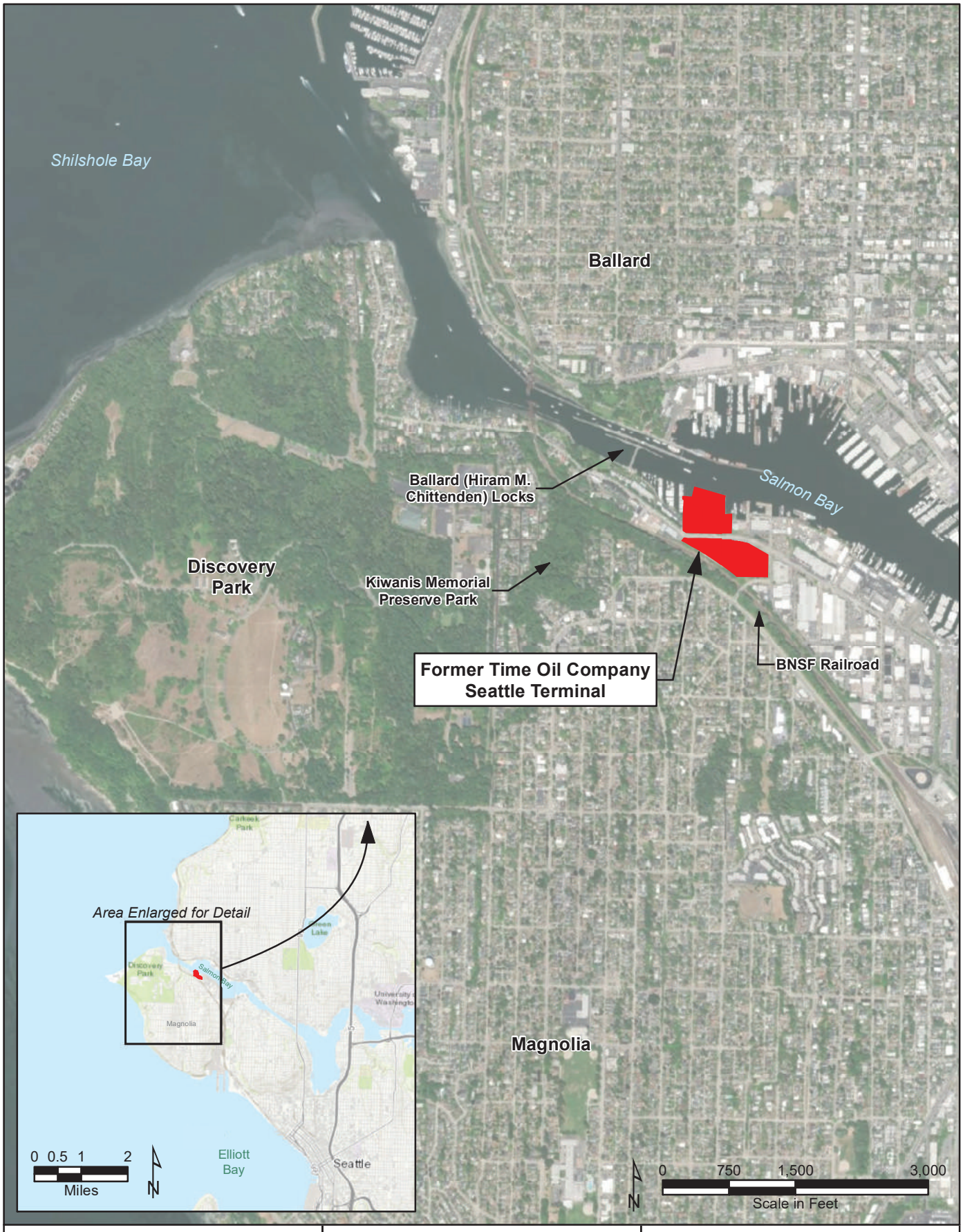
Abbreviations:

ARAR	Applicable or Relevant and Appropriate Requirement
CFR	Code of Federal Regulations
CWA	Clean Water Act
Ecology	Washington State Department of Ecology
MCL	Maximum Contaminant Level
MTCA	Model Toxics Control Act
NPDES	National Pollutant Discharge Elimination System
NWAPA	Northwest Air Pollution Authority
PSCAA	Puget Sound Clean Air Agency
RCRA	Resource Conservation and Recovery Act
RCW	Revised Code of Washington
SEPA	State Environmental Policy Act
SMC	Seattle Municipal Code
USC	U.S. Code
WAC	Washington Administrative Code

Time Oil Bulk Terminal PPA

Supplemental Upland Remedial Investigation and Feasibility Study

Figures



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Supplemental Upland RI/FS
Time Oil Bulk Terminal PPA
Seattle, Washington

Figure 1.1
Site Location Map

I:\GIS\Projects\Cantera-TOC\MXD\RIFS\RI 2019\Figure 1.1 Site Location Map.mxd
9/11/2020

Legend

- Property Boundary for the Seattle Terminal Properties
- Adjacent Parcel Boundary

LOCKHAVEN MARINA MOORAGE-DNR LEASE
PARCEL ID: 1125039108

DNR AQUATIC LEASE LAND PROPERTY
PARCEL ID: 1125039113

Salmon Bay

LOCKHAVEN APARTMENTS AND MARINA
PARCEL ID: 1125039047

EAST WATERFRONT PROPERTY
PARCEL ID: 1125039120

31st Ave W

WAREHOUSE
PARCEL ID: 4237900410

WEST WATERFRONT PROPERTY
PARCEL ID: 1125039081

MARTIME INDUSTRIAL CENTER
PARCEL ID: 1125039068

BNSF
PARCEL ID: 4237900240

WAREHOUSE
PARCEL ID: 4237900300

W. Commodore Way

27th Ave W

CSR BOATYARD
PARCEL ID: 2771605265

ASKO HYDRAULIC PROPERTY
PARCEL ID: 4237900405

BNSF
PARCEL ID: 4237900240

BNSF Railroad

BULK TERMINAL PROPERTY
PARCEL ID: 1125039050

WAREHOUSE
PARCEL ID: 2771605365

27th Ave W

WAREHOUSE
PARCEL ID: 2770606119

26th Ave W

W. Government Way

W. Fort St

BNSF
PARCEL ID: 7010701210

BNSF
PARCEL ID: 2770605900

Notes:
· Parcel boundaries obtained from King County Geographic Information Systems Center, 2011. Lot lines are approximate. Not for legal use.
· Orthoimagery obtained from Nearmap, 2018.

Abbreviation:
DNR = Washington State Department of Natural Resources

0 75 150 300
Scale in Feet

N

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Time Oil Bulk Terminal PPA
Seattle, Washington

Figure 1.2
Property Vicinity Map

I:\GIS\Projects\Cantera-TOC\MXD\RIFS\RI 2019\Figure 1.2 Property Vicinity Map.mxd
9/11/2020

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

FORMER WAREHOUSE
SHED
GARAGE
MATCH LINE
FORMER BARREL INCLINE
FORMER TESTING LABORATORY
FORMER UTILIDOR
FORMER OVERHEAD LOADING RACKS
FORMER BOTTOM LOADING RACK
W. COMMODORE WAY NORTH TRUCK SEWER
W. Commodore Way
27th Ave W
FORMER GASOLINE/ DIESEL USTS
EAST BARREL INCLINE
FORMER BARRELING SHED #1
FORMER TOC HOLDINGS OFFICE
FORMER PUMP ISLAND
FORMER TANK FARM
FORMER MANIFOLD PIT
FORMER BARRELING SHED #2
FORMER PENTA MIXING AST
LOWER TANK YARD
MARINE SERVICE AND SUPPLY
BULK TERMINAL PROPERTY
FORMER BOILER HOUSE
UPPER TANK YARD
BNSF Railroad
W. Fort St

Notes:
- Parcel boundaries obtained from King County Geographic Information Systems Center, 2011. Lot lines are approximate. Not for legal use.
- Orthoimagery obtained from U.S. Geological Survey, 2002.

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

0 30 60 120
Scale in Feet

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Supplemental Upland RI/FS
Time Oil Bulk Terminal PPA
Seattle, Washington

Figure 2.1a
Former TOC Seattle Terminal Features

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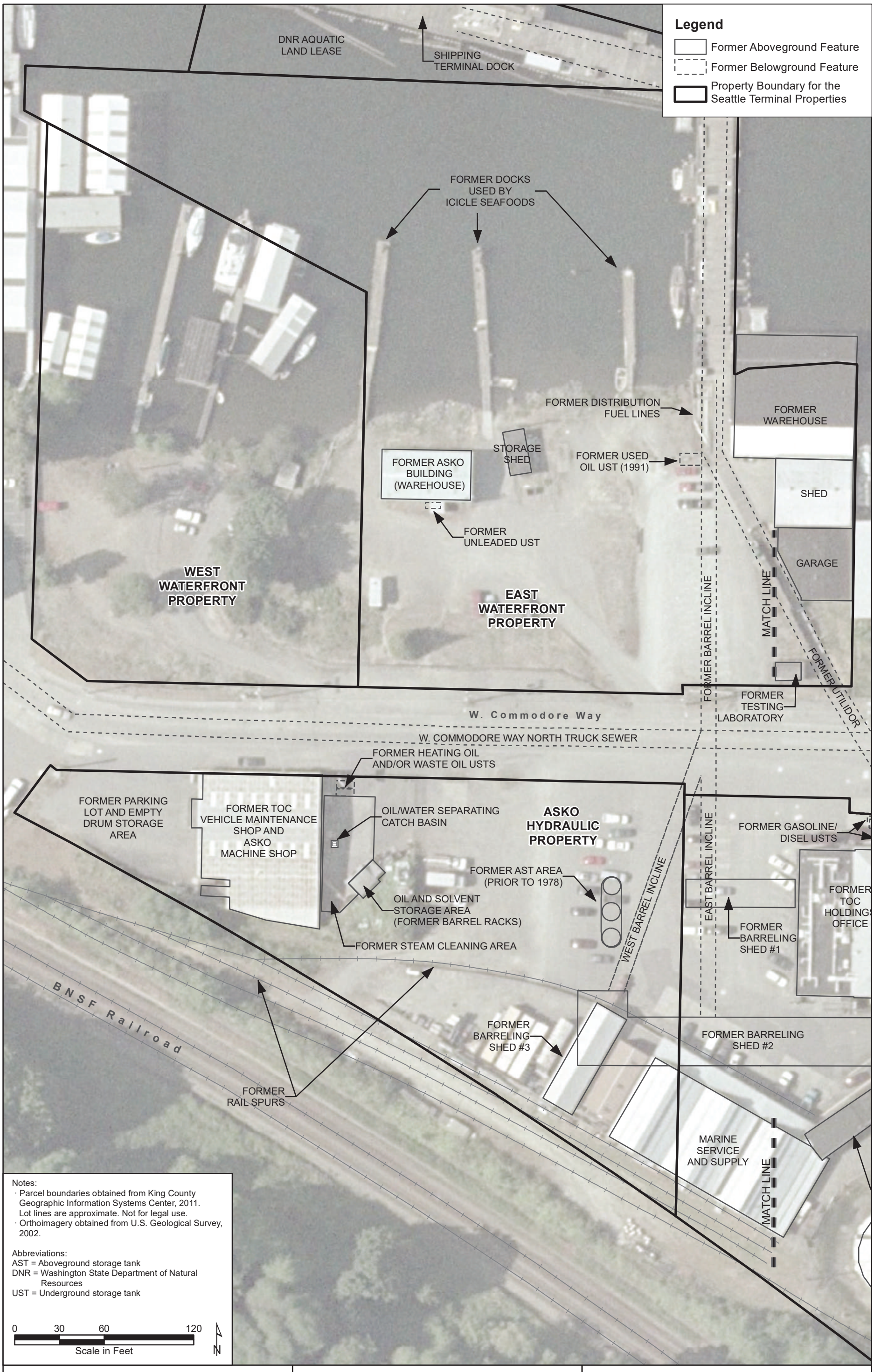
9/11/2020



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Time Oil Bulk Terminal PPA
Seattle, Washington

Figure 2.1b
Former TOC Seattle Terminal Features

I:\GIS\Projects\Cantera-TOC\MXD\RIFS\RI 2019\Figure 2.1b Former TOC Seattle Terminal Features.mxd
9/11/2020

Legend

Sewer Lines

- Combined/Sanitary Sewer Main Line
- Sewer Drainage Lateral

Other Site Features

- Property Boundary for the Seattle Terminal Properties

Salmon Bay

FORMER TOC DOCK (VACANT)

LOCKHAVEN MARINA HOUSEBOAT MOORAGE

FORMER ASKO WAREHOUSE (VACANT)

STORAGE SHED (VACANT)

LOCKHAVEN MARINA RESIDENT DRIVEWAY AND PARKING

WEST WATERFRONT PROPERTY

EAST WATERFRONT PROPERTY

FORMER TOC BUILDINGS (VACANT)

31st Ave W

W. COMMODORE WAY NORTH TRUCK SEWER

W. Commodore Way

ABOVEGROUND PIPING

TREATMENT SYSTEM AST AREA

27th Ave W

PAVED PARKING AREA

PAVED PARKING AREA

TREE/LOG STORAGE

PAVED PARKING AREAS

FORMER TOC OFFICE BUILDING (VACANT)

W. COMMODORE WAY NORTH TRUCK SEWER

FORMER ASKO MACHINE SHOP (VACANT)

ASKO HYDRAULIC PROPERTY

GROUNDWATER EXTRACTION WELL NETWORK

BNSF Railroad

KING COUNTY METRO SANITARY SEWER (STORMWATER SYSTEM DISCHARGE POINT)

TREATMENT SYSTEM SHEDS

MARINE SUPPLY SERVICE BUILDINGS AND LOADING AREA

ABOVEGROUND PIPING

BULK TERMINAL PROPERTY

27th Ave W

26th Ave W

W. Government Way

W. Fort St

Notes:
- Sewer line layer obtained from the City of Seattle, accessed June 2020, with adjustments as indicated on as-built drawings obtained from City of Seattle archives.
- Parcel boundaries obtained from King County Geographic Information Systems Center, 2011. Lot lines are approximate. Not for legal use.
- Orthoimagery obtained from Nearmap, 2018.

Abbreviation:
AST = Aboveground storage tank

0 62.5 125 250
Scale in Feet

N

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Seattle, Washington

Figure 2.2
Current Property Features

I:\GIS\Projects\Cantera-TOC\MXD\RIFS\RI 2019\Figure 2.2 Current Property Features.mxd
9/11/2020

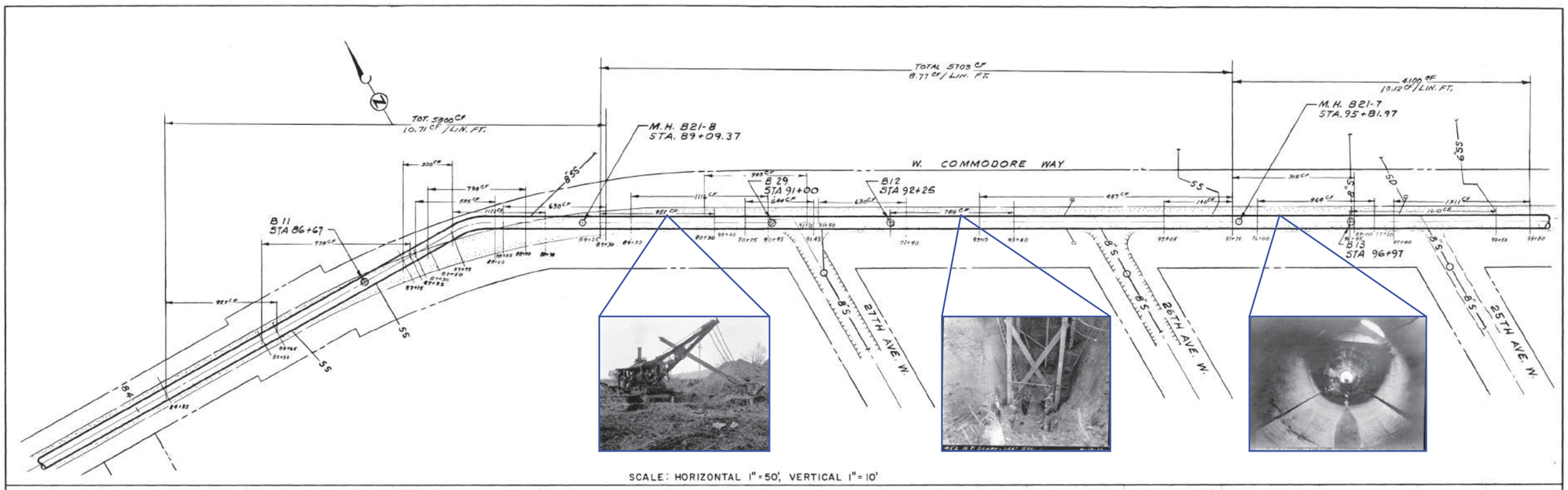

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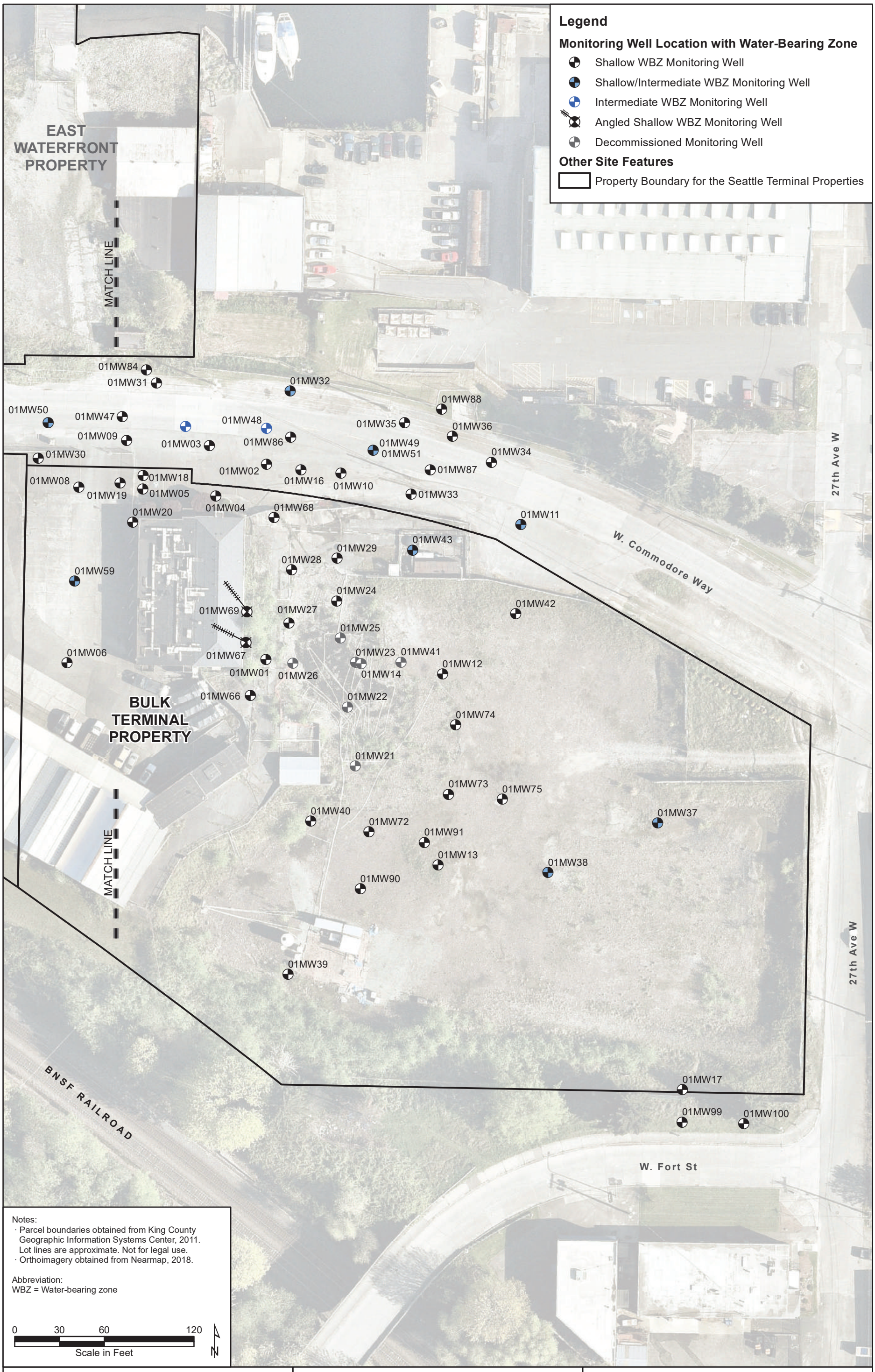
Figure 2.3
Historical Sewer Line

I:\GIS\Projects\Cantera-TOC\AI\North Trunk Sewer\Figure 2.3 Historical Sewer Line_2020-0402.ai
04/02/2020



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Supplemental Upland RI/FS
Time Oil Bulk Terminal PPA
Seattle, Washington

Figure 3.1a
Previous Investigation
Monitoring Well Locations

I:\GIS\Projects\Cantera-TOC\MXD\RIFS\RI 2019\Figure 3.1a Previous Investigation Monitoring Well Locations.mxd
9/11/2020

Legend

Monitoring Well Location with Water-Bearing Zone

- Shallow WBZ Monitoring Well
- Shallow/Intermediate WBZ Monitoring Well
- Intermediate WBZ Monitoring Well
- Deep WBZ Monitoring Well
- Perched WBZ Monitoring Well
- Decommissioned Monitoring Well

Other Site Features

- Property Boundary for the Seattle Terminal Properties

DNR AQUATIC LEASE LAND PROPERTY

WEST WATERFRONT PROPERTY

EAST WATERFRONT PROPERTY

ASKO HYDRAULIC PROPERTY

BULK TERMINAL PROPERTY

MATCH LINE

MATCH LINE

W. Commodore Way

BNSF RAILROAD

02MW01 02MW02 02MW03 02MW04 02MW05 02MW06 02MW07 02MW08 02MW09 02MW10 02MW11 02MW12 02MW13 02MW14 02MW15 02MW16

01MW15 01MW30 01MW44 01MW45 01MW46 01MW52 01MW53 01MW54 01MW55 01MW56 01MW57 01MW58 01MW59 01MW60 01MW61 01MW62 01MW63 01MW64 01MW65 01MW70 01MW71 01MW76 01MW77 01MW78 01MW79 01MW80 01MW83 01MW85 01MW89 01MW92 01MW93 01MW94 01MW95 01MW96 01MW97 01MW98 01MW108

MW01 MW02 MW03 MW04 MW05 MW06

Notes:
- Parcel boundaries obtained from King County Geographic Information Systems Center, 2011. Lot lines are approximate. Not for legal use.
- Orthoimagery obtained from Nearmap, 2018.

Abbreviations:
DNR = Washington State Department of Natural Resources
WBA = Water-bearing zone

0 30 60 120
Scale in Feet

N

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Time Oil Bulk Terminal PPA
Seattle, Washington

Figure 3.1b
Previous Investigation
Monitoring Well Locations

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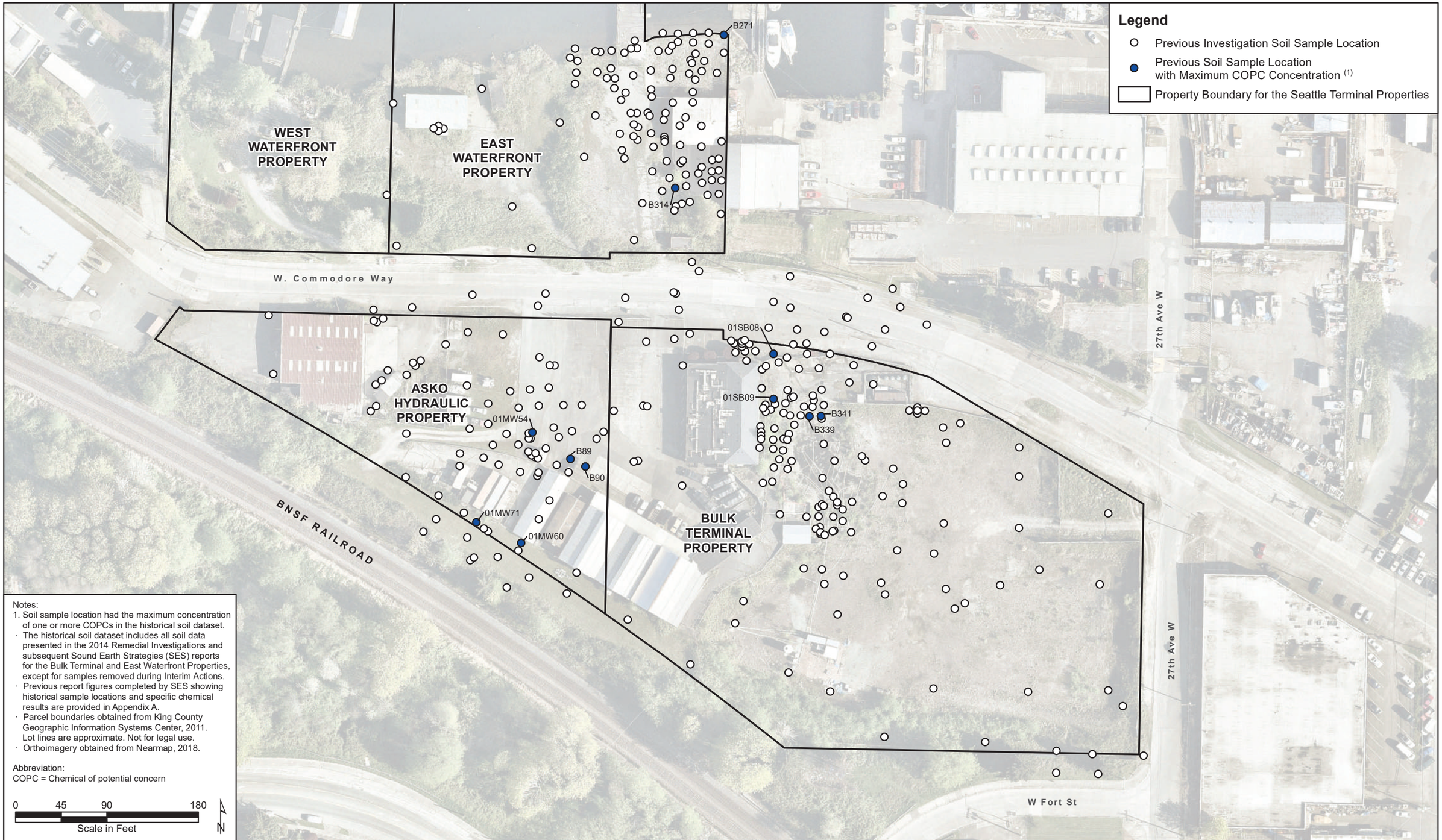
9/11/2020



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Time Oil Bulk Terminal PPA
Seattle, Washington

Figure 3.2
Previous Investigation Soil Sample Locations

I:\GIS\Projects\Cantera-TOC\MXD\RIFS\RI 2019\Figure 3.2 Previous Investigation Soil Sample Locations.mxd
9/11/2020

Legend

Historical Excavation Areas

- 2014: UST Excavation
- 2012: Penta and Dioxin/Furan Final Excavation
- 2012: Pipeline and TPH Soil Removal
- 2011: Penta and Dioxin/Furan Hot Spot Excavation
- 2010: UST Excavation
- 2006: Vapor Knockout UST Removal
- 2002: Former Penta Mixing AST Excavation
- 1991: Gasoline UST Excavation
- 1991: UST and Fuel Dispenser Removal

Other Site Features

- Property Boundary for the Seattle Terminal Properties
- Former AST

FORMER UTILIDOR

W. Commodore Way

27th Ave W

BULK TERMINAL PROPERTY

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

Notes:
· Parcel boundaries obtained from King County Geographic Information Systems Center, 2011. Lot lines are approximate. Not for legal use.
· Orthoimagery obtained from Nearmap, 2018.

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

0 25 50 100
Scale in Feet

N

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Time Oil Bulk Terminal PPA
Seattle, Washington

Figure 3.3
Historical Soil Excavation Areas—
Bulk Terminal Property

I:\GIS\Projects\Cantera-TOC\MXD\RIFS\RI 2019\Figure 3.3 Historical Soil Excavation Areas-Bulk Terminal Property.mxd
9/11/2020

Legend

Historical Excavation Areas

- 2013: TPH Excavation
- 2012: Pipeline and TPH Soil Removal
- 2011: Gasoline UST Excavation
- 1992: TPH Surface Staining Excavation
- 1992: Metals/Sandblast Grit Excavation
- 1991–1992: Waste Oil UST Excavation

Other Site Features

- Property Boundary for the Seattle Terminal Properties

Excavation B
Pit 2
Excavation C
Pit 1
Pit 3
Pit 4
TP01
Pit 5
Excavation A
FORMER UTILIDOR
FORMER UTILIDOR
WEST WATERFRONT PROPERTY
EAST WATERFRONT PROPERTY
W. Commodore Way

Notes:
· Parcel boundaries obtained from King County Geographic Information Systems Center, 2011. Lot lines are approximate. Not for legal use.
· Orthoimagery obtained from Nearmap, 2018.

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

0 20 40 80
Scale in Feet
N

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Time Oil Bulk Terminal PPA
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Figure 3.4
Historical Soil Excavation Areas—
East Waterfront Property

I:\GIS\Projects\Cantera-TOC\MXD\RIFS\RI 2019\Figure 3.4 Historical Soil Excavation Areas-East Waterfront Property.mxd
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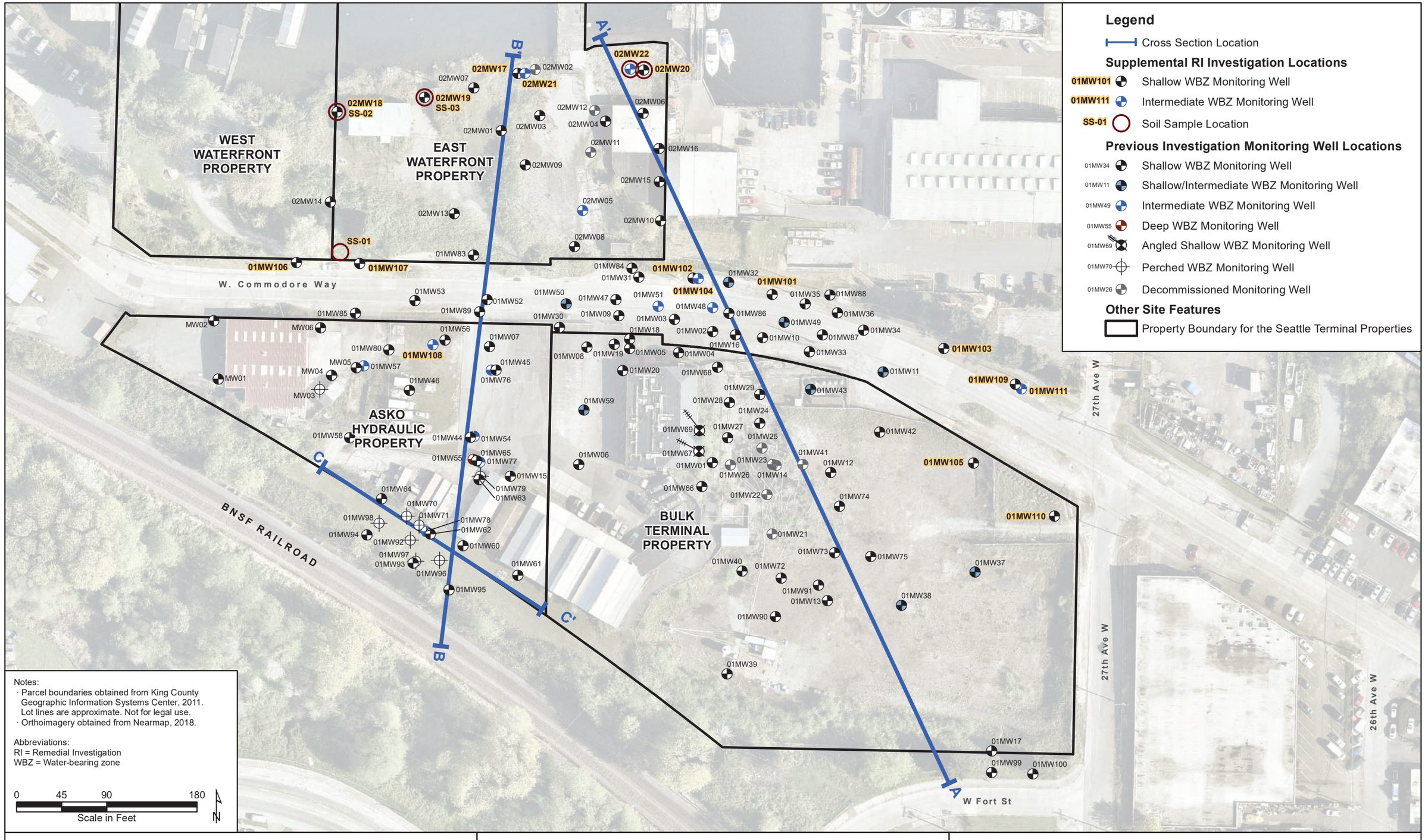

Legend

Cross Section Location

Supplemental RI Investigation Locations

- 01MW101 — Shallow WBZ Monitoring Well
- 01MW111 — Intermediate WBZ Monitoring Well
- SS-01 — Soil Sample Location

Previous Investigation Monitoring Well Locations

- 01MW34 — Shallow WBZ Monitoring Well
- 01MW11 — Shallow/Intermediate WBZ Monitoring Well
- 01MW49 — Intermediate WBZ Monitoring Well
- 01MW55 — Deep WBZ Monitoring Well
- 01MW69 — Angled Shallow WBZ Monitoring Well
- 01MW70 — Perched WBZ Monitoring Well
- 01MW26 — Decommissioned Monitoring Well

Other Site Features

Property Boundary for the Seattle Terminal Properties

Notes:
· Parcel boundaries obtained from King County Geographic Information Systems Center, 2011. Lot lines are approximate. Not for legal use.
· Orthoimagery obtained from Nearmap, 2018.

Abbreviations:
RI = Remedial Investigation
WBZ = Water-bearing zone

0 45 90 180
Scale in Feet
N

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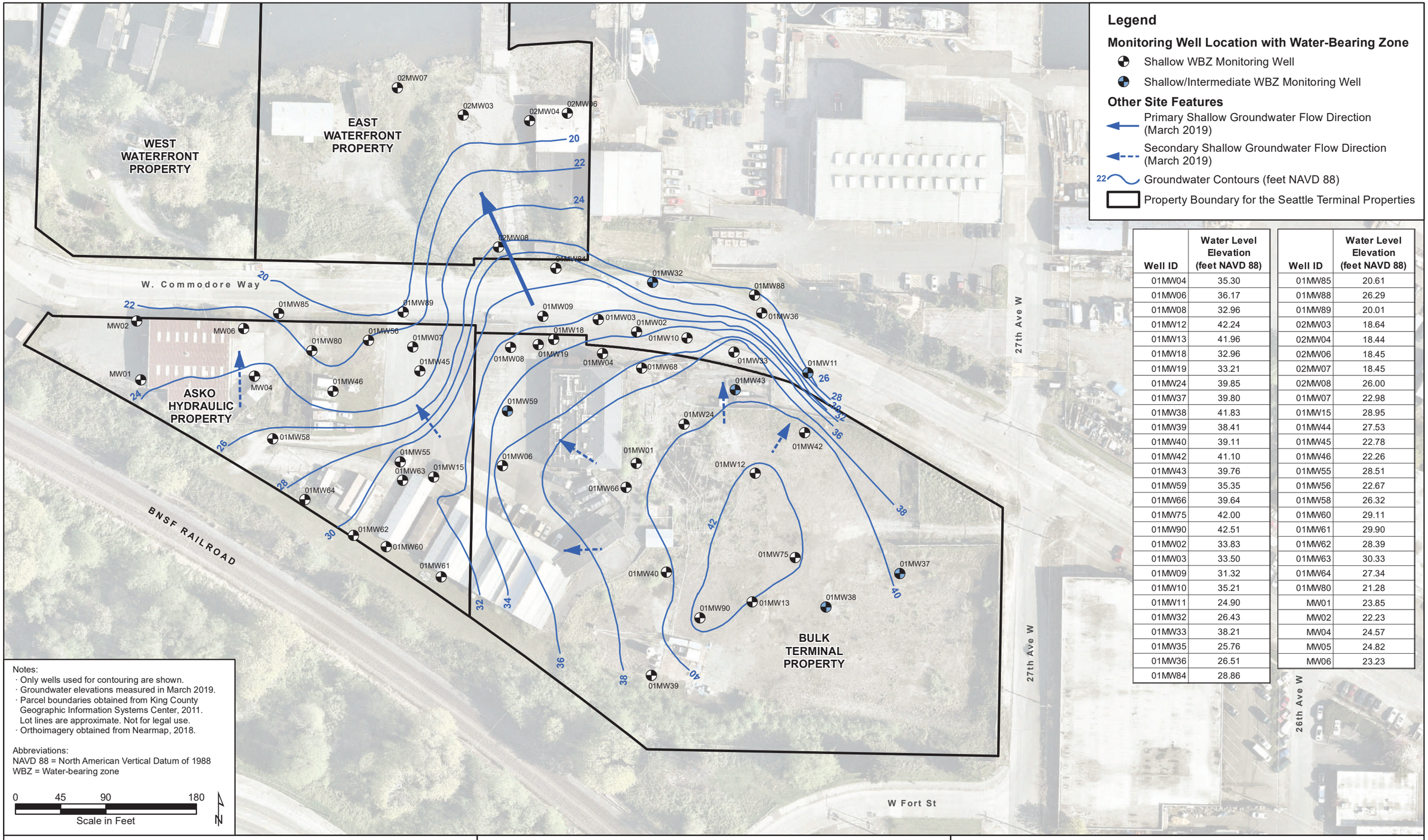
Seattle, Washington

Figure 5.1
Supplemental RI Locations and Cross-Section Transects

I:\GIS\Projects\Cantera-TOC\MXD\RIFS\RI 2019\Figure 5.1 Supplemental RI Locations and Cross-Section Transects.mxd
9/11/2020



Legend

Monitoring Well Location with Water-Bearing Zone

- Shallow WBZ Monitoring Well
- Shallow/Intermediate WBZ Monitoring Well

Other Site Features

- Primary Shallow Groundwater Flow Direction (March 2019)
- Secondary Shallow Groundwater Flow Direction (March 2019)
- 22 Groundwater Contours (feet NAVD 88)
- Property Boundary for the Seattle Terminal Properties

Well ID	Water Level Elevation (feet NAVD 88)
01MW04	35.30
01MW06	36.17
01MW08	32.96
01MW12	42.24
01MW13	41.96
01MW18	32.96
01MW19	33.21
01MW24	39.85
01MW37	39.80
01MW38	41.83
01MW39	38.41
01MW40	39.11
01MW42	41.10
01MW43	39.76
01MW59	35.35
01MW66	39.64
01MW75	42.00
01MW90	42.51
01MW02	33.83
01MW03	33.50
01MW09	31.32
01MW10	35.21
01MW11	24.90
01MW32	26.43
01MW33	38.21
01MW35	25.76
01MW36	26.51
01MW84	28.86

Well ID	Water Level Elevation (feet NAVD 88)
01MW85	20.61
01MW88	26.29
01MW89	20.01
02MW03	18.64
02MW04	18.44
02MW06	18.45
02MW07	18.45
02MW08	26.00
01MW07	22.98
01MW15	28.95
01MW44	27.53
01MW45	22.78
01MW46	22.26
01MW55	28.51
01MW56	22.67
01MW58	26.32
01MW60	29.11
01MW61	29.90
01MW62	28.39
01MW63	30.33
01MW64	27.34
01MW80	21.28
MW01	23.85
MW02	22.23
MW04	24.57
MW05	24.82
MW06	23.23

Notes:
- Only wells used for contouring are shown.
- Groundwater elevations measured in March 2019.
- Parcel boundaries obtained from King County Geographic Information Systems Center, 2011. Lot lines are approximate. Not for legal use.
- Orthoimagery obtained from Nearmap, 2018.

Abbreviations:
NAVD 88 = North American Vertical Datum of 1988
WBZ = Water-bearing zone

0 45 90 180
Scale in Feet

N

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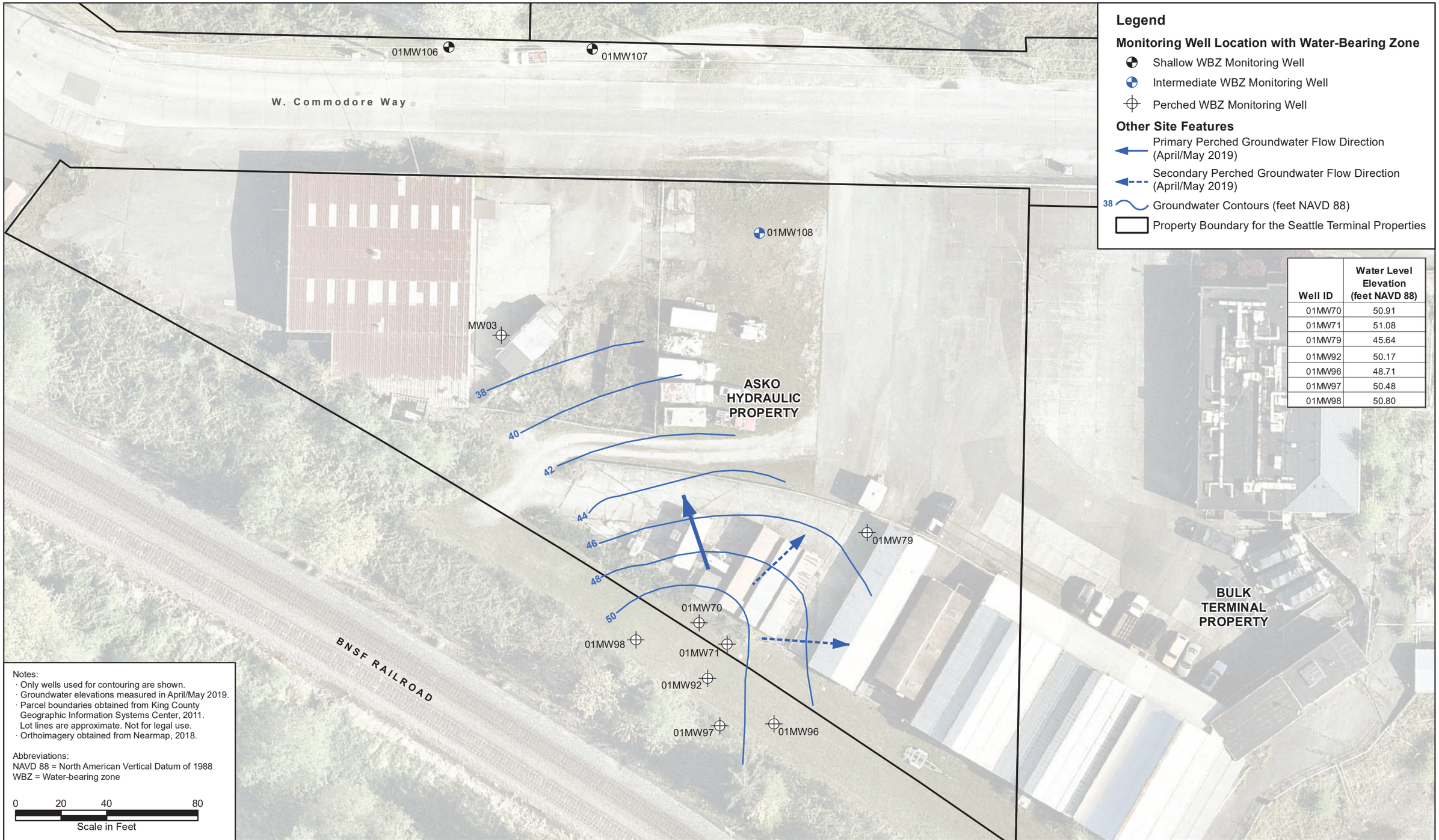
Time Oil Bulk Terminal PPA
Seattle, Washington

Figure 5.2
Shallow WBZ Groundwater Elevations—March 2019

I:\GIS\Projects\Cantera-TOC\MXD\RIFS\RI 2019\Figure 5.2 Shallow WBZ GW Elevations March 2019.mxd
9/11/2020



Legend

Monitoring Well Location with Water-Bearing Zone

- Shallow WBZ Monitoring Well
- Intermediate WBZ Monitoring Well
- Perched WBZ Monitoring Well

Other Site Features

- Primary Perched Groundwater Flow Direction (April/May 2019)
- Secondary Perched Groundwater Flow Direction (April/May 2019)
- 38 Groundwater Contours (feet NAVD 88)
- Property Boundary for the Seattle Terminal Properties

Well ID	Water Level Elevation (feet NAVD 88)
01MW70	50.91
01MW71	51.08
01MW79	45.64
01MW92	50.17
01MW96	48.71
01MW97	50.48
01MW98	50.80

Notes:
- Only wells used for contouring are shown.
- Groundwater elevations measured in April/May 2019.
- Parcel boundaries obtained from King County Geographic Information Systems Center, 2011. Lot lines are approximate. Not for legal use.
- Orthoimagery obtained from Nearmap, 2018.

Abbreviations:
NAVD 88 = North American Vertical Datum of 1988
WBZ = Water-bearing zone

0 20 40 80
Scale in Feet

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Seattle, Washington

Figure 5.3
Perched WBZ Groundwater Elevations—April/May 2019

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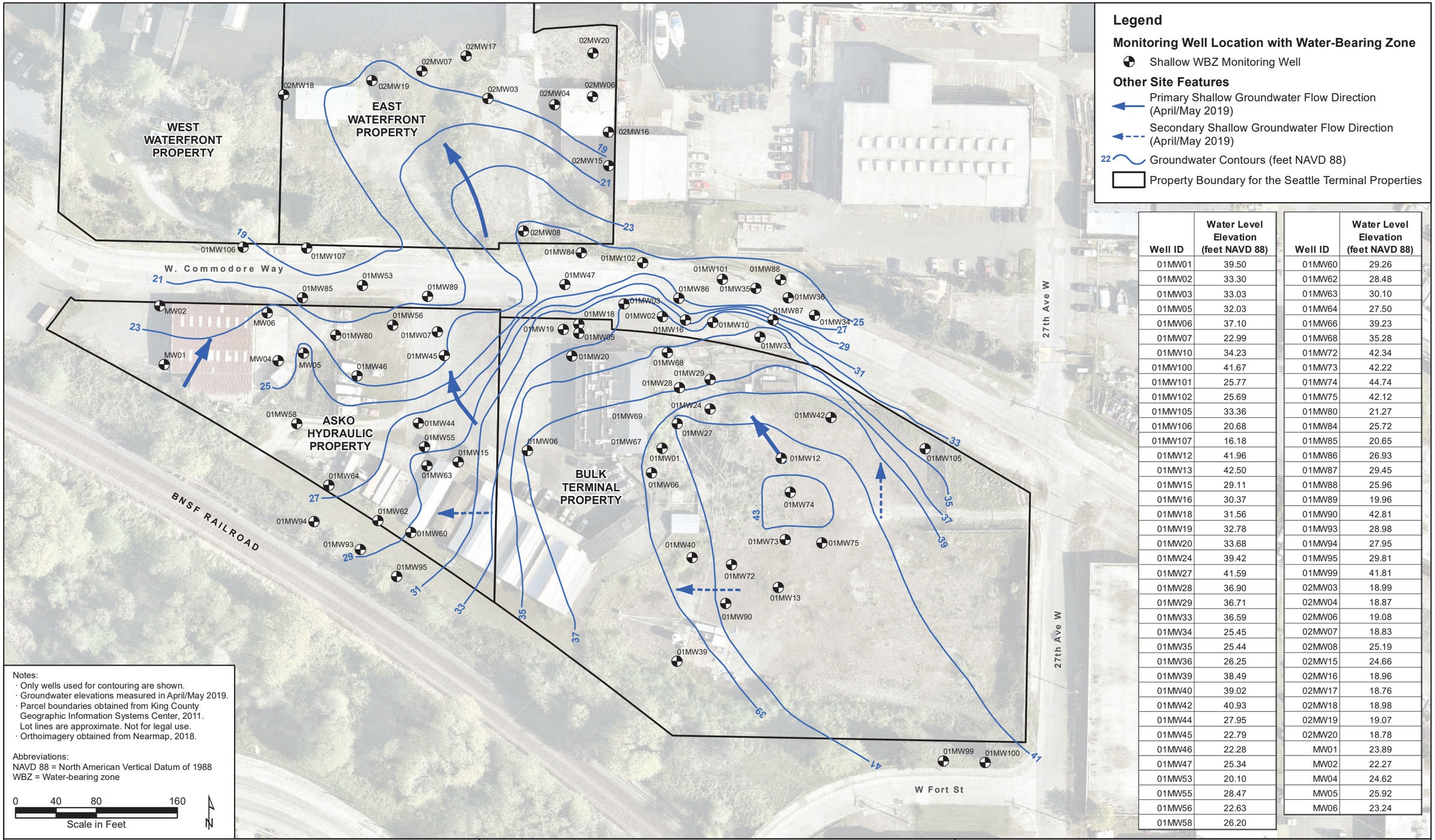
9/11/2020



Legend

Monitoring Well Location with Water-Bearing Zone

- Shallow WBZ Monitoring Well

Other Site Features

- Primary Shallow Groundwater Flow Direction (April/May 2019)
- Secondary Shallow Groundwater Flow Direction (April/May 2019)
- 22 Groundwater Contours (feet NAVD 88)
- Property Boundary for the Seattle Terminal Properties

Well ID	Water Level Elevation (feet NAVD 88)
01MW01	39.50
01MW02	33.30
01MW03	33.03
01MW05	32.03
01MW06	37.10
01MW07	22.99
01MW10	34.23
01MW100	41.67
01MW101	25.77
01MW102	25.69
01MW105	33.36
01MW106	20.68
01MW107	16.18
01MW12	41.96
01MW13	42.50
01MW15	29.11
01MW16	30.37
01MW18	31.56
01MW19	32.78
01MW20	33.68
01MW24	39.42
01MW27	41.59
01MW28	36.90
01MW29	36.71
01MW33	36.59
01MW34	25.45
01MW35	25.44
01MW36	26.25
01MW39	38.49
01MW40	39.02
01MW42	40.93
01MW44	27.95
01MW45	22.79
01MW46	22.28
01MW47	25.34
01MW53	20.10
01MW55	28.47
01MW56	22.63
01MW58	26.20

Well ID	Water Level Elevation (feet NAVD 88)
01MW60	29.26
01MW62	28.48
01MW63	30.10
01MW64	27.50
01MW66	39.23
01MW68	35.28
01MW72	42.34
01MW73	42.22
01MW74	44.74
01MW75	42.12
01MW80	21.27
01MW84	25.72
01MW85	20.65
01MW86	26.93
01MW87	29.45
01MW88	25.96
01MW89	19.96
01MW90	42.81
01MW93	28.98
01MW94	27.95
01MW95	29.81
01MW99	41.81
02MW03	18.99
02MW04	18.87
02MW06	19.08
02MW07	18.83
02MW08	25.19
02MW15	24.66
02MW16	18.96
02MW17	18.76
02MW18	18.98
02MW19	19.07
02MW20	18.78
MW01	23.89
MW02	22.27
MW04	24.62
MW05	25.92
MW06	23.24

Notes:
- Only wells used for contouring are shown.
- Groundwater elevations measured in April/May 2019.
- Parcel boundaries obtained from King County Geographic Information Systems Center, 2011. Lot lines are approximate. Not for legal use.
- Orthoimagery obtained from Nearmap, 2018.

Abbreviations:
NAVD 88 = North American Vertical Datum of 1988
WBZ = Water-bearing zone

0 40 80 160
Scale in Feet

N

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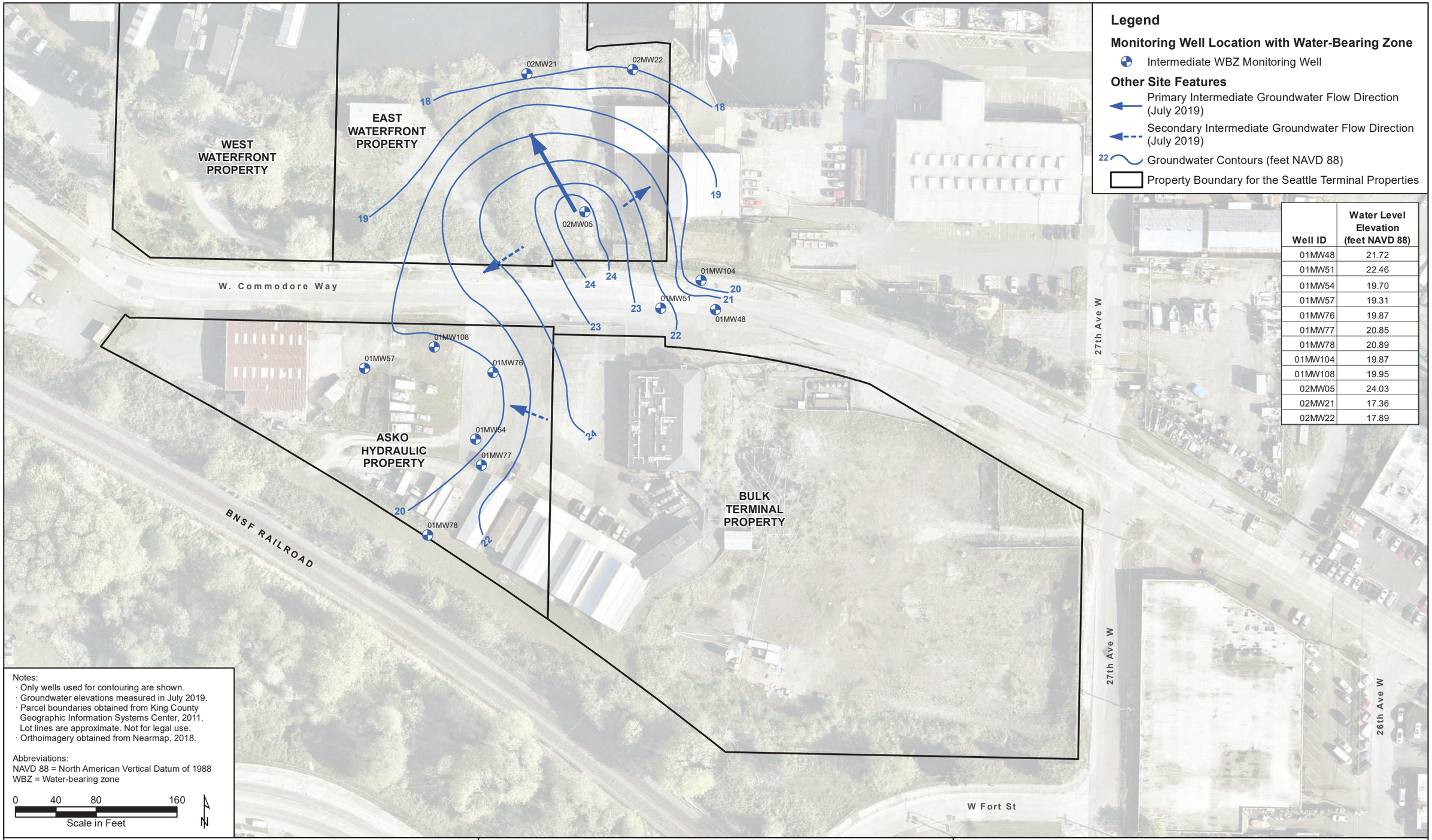
Time Oil Bulk Terminal PPA
Seattle, Washington

Figure 5.4
Shallow WBZ Groundwater Elevations—April/May 2019

I:\GIS\Projects\Cantera-TOC\MXD\RIFS\RI 2019\Figure 5.4 Shallow WBZ GW Elevations April_May 2019.mxd
9/11/2020



Legend

Monitoring Well Location with Water-Bearing Zone

- Intermediate WBZ Monitoring Well

Other Site Features

- Primary Intermediate Groundwater Flow Direction (July 2019)
- Secondary Intermediate Groundwater Flow Direction (July 2019)
- 22 Groundwater Contours (feet NAVD 88)
- Property Boundary for the Seattle Terminal Properties

Well ID	Water Level Elevation (feet NAVD 88)
01MW48	21.72
01MW51	22.46
01MW54	19.70
01MW57	19.31
01MW76	19.87
01MW77	20.85
01MW78	20.89
01MW104	19.87
01MW108	19.95
02MW05	24.03
02MW21	17.36
02MW22	17.89

Notes:
- Only wells used for contouring are shown.
- Groundwater elevations measured in July 2019.
- Parcel boundaries obtained from King County Geographic Information Systems Center, 2011. Lot lines are approximate. Not for legal use.
- Orthoimagery obtained from Nearmap, 2018.

Abbreviations:
NAVD 88 = North American Vertical Datum of 1988
WBZ = Water-bearing zone

0 40 80 160
Scale in Feet

N

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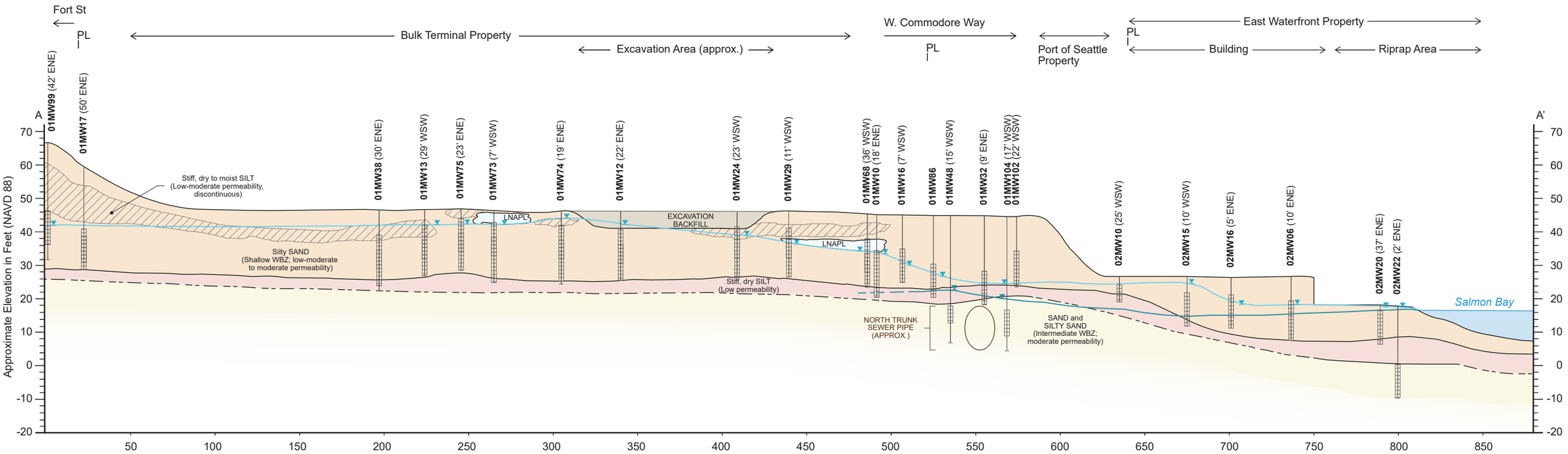
Figure 5.5
Intermediate WBZ Groundwater Elevations—July 2019

I:\GIS\Projects\Cantera-TOC\MXD\RIFS\RI 2019\Figure 5.5 Intermediate WBZ GW Elevations July 2019.mxd
9/11/2020



Legend

- Observed Shallow Groundwater (April/May 2019)
- Observed Intermediate Groundwater (July 2019)
- Shallow WBZ Potentiometric Surface
- Intermediate WBZ Potentiometric Surface (dashed where inferred)
- Contact Boundary Between Lithologies (dashed where inferred)

Horizontal Scale in Feet
0 60 120
0 30 60
Vertical Scale in Feet
Vertical Exageration X 2

Note:
• Lithology based on soil borings installed by IT Corporation, SoundEarth Strategies, and Floyd|Snider.

Abbreviations:
LNAPL = Light non-aqueous-phase liquid
NAVD 88 = North American Vertical Datum of 1988
PL = Property line (approximate)
WBZ = Water-bearing zone

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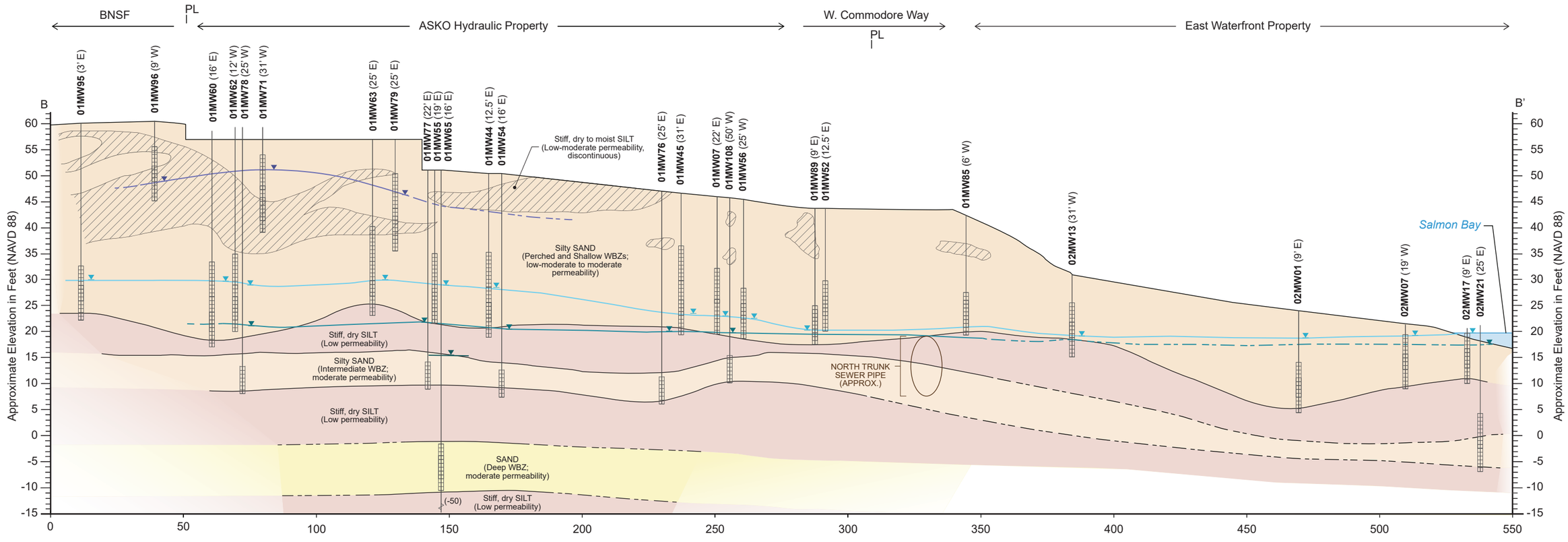
Figure 5.6
Cross-Section A-A'

I:\GIS\Projects\Cantera-TOC\AI\RI Cross-Sections\Figure 5.6 Cross-Section A-A'_2020-0402.ai
04/02/2020



Legend

- Observed Perched Groundwater (April/May 2019)
- Observed Shallow Groundwater (April/May 2019)
- Observed Intermediate Groundwater (July 2019)
- Observed Deep Groundwater (April/May 2019)
- Perched WBZ Potentiometric Surface (dashed where inferred)
- Shallow WBZ Potentiometric Surface
- Intermediate WBZ Potentiometric Surface (dashed where inferred)
- Deep WBZ Potentiometric Surface
- Contact Boundary Between Lithologies (dashed where inferred)

Horizontal Scale in Feet
0 40 80
0 20 40
Vertical Scale in Feet
Vertical Exaggeration X 2

Note:
• Lithology based on soil borings installed by IT Corporation, SoundEarth Strategies, and Floyd|Snider.

Abbreviations:
BNSF = BNSF Railway
NAVD 88 = North American Vertical Datum of 1988
PL = Property line (approximate)
WBZ = Water-bearing zone

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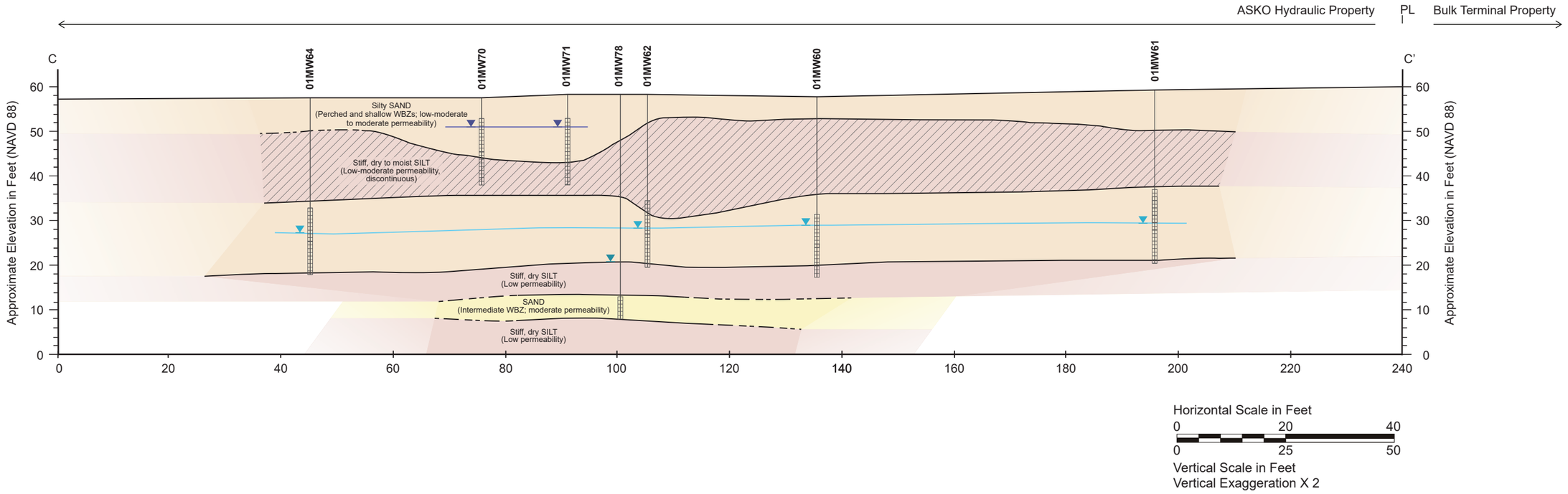
Figure 5.7
Cross-Section B-B'

I:\GIS\Projects\Cantera-TOC\AI\RI Cross-Sections\Figure 5.7 Cross-Section B-B'_2020-0402.ai
04/02/2020



Legend

- Observed Perched Groundwater (April/May 2019)
- Observed Shallow Groundwater (April/May 2019)
- Observed Intermediate Groundwater (July 2019)
- Perched WBZ Potentiometric Surface
- Shallow WBZ Potentiometric Surface
- Contact Boundary Between Lithologies (dashed where inferred)

Note:
• Lithology based on soil borings installed by IT Corporation, SoundEarth Strategies, and Floyd|Snider.

Abbreviations:
NAVD 88 = North American Vertical Datum of 1988
PL = Property line
WBZ = Water-bearing zone

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Figure 5.8
Cross-Section C-C'

I:\GIS\Projects\Cantera-TOC\AI\RI Cross-Sections\Figure 5.8 Cross-Section C-C'_2020-0402.ai
04/02/2020

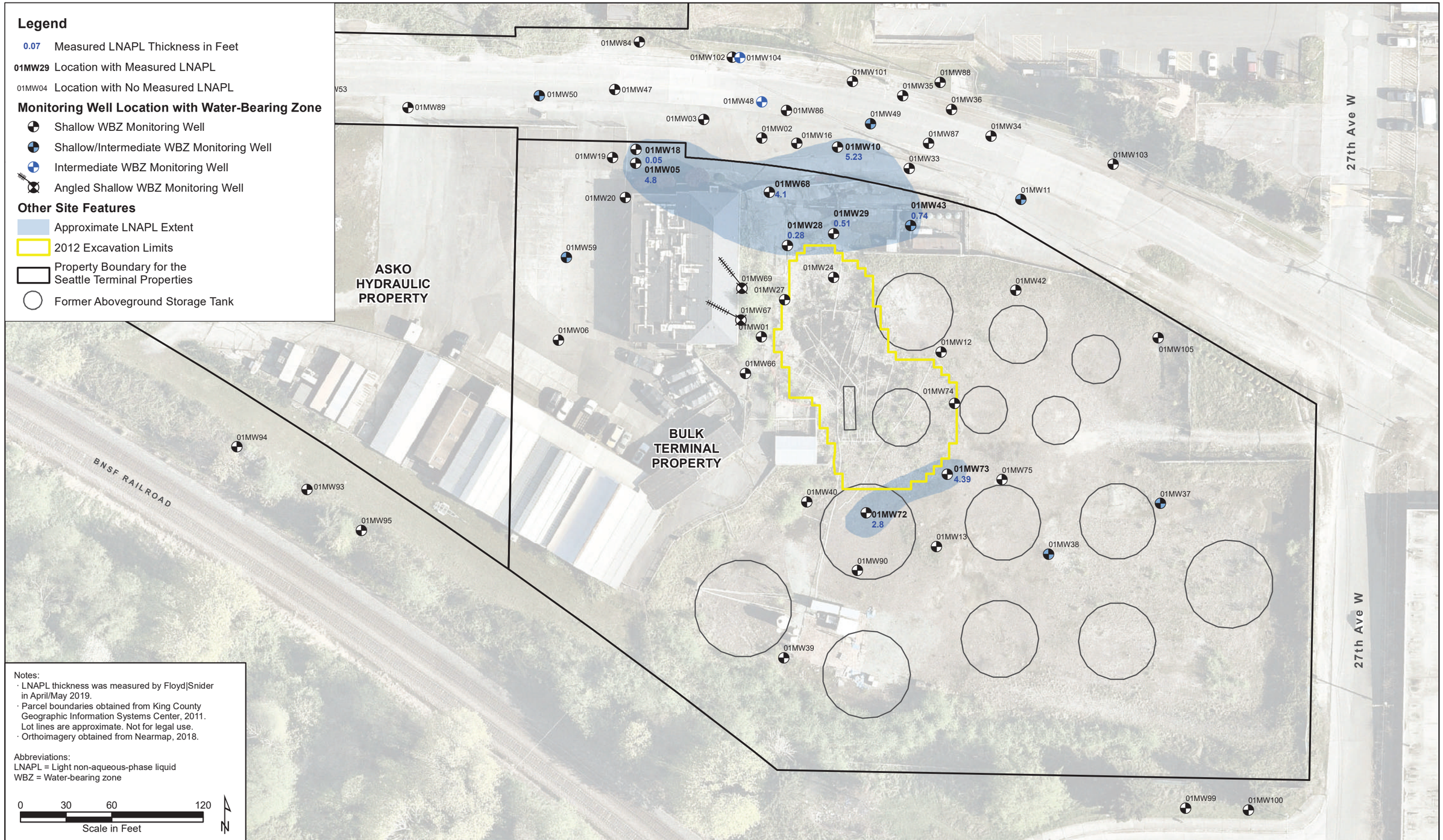

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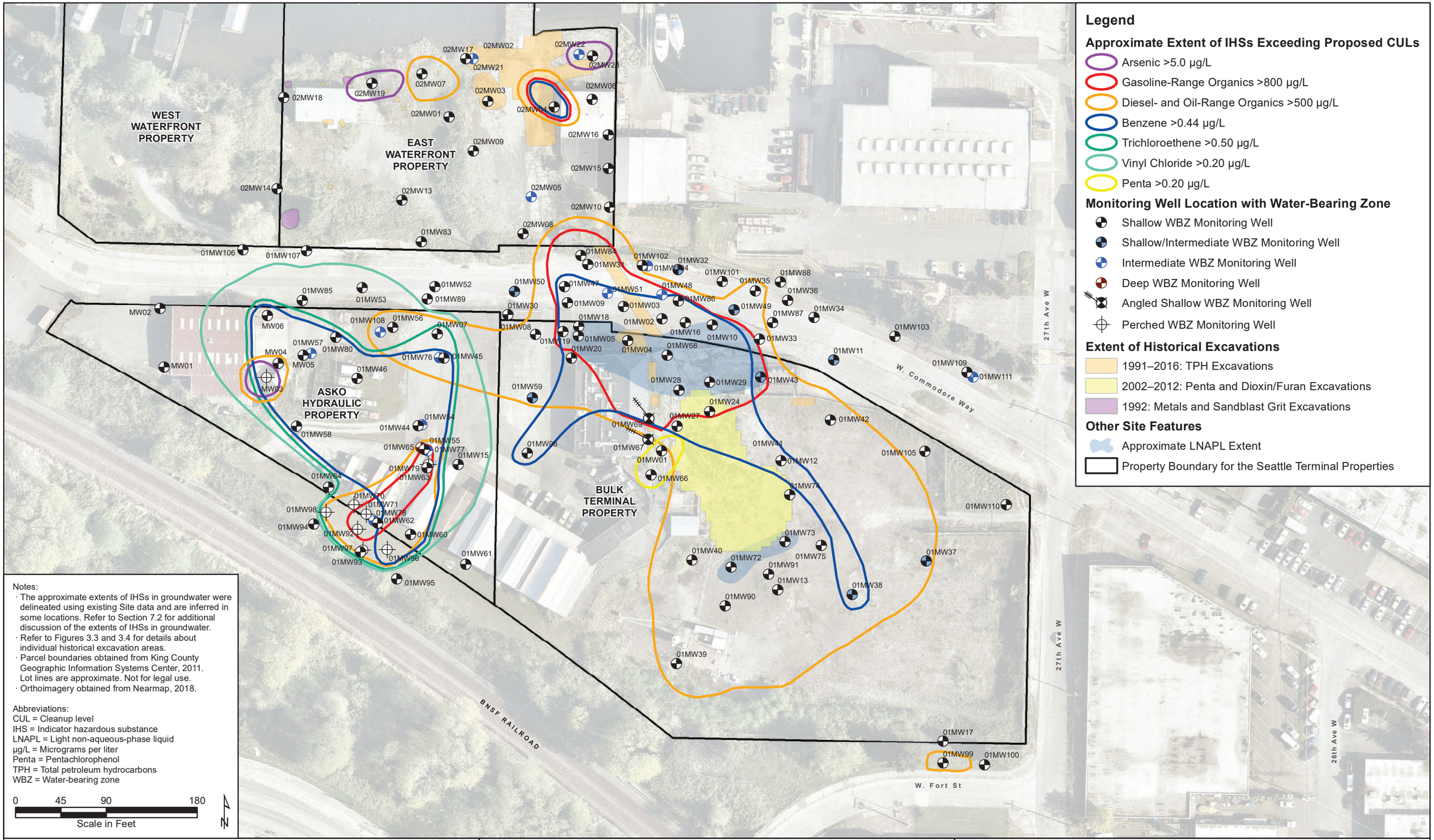
Figure 5.9
LNAPL Distribution and Thickness—April/May 2019

I:\GIS\Projects\Cantera-TOC\MXD\RIFS\RI 2019\Figure 5.9 LNAPL Distribution and Thickness-April_May 2019.mxd
9/11/2020



Legend

Approximate Extent of IHSs Exceeding Proposed CULs

- Arsenic >5.0 µg/L
- Gasoline-Range Organics >800 µg/L
- Diesel- and Oil-Range Organics >500 µg/L
- Benzene >0.44 µg/L
- Trichloroethene >0.50 µg/L
- Vinyl Chloride >0.20 µg/L
- Penta >0.20 µg/L

Monitoring Well Location with Water-Bearing Zone

- Shallow WBZ Monitoring Well
- Shallow/Intermediate WBZ Monitoring Well
- Intermediate WBZ Monitoring Well
- Deep WBZ Monitoring Well
- Angled Shallow WBZ Monitoring Well
- Perched WBZ Monitoring Well

Extent of Historical Excavations

- 1991–2016: TPH Excavations
- 2002–2012: Penta and Dioxin/Furan Excavations
- 1992: Metals and Sandblast Grit Excavations

Other Site Features

- Approximate LNAPL Extent
- Property Boundary for the Seattle Terminal Properties

Notes:
- The approximate extents of IHSs in groundwater were delineated using existing Site data and are inferred in some locations. Refer to Section 7.2 for additional discussion of the extents of IHSs in groundwater.
- Refer to Figures 3.3 and 3.4 for details about individual historical excavation areas.
- Parcel boundaries obtained from King County Geographic Information Systems Center, 2011. Lot lines are approximate. Not for legal use.
- Orthoimagery obtained from Nearmap, 2018.

Abbreviations:
CUL = Cleanup level
IHS = Indicator hazardous substance
LNAPL = Light non-aqueous-phase liquid
µg/L = Micrograms per liter
Penta = Pentachlorophenol
TPH = Total petroleum hydrocarbons
WBZ = Water-bearing zone

0 45 90 180
Scale in Feet

N

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Figure 7.1
Indicator Hazardous Substances in Groundwater

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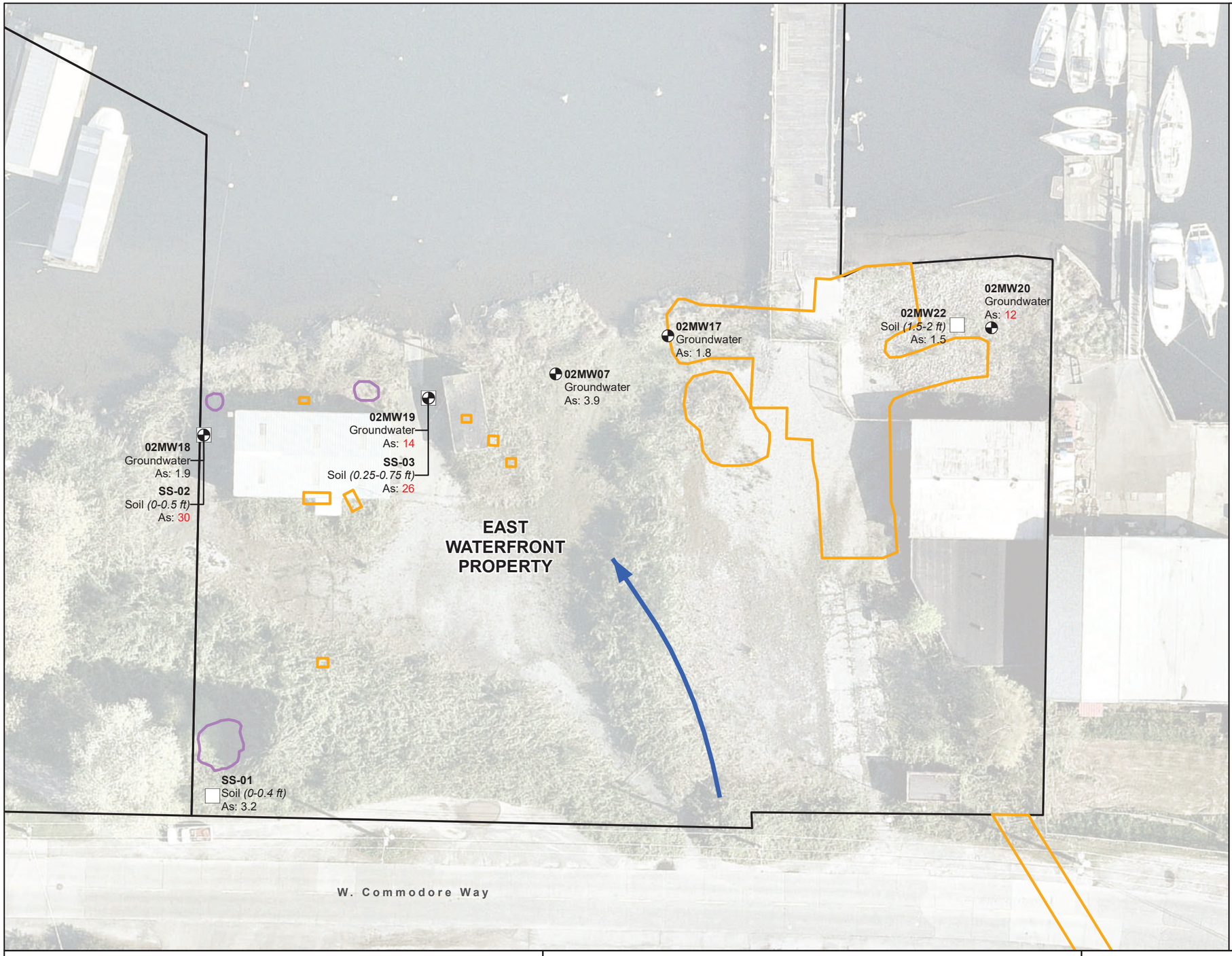
9/11/2020



Legend

Sample Location Type

- Shallow WBZ Monitoring Well
- Shallow WBZ Monitoring Well with Surface Soil
- Surface Soil

Extent of Historical Excavations

- 1991–2016: TPH Excavations
- 1992: Metals and Sandblast Grit Excavations

Other Site Features

- Primary Shallow Groundwater Flow Direction (April/May 2019)
- Property Boundary for the Seattle Terminal Properties

Groundwater
Proposed Cleanup Level
Arsenic: 5.0 µg/L

Soil
Proposed Cleanup Level
Arsenic: 7.3 mg/kg

Notes:
- Results presented in µg/L for groundwater and mg/kg for soil.
- Results shown in RED indicate exceedances of criteria.
- Refer to Figure 3.4 for details about individual historical excavation areas.
- Parcel boundaries obtained from King County Geographic Information Systems Center, 2011. Lot lines are approximate. Not for legal use.
- Orthoimagery obtained from Nearmap, 2018.

Abbreviations:
As = Arsenic
µg/L = Micrograms per liter
mg/kg = Milligrams per kilogram
TPH = Total petroleum hydrocarbons
WBZ = Water-bearing zone

N

0 20 40 80
Scale in Feet

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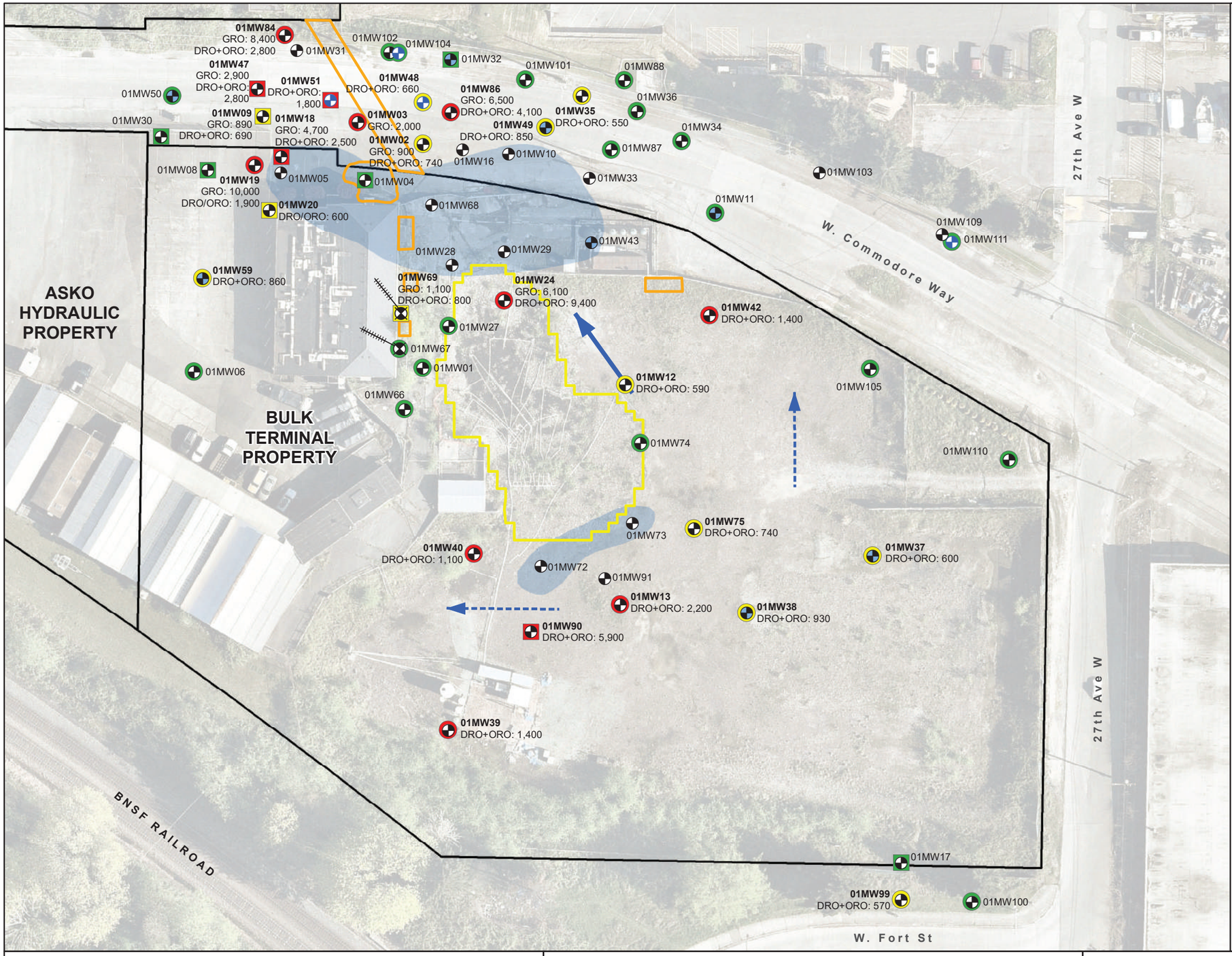
Figure 7.2
Arsenic Distribution in Groundwater and Soil—
East Waterfront Property

I:\GIS\Projects\Cantera-TOC\MXD\RIFS\RI 2019\Figure 7.2 Arsenic in Groundwater and Soil-East Waterfront.mxd
9/11/2020



Legend

Monitoring Well Location with Water-Bearing Zone

- Shallow WBZ Monitoring Well
- Shallow/Intermediate WBZ Monitoring Well
- Intermediate WBZ Monitoring Well
- Angled Shallow WBZ Monitoring Well

Groundwater Sample Results–2019

- 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

Groundwater Sample Results–2013–2016

- 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

Extent of Historical Excavations

- 1991–2016: TPH Excavations
- 2002–2012: Penta and Dioxin/Furan Excavations

Other Site Features

- Primary Shallow Groundwater Flow Direction (April/May 2019)
- Secondary Shallow Groundwater Flow Direction (April/May 2019)
- Approximate LNAPL Extent
- Property Boundary for the Seattle Terminal Properties

Proposed Cleanup Level
GRO: 800 µg/L
DRO+ORO: 500 µg/L

Notes:
- Chemical results are presented only where the result exceeds the criterion.
- Results presented in µg/L.
- Most recent results collected in 2019 are shown.
- Monitoring wells with measureable LNAPL were not analyzed.
- Refer to Figure 3.3 for details about individual historical excavation areas.
- Parcel boundaries obtained from King County Geographic Information Systems Center, 2011. Lot lines are approximate. Not for legal use.
- 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
ORO = Oil-range organics
Penta = Pentachlorophenol
TPH = Total petroleum hydrocarbons
WBZ = Water-bearing zone

N
0 30 60 120
Scale in Feet

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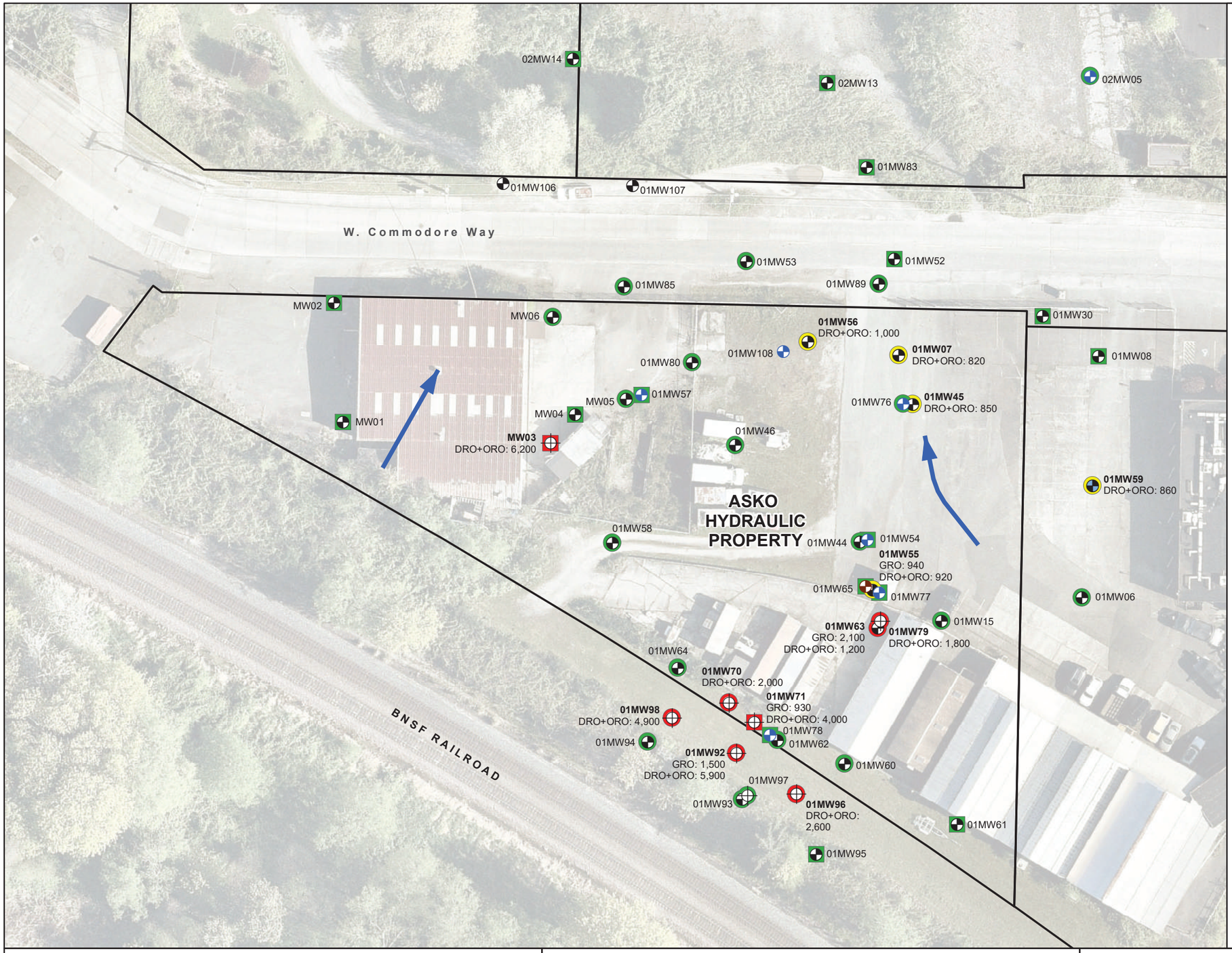
Figure 7.3
Total Petroleum Hydrocarbons Distribution in Groundwater—
Bulk Terminal Property

I:\GIS\Projects\Cantera-TOC\MXD\RIFS\RI 2019\Figure 7.3 TPH Distribution in Groundwater-Bulk Terminal.mxd
9/11/2020



Legend

Monitoring Well Location with Water-Bearing Zone

- Shallow WBZ Monitoring Well
- Shallow/Intermediate WBZ Monitoring Well
- Intermediate WBZ Monitoring Well
- Deep WBZ Monitoring Well
- Perched WBZ Monitoring Well

Groundwater Sample Results–2019

- 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

Groundwater Sample Results–2013–2016

- 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 Site Features

- Primary Shallow Groundwater Flow Direction (April/May 2019)
- Property Boundary for the Seattle Terminal Properties

Proposed Cleanup Level
GRO: 800 µg/L
DRO+ORO: 500 µg/L

Notes:
· Chemical results are presented only where the result exceeds the criterion.
· Results presented in µg/L.
· Parcel boundaries obtained from King County Geographic Information Systems Center, 2011. Lot lines are approximate. Not for legal use.
· Orthoimagery obtained from Nearmap, 2018.

Abbreviations:
DRO = Diesel-range organics
GRO = Gasoline-range organics
µg/L = Micrograms per liter
ORO = Oil-range organics
WBZ = Water-bearing zone

N

0 25 50 100
Scale in Feet

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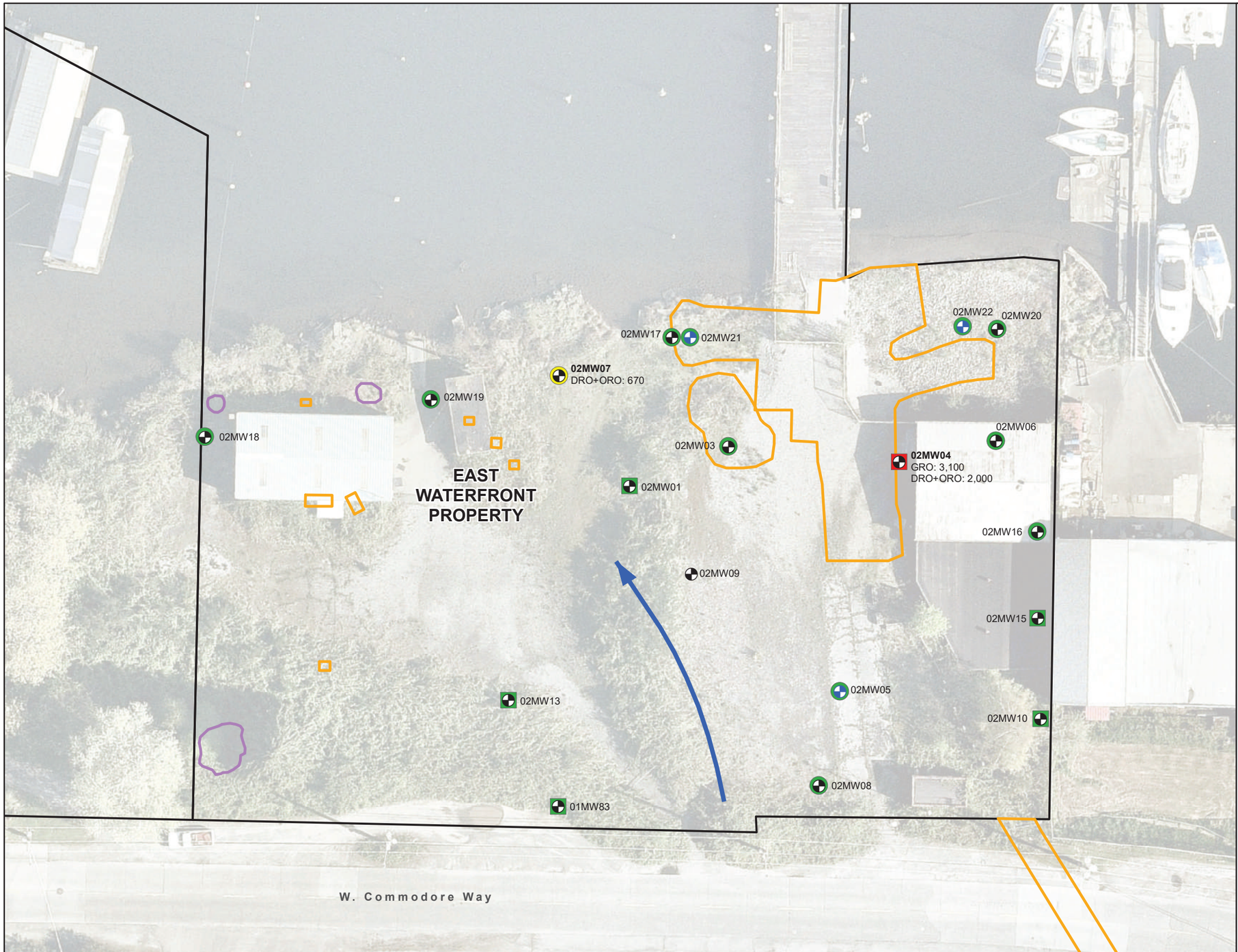
Figure 7.4
Total Petroleum Hydrocarbons Distribution in Groundwater—
ASKO Property

I:\GIS\Projects\Cantera-TOC\MXD\RIFS\RI 2019\Figure 7.4 TPH Distribution in Groundwater-ASKO.mxd
9/11/2020



Legend

Monitoring Well Location with Water-Bearing Zone

- Shallow WBZ Monitoring Well
- Intermediate WBZ Monitoring Well

Groundwater Sample Results–2019

- 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

Groundwater Sample Results–2013–2016

- 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

Extent of Historical Excavations

- 1991–2016: TPH Excavations
- 1992: Metals and Sandblast Grit Excavations

Other Site Features

- Primary Shallow Groundwater Flow Directions (April/May 2019)
- Property Boundary for the Seattle Terminal Properties

Proposed Cleanup Level
GRO: 800 µg/L
DRO+ORO: 500 µg/L

Notes:
· Chemical results are presented only where the result exceeds the criterion.
· Results presented in µg/L.
· Refer to Figure 3.4 for details about individual historical excavation areas.
· Parcel boundaries obtained from King County Geographic Information Systems Center, 2011. Lot lines are approximate. Not for legal use.
· Orthoimagery obtained from Nearmap, 2018.

Abbreviations:
DRO = Diesel-range organics
GRO = Gasoline-range organics
µg/L = Micrograms per liter
ORO = Oil-range organics
TPH = Total petroleum hydrocarbons
WBZ = Water-bearing zone

N

0 20 40 80
Scale in Feet

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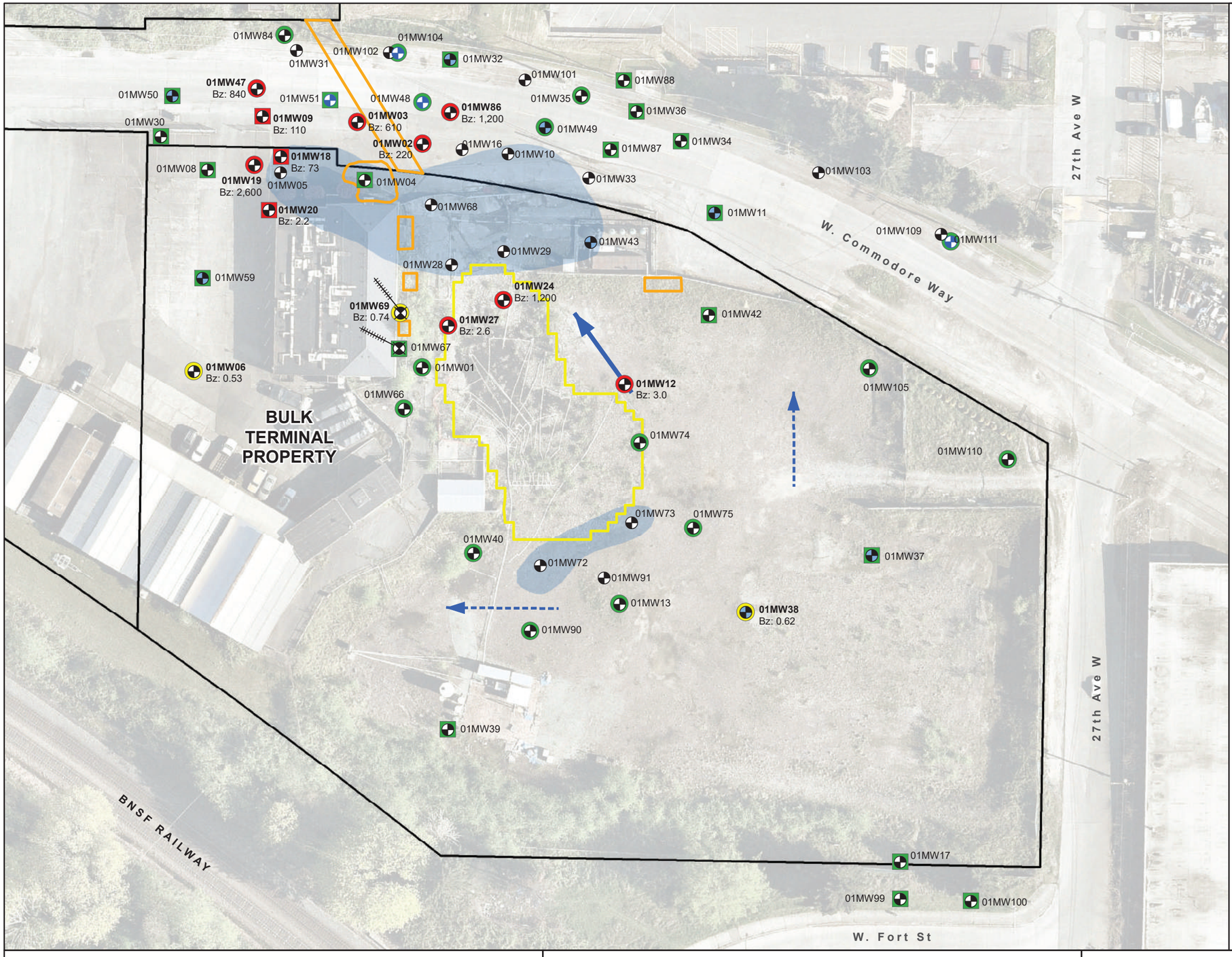
Figure 7.5
Total Petroleum Hydrocarbons Distribution in Groundwater—
East Waterfront Property

I:\GIS\Projects\Cantera-TOC\MXD\RIFS\RI 2019\Figure 7.5 TPH Distribution in Groundwater-East Waterfront.mxd
9/11/2020



Legend

Monitoring Well Location with Water-Bearing Zone

- Shallow WBZ Monitoring Well
- Shallow/Intermediate WBZ Monitoring Well
- Intermediate WBZ Monitoring Well
- Angled Shallow WBZ Monitoring Well

Groundwater Sample Results–2019

- 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

Groundwater Sample Results–2013–2016

- 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

Extent of Historical Excavations

- 1991–2016: TPH Excavations
- 2002–2012: Penta and Dioxin/Furan Excavations

Other Site Features

- Primary Shallow Groundwater Flow Direction (April/May 2019)
- Secondary Shallow Groundwater Flow Direction (April/May 2019)
- Approximate LNAPL Extent
- Property Boundary for the Seattle Terminal Properties

Proposed Cleanup Level
Benzene: 0.44 µg/L

Notes:
· Chemical results are presented only where the result exceeds the criterion.
· Results presented in µg/L.
· Refer to Figure 3.3 for details about individual historical excavation areas.
· Parcel boundaries obtained from King County Geographic Information Systems Center, 2011. Lot lines are approximate. Not for legal use.
· Orthoimagery obtained from Nearmap, 2018.

Abbreviations:
Bz = Benzene
LNAPL = Light non-aqueous-phase liquid
µg/L = Micrograms per liter
Penta = Pentachlorophenol
TPH = Total petroleum hydrocarbons
WBZ = Water-bearing zone

N

0 30 60 120
Scale in Feet

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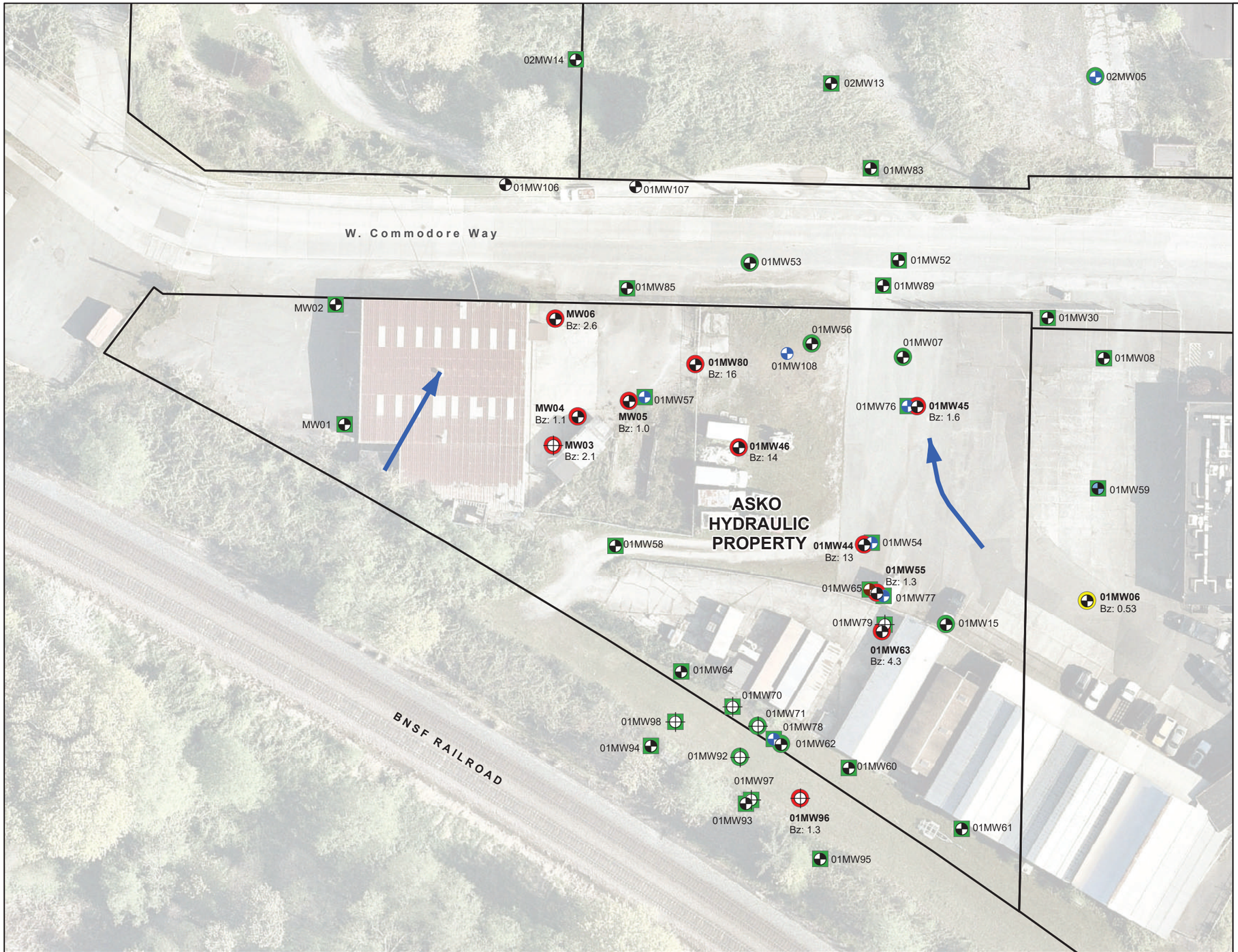
Figure 7.6
Benzene Distribution in Groundwater—
Bulk Terminal Property

I:\GIS\Projects\Cantera-TOC\MXD\RIFS\RI 2019\Figure 7.6 Benzene Distribution in Groundwater-Bulk Terminal.mxd
9/11/2020



Legend

Monitoring Well Location with Water-Bearing Zone

- Shallow WBZ Monitoring Well
- Shallow/Intermediate WBZ Monitoring Well
- Intermediate WBZ Monitoring Well
- Deep WBZ Monitoring Well
- Perched Zone Monitoring Well

Groundwater Sample Results–2019

- 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

Groundwater Sample Results–2013–2016

- 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 Site Features

- Primary Shallow Groundwater Flow Direction (April/May 2019)
- Property Boundary for the Seattle Terminal Properties

Proposed Cleanup Level
Benzene: 0.44 µg/L

Notes:
· Chemical results are presented only where the result exceeds the criterion.
· Results presented in µg/L.
· Parcel boundaries obtained from King County Geographic Information Systems Center, 2011. Lot lines are approximate. Not for legal use.
· Orthoimagery obtained from Nearmap, 2018.

Abbreviations:
Bz = Benzene
µg/L = Micrograms per liter

N

0 25 50 100
Scale in Feet

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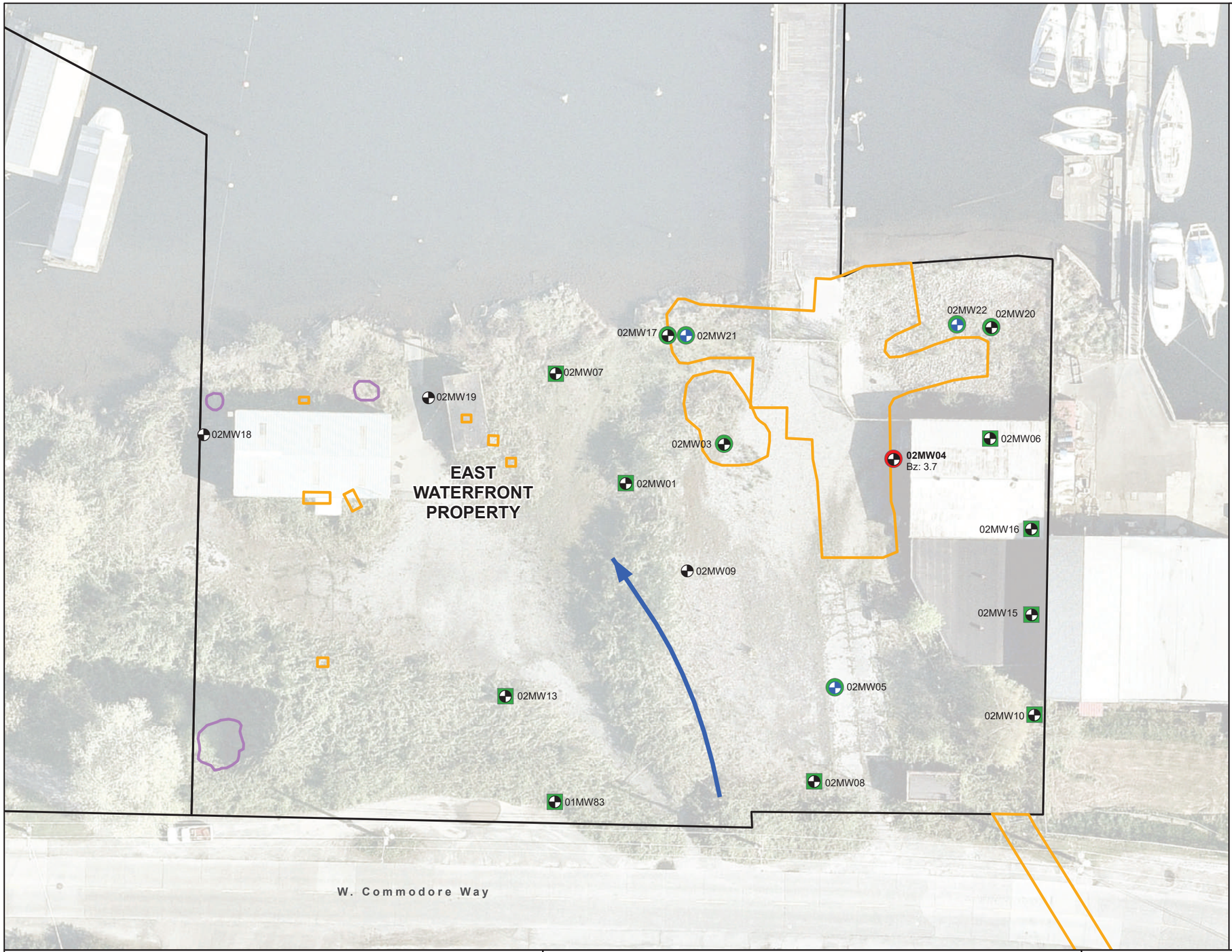
Figure 7.7
Benzene Distribution in Groundwater—
ASKO Property

I:\GIS\Projects\Cantera-TOC\MXD\RIFS\RI 2019\Figure 7.7 Benzene Distribution in Groundwater-ASKO.mxd
9/11/2020



Legend

Monitoring Well Location with Water-Bearing Zone

- Shallow WBZ Monitoring Well
- Intermediate WBZ Monitoring Well

Groundwater Sample Results–2019

- 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

Groundwater Sample Results–2013–2016

- 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

Extent of Historical Excavations

- 1991–2016: TPH Excavations
- 1992: Metals and Sandblast Grit Excavations

Other Site Features

- Primary Shallow Groundwater Flow Directions (April/May 2019)
- Property Boundary for the Seattle Terminal Properties

Proposed Cleanup Level
Benzene: 0.44 µg/L

Notes:
· Chemical results are presented only where the result exceeds the criterion.
· Results presented in µg/L.
· Refer to Figure 3.4 for details about individual historical excavation areas.
· Parcel boundaries obtained from King County Geographic Information Systems Center, 2011. Lot lines are approximate. Not for legal use.
· Orthoimagery obtained from Nearmap, 2018.

Abbreviations:
Bz = Benzene
µg/L = Micrograms per liter
TPH = Total petroleum hydrocarbons
WBZ = Water-bearing zone

N
0 20 40 80
Scale in Feet

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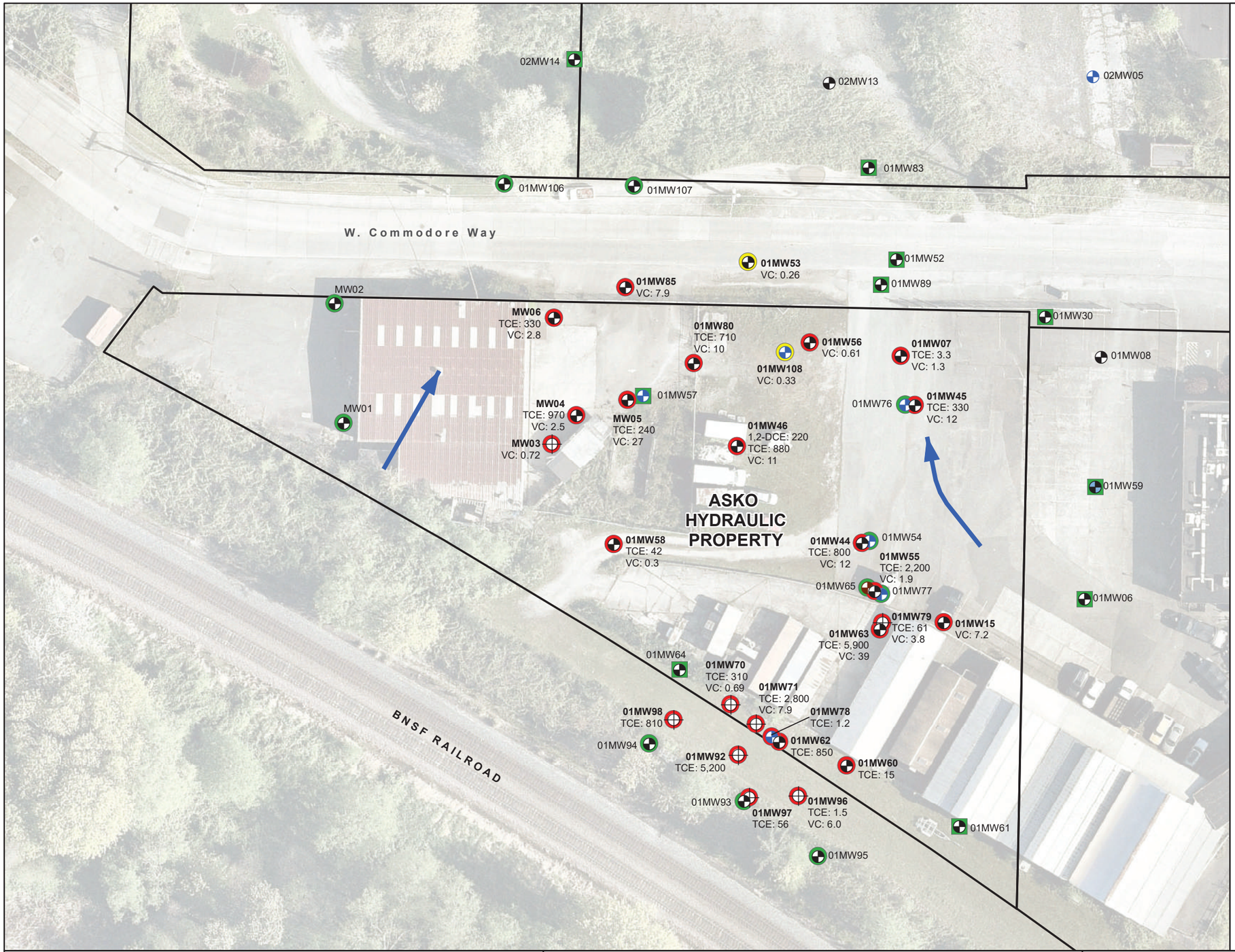
Figure 7.8
Benzene Distribution in Groundwater—
East Waterfront Property

I:\GIS\Projects\Cantera-TOC\MXD\RIFS\RI 2019\Figure 7.8 Benzene Distribution in Groundwater-East Waterfront.mxd
9/11/2020



Legend

Monitoring Well Location with Water-Bearing Zone

- Shallow WBZ Monitoring Well
- Shallow/Intermediate WBZ Monitoring Well
- Intermediate WBZ Monitoring Well
- Deep WBZ Monitoring Well
- Perched WBZ Monitoring Well

Groundwater Sample Results–2019

- 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

Groundwater Sample Results–2013–2016

- 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 Site Features

- Primary Shallow Groundwater Flow Direction (April/May 2019)
- Property Boundary for the Seattle Terminal Properties

Proposed Cleanup Level
Trichloroethene: 0.50 µg/L
Vinyl Chloride: 0.20 µg/L

Notes:
- Chemical results are presented only where the result exceeds the criterion.
- Results presented in µg/L.
- Parcel boundaries obtained from King County Geographic Information Systems Center, 2011. Lot lines are approximate. Not for legal use.
- Orthoimagery obtained from Nearmap, 2018.

Abbreviations:
µg/L = Micrograms per liter
TCE = Trichloroethene
VC = Vinyl chloride
WBZ = Water-bearing zone

N

0 25 50 100
Scale in Feet

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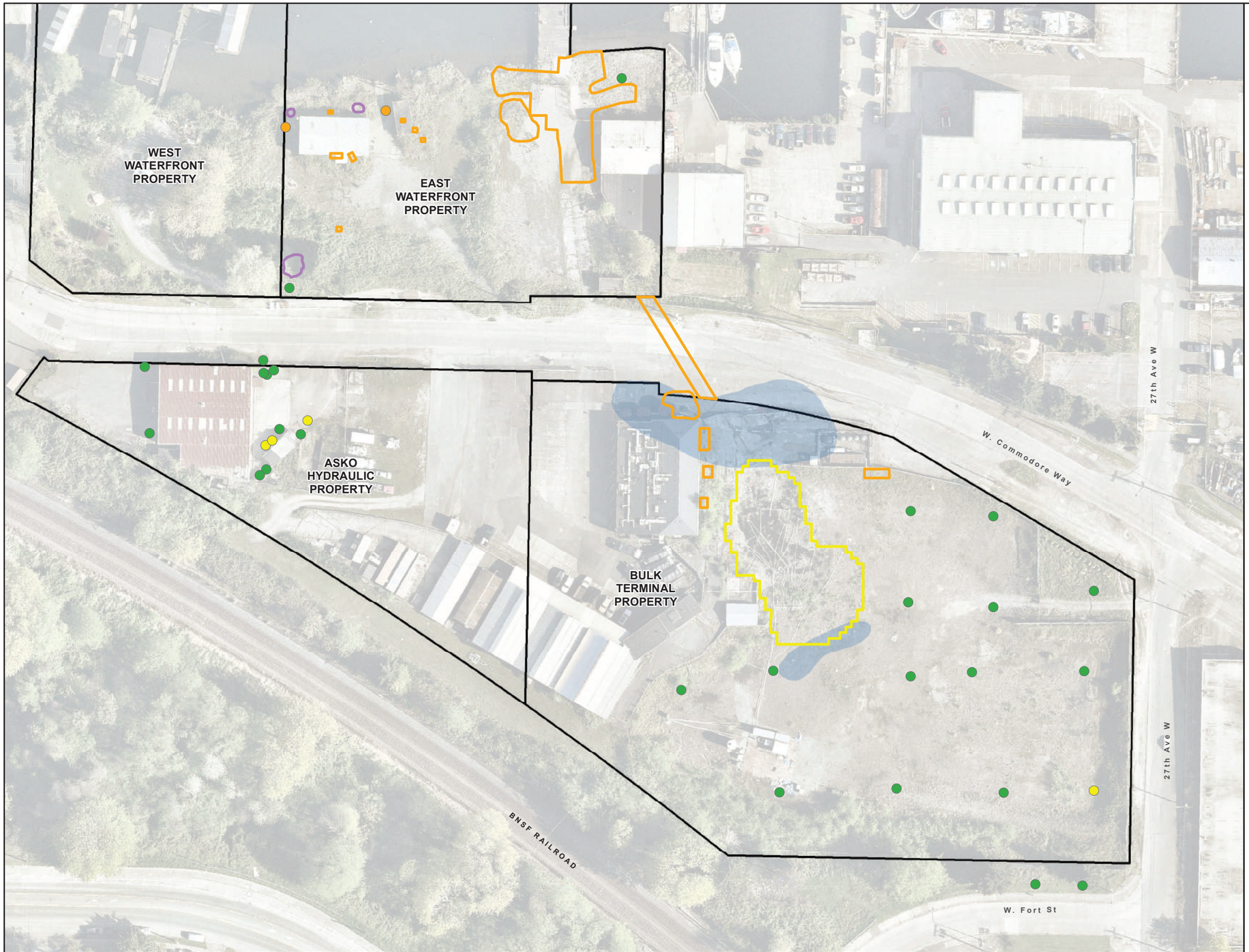
Figure 7.9
Chlorinated Volitile Organic Compounds Distribution in Groundwater—ASKO Property

I:\GIS\Projects\Cantera-TOC\MXD\RIFS\RI 2019\Figure 7.9 cVOC Distribution in Groundwater-ASKO.mxd
9/11/2020



Legend

Soil Sample Results

- All Results Less Than Criteria
- One or More Results Greater Than Criteria by ≤ 2 times
- One or More Results Greater Than Criteria by > 2 to < 5 times
- One or More Results Greater Than Criteria by ≥ 5 times

Extent of Historical Excavations

- 1991–2016: TPH Excavations
- 2002–2012: Penta and Dioxin/Furan Excavations
- 1992: Metals and Sandblast Grit Excavations

Other Site Features

- Approximate LNAPL Extent
- Property Boundary for the Seattle Terminal Properties

Proposed Cleanup Level
Arsenic: 7.3 mg/kg

Notes:
- Refer to Figures 3.3 and 3.4 for details about individual historical excavation areas.
- Parcel boundaries obtained from King County Geographic Information Systems Center, 2011. Lot lines are approximate. Not for legal use.
- Orthoimagery obtained from Nearmap, 2018.

Abbreviations:
LNAPL = Light non-aqueous-phase liquid
mg/kg = Milligrams per kilogram
Penta = Pentachlorophenol
TPH = Total petroleum hydrocarbons

N

0 45 90 180
Scale in Feet

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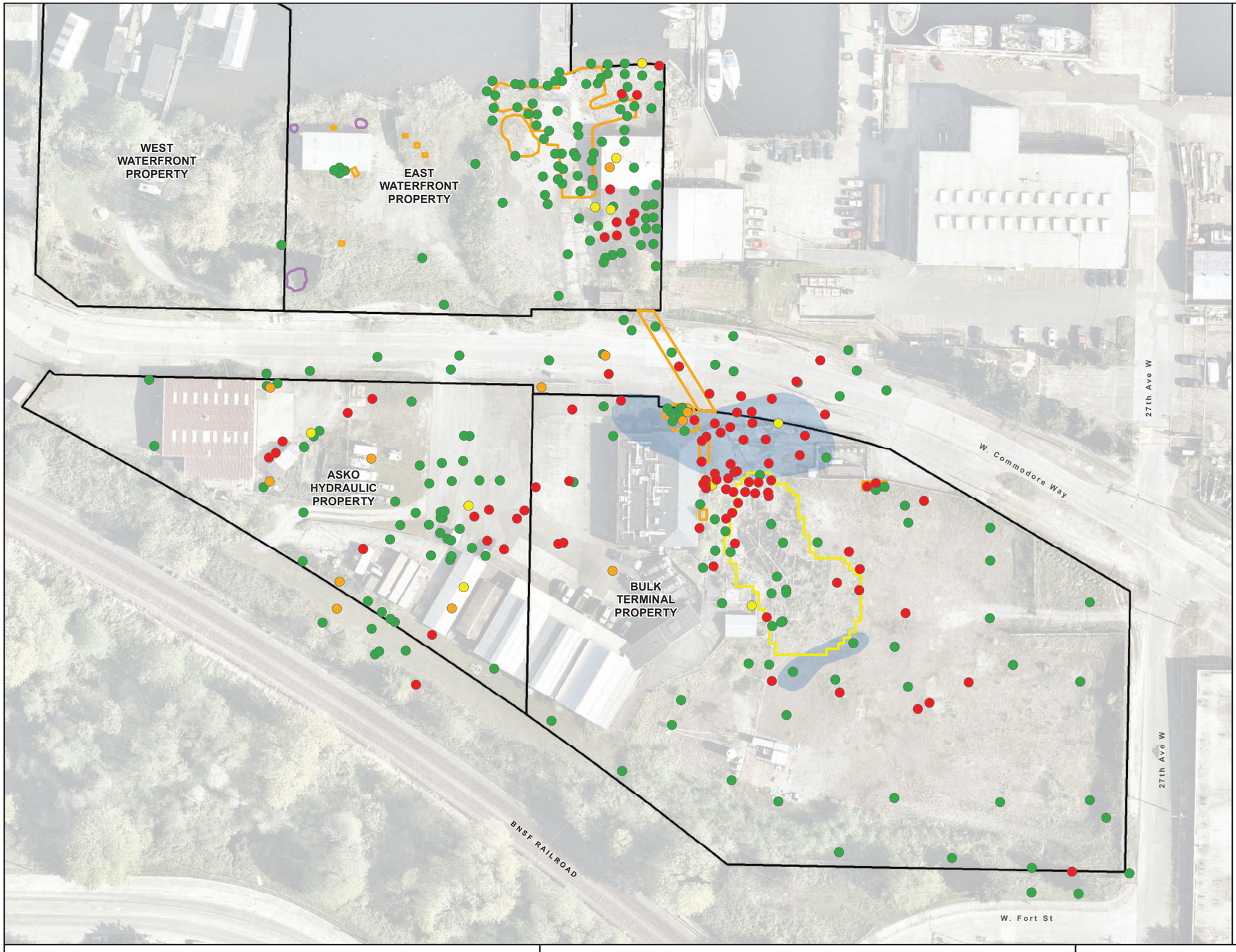
Supplemental Upland RI/FS
Time Oil Bulk Terminal PPA
Seattle, Washington

Figure 7.10
Arsenic Distribution in Soil—Sitewide

I:\GIS\Projects\Cantera-TOC\MXD\RIFS\RI 2019\Figure 7.10 Arsenic in Soil-Sitewide.mxd
9/11/2020



Legend

Soil Sample Results

- All Results Less Than Criteria
- One or More Results Greater Than Criteria by ≤ 2 times
- One or More Results Greater Than Criteria by > 2 to < 5 times
- One of More Results Greater Than Criteria by ≥ 5 times

Extent of Historical Excavations

- 1991–2016: TPH Excavations
- 2002–2012: Penta and Dioxin/Furan Excavations
- 1992: Metals and Sandblast Grit Excavations

Other Site Features

- Approximate LNAPL Extent
- Property Boundary for the Seattle Terminal Properties

Proposed Cleanup Level
GRO: 30 mg/kg

Notes:
· Refer to Figures 3.3 and 3.4 for details about individual historical excavation areas.
· Parcel boundaries obtained from King County Geographic Information Systems Center, 2011. Lot lines are approximate. Not for legal use.
· Orthoimagery obtained from Nearmap, 2018.

Abbreviations:
GRO = Gasoline-range organics
LNAPL = Light non-aqueous-phase liquid
mg/kg = Milligrams per kilogram
Penta = Pentachlorophenol
TPH = Total petroleum hydrocarbons

N
0 45 90 180
Scale in Feet

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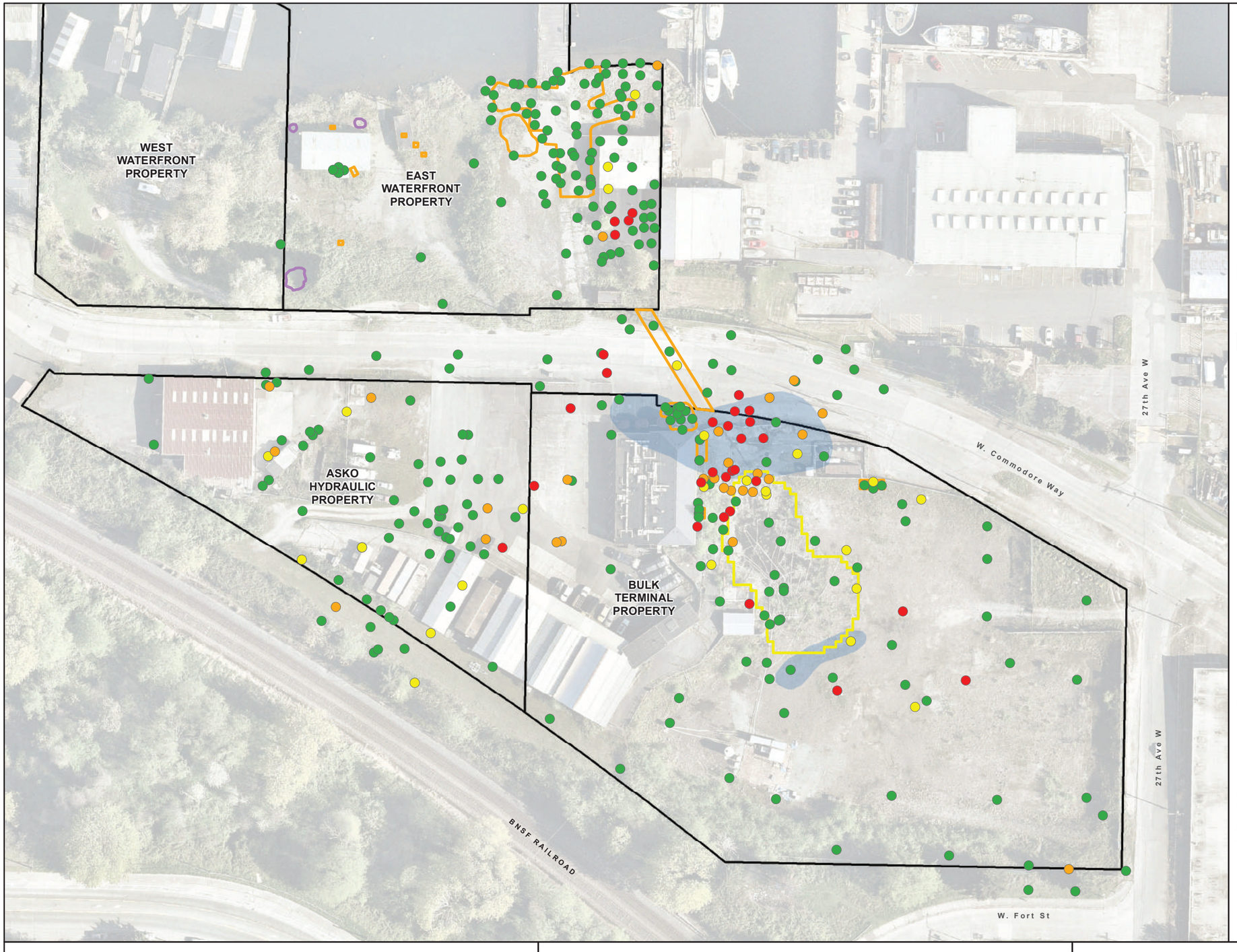
Time Oil Bulk Terminal PPA
Seattle, Washington

Figure 7.11
Gasoline-Range Organics Distribution in Soil—Sitewide

I:\GIS\Projects\Cantera-TOC\MXD\RIFS\RI 2019\Figure 7.11 GRO in Soil-Sitewide.mxd
9/11/2020



Legend

Soil Sample Results

- All Results Less Than Criteria
- One or More Results Greater Than Criteria by ≤ 2 times
- One or More Results Greater Than Criteria by > 2 to < 5 times
- One or More Results Greater Than Criteria by ≥ 5 times

Extent of Historical Excavations

- 1991–2016: TPH Excavations
- 2002–2012: Penta and Dioxin/Furan Excavations
- 1992: Metals and Sandblast Grit Excavations

Other Site Features

- Approximate LNAPL Extent
- Property Boundary for the Seattle Terminal Properties

Proposed Cleanup Level
DRO+ORO: 2,000 mg/kg

Notes:
- Refer to Figures 3.3 and 3.4 for details about individual historical excavation areas.
- Parcel boundaries obtained from King County Geographic Information Systems Center, 2011. Lot lines are approximate. Not for legal use.
- Orthoimagery obtained from Nearmap, 2018.

Abbreviations:
DRO = Diesel-range organics
LNAPL = Light non-aqueous-phase liquid
mg/kg = Milligrams per kilogram
Penta = Pentachlorophenol
ORO = Oil-range organics
TPH = Total petroleum hydrocarbons

N

0 45 90 180
Scale in Feet

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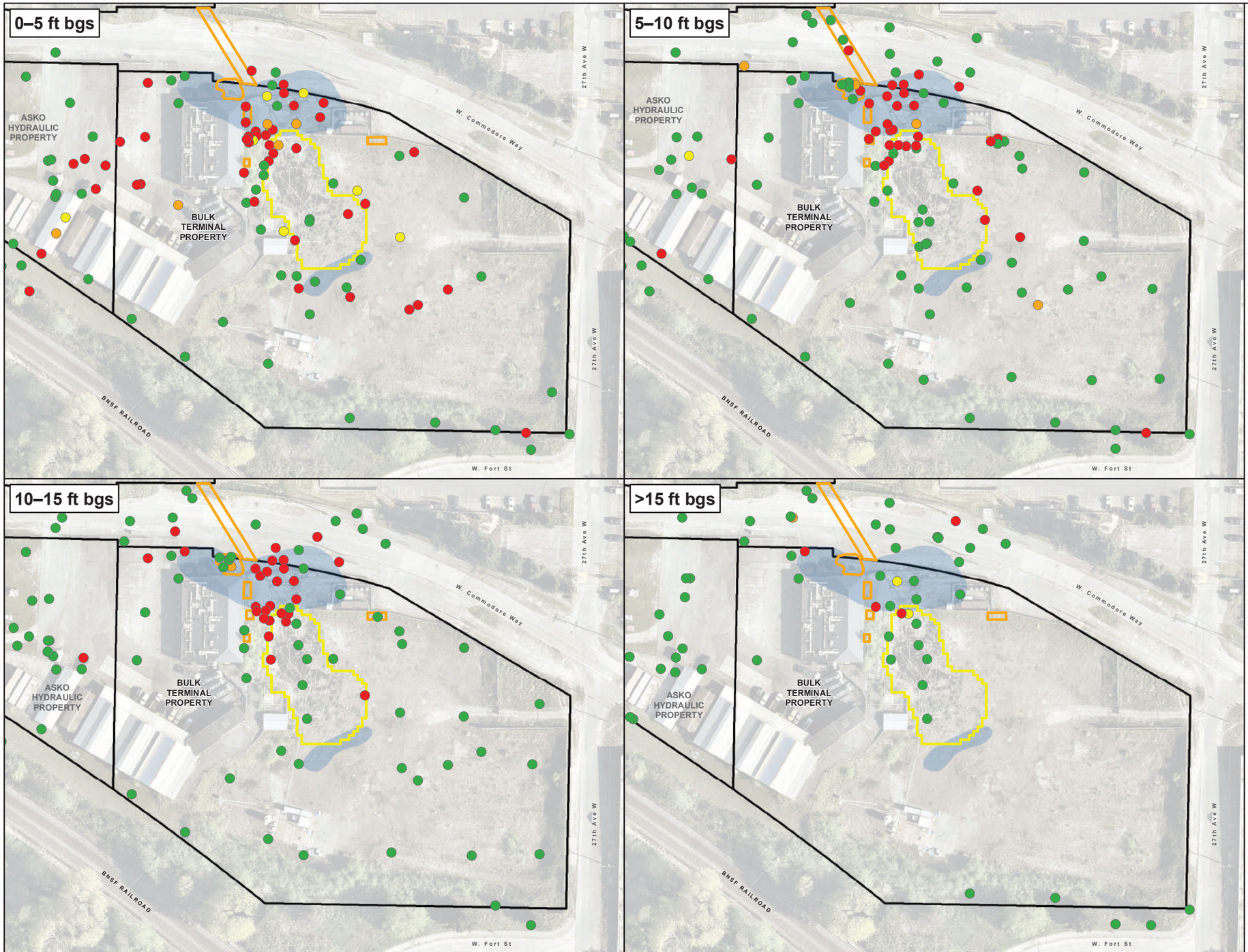
Time Oil Bulk Terminal PPA
Seattle, Washington

Figure 7.12
Diesel- and Oil-Range Organics Distribution in Soil—Sitewide

I:\GIS\Projects\Cantera-TOC\MXD\RIFS\RI 2019\Figure 7.12 DRO+ORO in Soil-Sitewide.mxd
9/11/2020



Legend

Soil Sample Results

- All Results Less Than Criteria
- One or More Results Greater Than Criteria by ≤ 2 times
- One or More Results Greater Than Criteria by > 2 to < 5 times
- One or More Results Greater Than Criteria by ≥ 5 times

Extent of Historical Excavations

- 1991–2016: TPH Excavations
- 2002–2012: Penta and Dioxin/Furan Excavations

Other Site Features

- Approximate LNAPL Extent
- Property Boundary for the Seattle Terminal Properties

Proposed Cleanup Level
GRO: 30 mg/kg

Notes:
· Refer to Figure 3.3 for details about individual historical excavation areas.
· Parcel boundaries obtained from King County Geographic Information Systems Center, 2011. Lot lines are approximate. Not for legal use.
· Orthoimagery obtained from Nearmap, 2018.

Abbreviations:
ft bgs = Feet below ground surface
GRO = Gasoline-range organics
LNAPL = Light non-aqueous-phase liquid
mg/kg = Milligrams per kilogram
Penta = Pentachlorophenol
TPH = Total petroleum hydrocarbons

N

0 60 120 240
Scale in Feet

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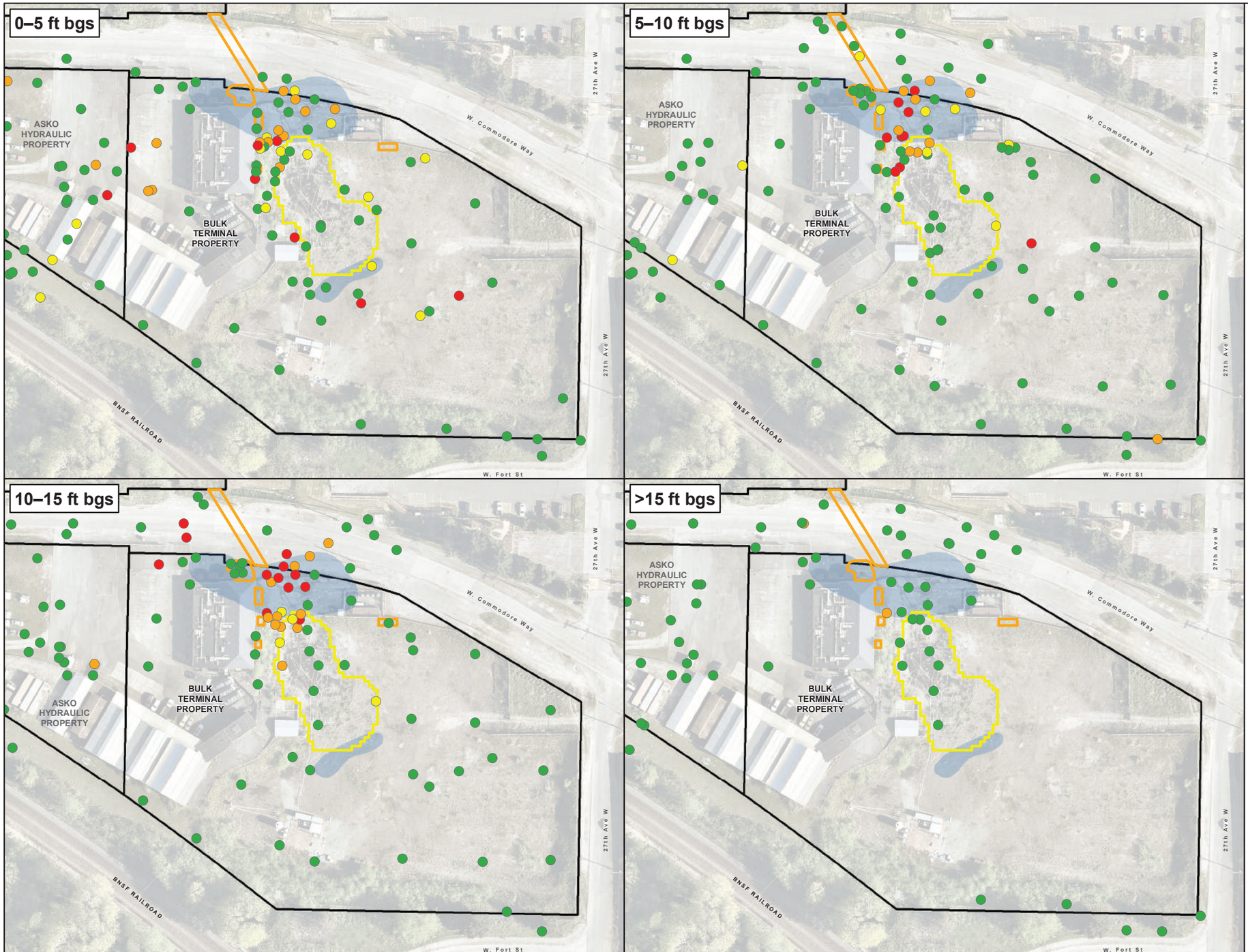
Time Oil Bulk Terminal PPA
Seattle, Washington

Figure 7.13
Gasoline-Range Organics Distribution in Soil—
Bulk Terminal Property

I:\GIS\Projects\Cantera-TOC\MXD\RIFS\RI 2019\Figure 7.13 GRO in Soil-Bulk Terminal.mxd
9/11/2020



Legend

Soil Sample Results

- All Results Less Than Criteria
- One or More Results Greater Than Criteria by ≤ 2 times
- One or More Results Greater Than Criteria by > 2 to < 5 times
- One or More Results Greater Than Criteria by ≥ 5 times

Extent of Historical Excavations

- 1991–2016: TPH Excavations
- 2002–2012: Penta and Dioxin/Furan Excavations

Other Site Features

- Approximate LNAPL Extent
- Property Boundary for the Seattle Terminal Properties

Proposed Cleanup Level
DRO+ORO: 2,000 mg/kg

Notes:
· Refer to Figure 3.3 for details about individual historical excavation areas.
· Parcel boundaries obtained from King County Geographic Information Systems Center, 2011. Lot lines are approximate. Not for legal use.
· Orthoimagery obtained from Nearmap, 2018.

Abbreviations:
DRO = Diesel-range organics
ft bgs = Feet below ground surface
LNAPL = Light non-aqueous-phase liquid
mg/kg = Milligrams per kilogram
Penta = Pentachlorophenol
ORO = Oil-range organics
TPH = Total petroleum hydrocarbons

N

0 60 120 240
Scale in Feet

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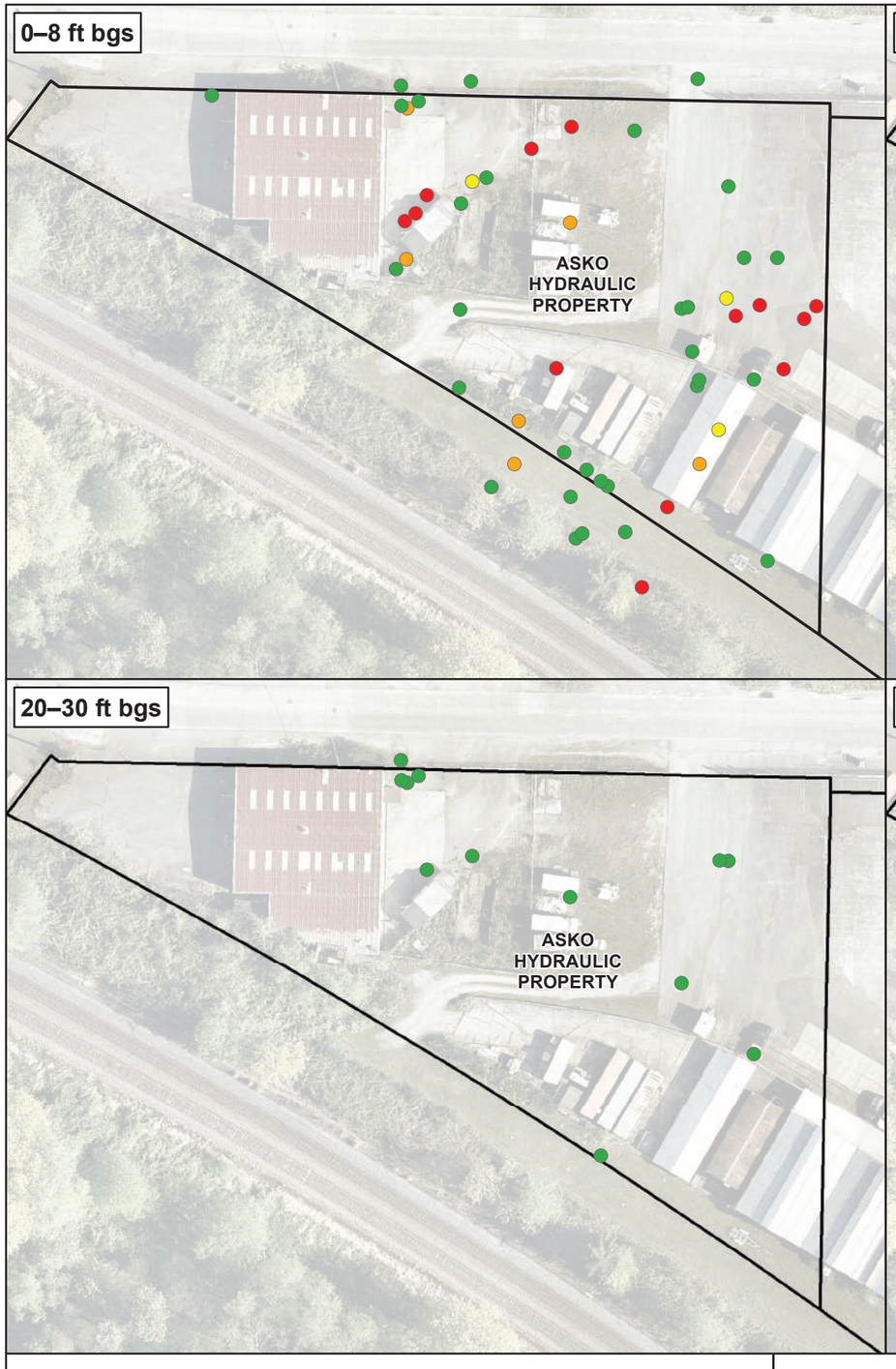
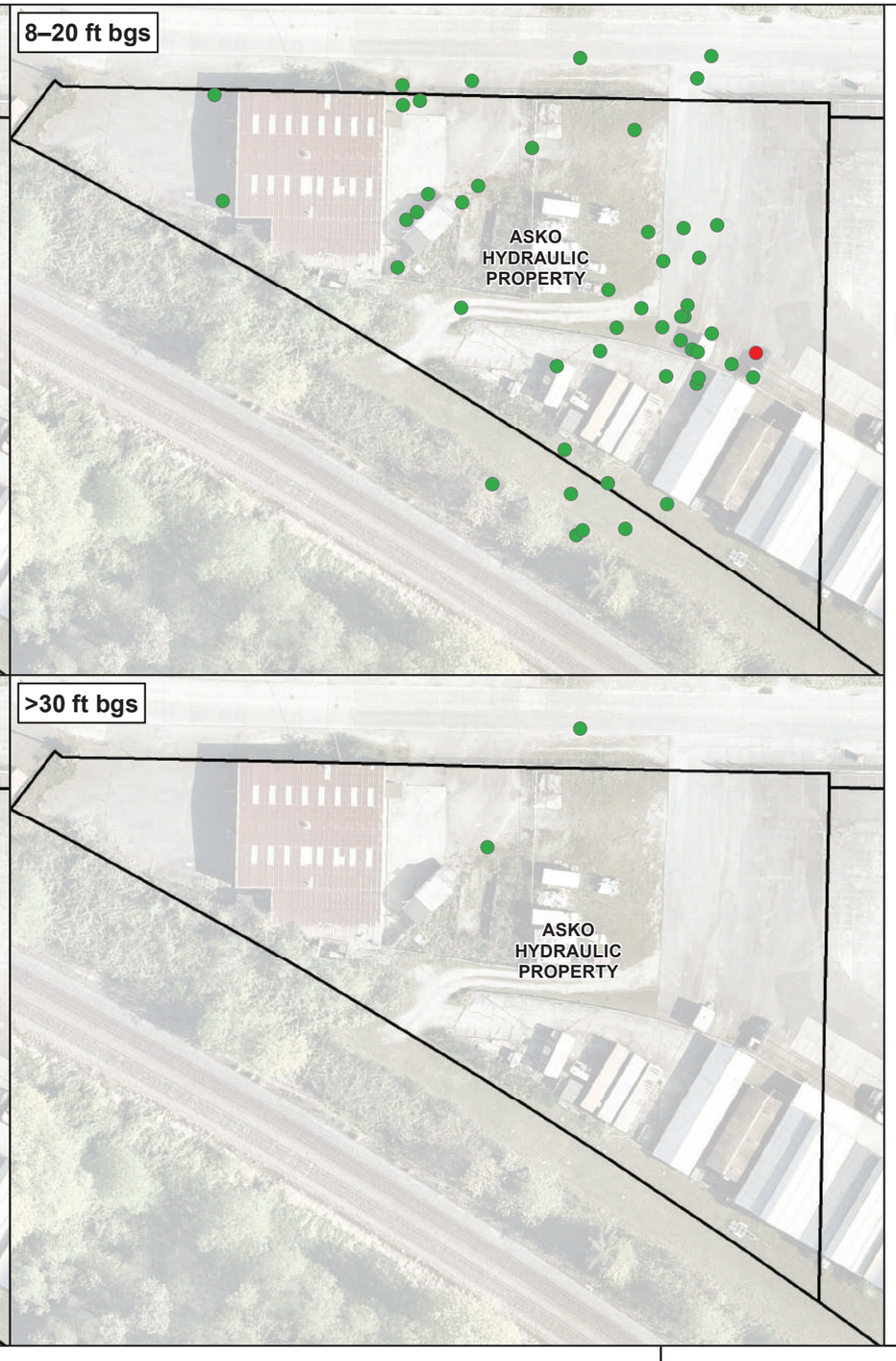
Time Oil Bulk Terminal PPA
Seattle, Washington

Figure 7.14
Diesel- and Oil-Range Organics Distribution in Soil—
Bulk Terminal Property

I:\GIS\Projects\Cantera-TOC\MXD\RIFS\RI 2019\Figure 7.14 DRO and ORO in Soil-Bulk Terminal.mxd
9/11/2020





Legend

Soil Sample Results

- All Results Less Than Criteria
- One or More Results Greater Than Criteria by ≤ 2 times
- One or More Results Greater Than Criteria by > 2 to < 5 times
- One or More Results Greater Than Criteria by ≥ 5 times

Other Site Features

- Property Boundary for the Seattle Terminal Properties

Proposed Cleanup Level
GRO: 30 mg/kg

Notes:
· Parcel boundaries obtained from King County Geographic Information Systems Center, 2011. Lot lines are approximate. Not for legal use.
· Orthoimagery obtained from Nearmap, 2018.

Abbreviations:
ft bgs = Feet below ground surface
GRO = Gasoline-range organics
mg/kg = Milligrams per kilogram

N

0 40 80 160
Scale in Feet

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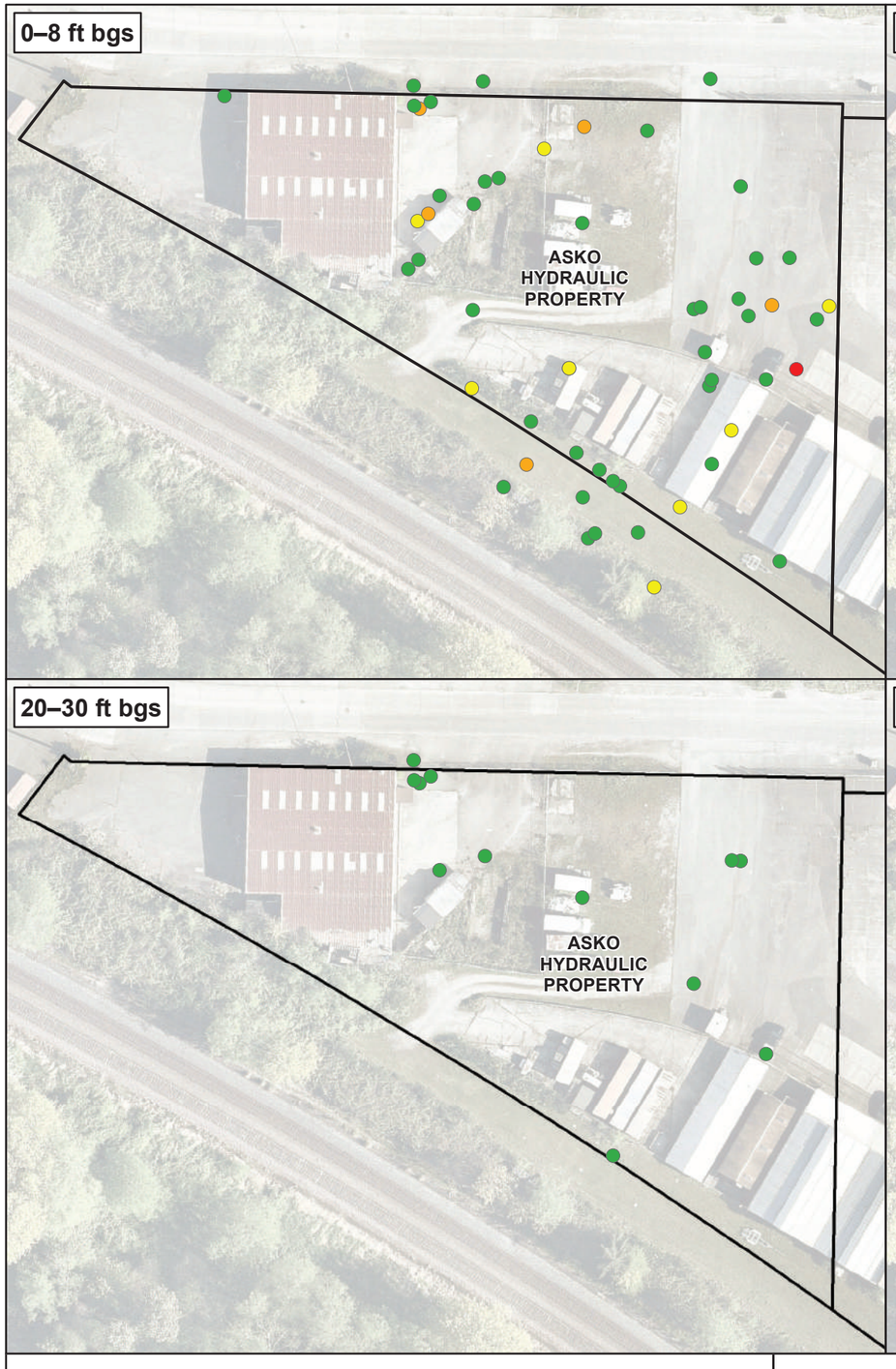
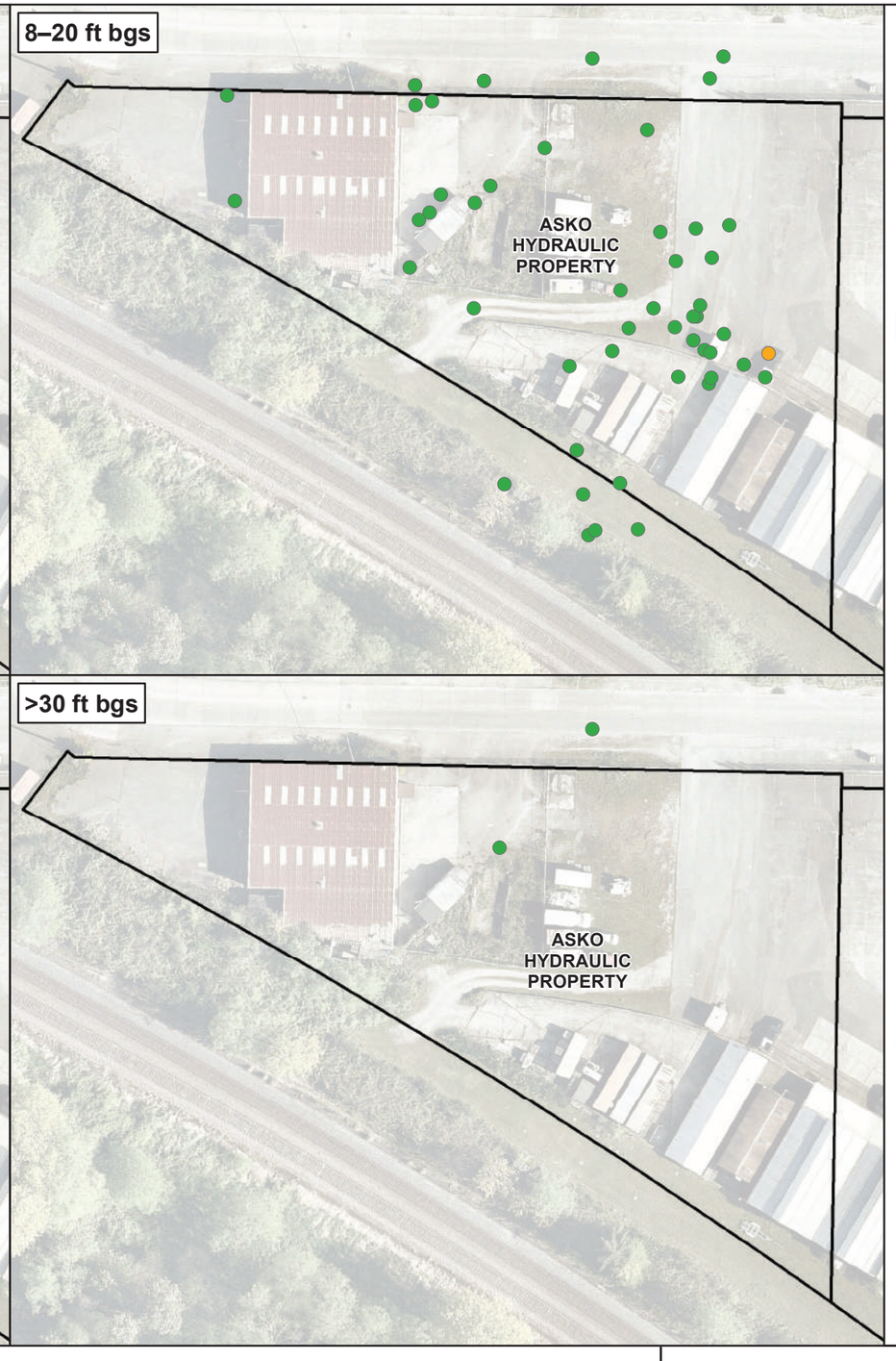
Time Oil Bulk Terminal PPA
Seattle, Washington

Figure 7.15
Gasoline-Range Organics Distribution in Soil—
ASKO Property

I:\GIS\Projects\Cantera-TOC\MXD\RIFS\RI 2019\Figure 7.15 GRO in Soil-ASKO.mxd
9/11/2020





Legend

Soil Sample Results

- All Results Less Than Criteria
- One or More Results Greater Than Criteria by ≤ 2 times
- One or More Results Greater Than Criteria by > 2 to < 5 times
- One or More Results Greater Than Criteria by ≥ 5 times

Other Site Features

- Property Boundary for the Seattle Terminal Properties

Proposed Cleanup Level
DRO+ORO: 2,000 mg/kg

Notes:
· Parcel boundaries obtained from King County Geographic Information Systems Center, 2011. Lot lines are approximate. Not for legal use.
· Orthoimagery obtained from Nearmap, 2018.

Abbreviations:
DRO = Diesel-range organics
ft bgs = Feet below ground surface
mg/kg = Milligrams per kilogram
ORO = Oil-range organics

N

0 40 80 160
Scale in Feet

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Time Oil Bulk Terminal PPA
Seattle, Washington

Figure 7.16
Diesel- and Oil-Range Organics Distribution in Soil—
ASKO Property

I:\GIS\Projects\Cantera-TOC\MXD\RIFS\RI 2019\Figure 7.16 DRO and ORO in Soil-ASKO.mxd
9/11/2020

EAST
WATERFRONT
PROPERTY

W. Commodore Way

Legend

Soil Sample Results

- All Results Less Than Criteria
- One or More Results Greater Than Criteria

Extent of Historical Excavations

- 1991–2016: TPH Excavations
- 1992: Metals and Sandblast Grit Excavations

Other Site Features

- Property Boundary for the Seattle Terminal Properties

Proposed Cleanup Level
GRO: 30 mg/kg
DRO+ORO: 2,000 mg/kg

Notes:
· Refer to Figure 3.4 for details about individual historical excavation areas.
· Parcel boundaries obtained from King County Geographic Information Systems Center, 2011. Lot lines are approximate. Not for legal use.
· Orthoimagery obtained from Nearmap, 2018.

Abbreviations:
DRO = Diesel-range organics
GRO = Gasoline-range organics
mg/kg = Milligrams per kilogram
ORO = Oil-range organics
TPH = Total petroleum hydrocarbons

N

0 20 40 80
Scale in Feet

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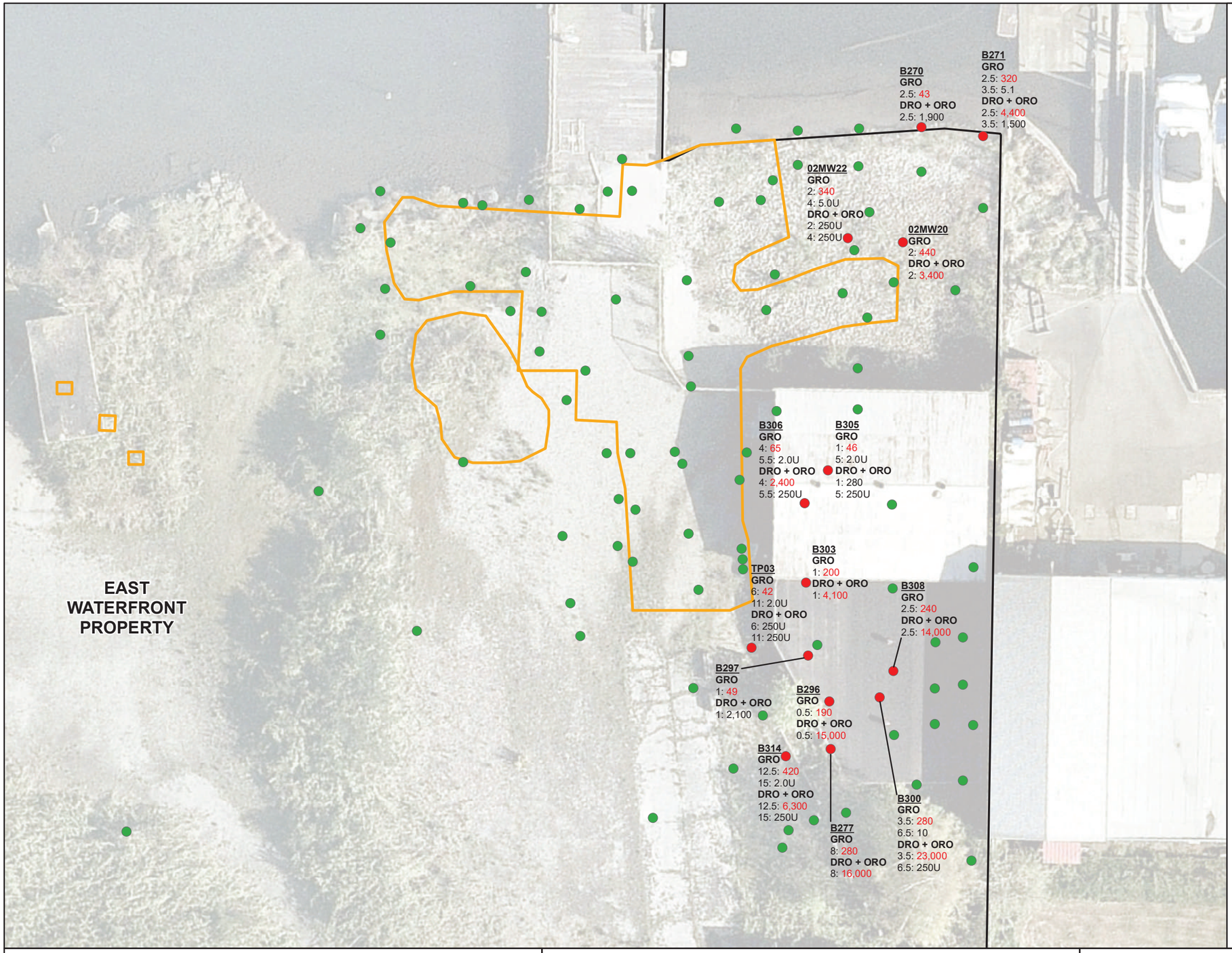
Supplemental Upland RI/FS
Time Oil Bulk Terminal PPA
Seattle, Washington

Figure 7.17
Total Petroleum Hydrocarbons Distribution in Soil—
East Waterfront Property

I:\GIS\Projects\Cantera-TOC\MXD\RIFS\RI 2019\Figure 7.17 TPH in Soil-East Waterfront.mxd
9/11/2020



Legend

Soil Sample Results

- All Results Less Than Criteria
- One or More Results Greater Than Criteria

Extent of Historical Excavations

- 1991–2016: TPH Excavations

Other Site Features

- Property Boundary for the Seattle Terminal Properties

Proposed Cleanup Level
GRO: 30 mg/kg
DRO+ORO: 2,000 mg/kg

Notes:
- Results shown in RED indicate exceedances of criteria.
- Chemical results are presented only at locations where a result exceeds the criterion.
- Results presented in mg/kg.
- Refer to Figure 3.4 for details about individual historical excavation areas.
- Parcel boundaries obtained from King County Geographic Information Systems Center, 2011. Lot lines are approximate. Not for legal use.
- Orthoimagery obtained from Nearmap, 2018.

Abbreviations:
DRO = Diesel-range organics
GRO = Gasoline-range organics
mg/kg = Milligrams per kilogram
ORO = Oil-range organics
TPH = Total petroleum hydrocarbons

Qualifier:
U Analyte was not detected at the given reporting limit.

N

0 12.5 25 50
Scale in Feet

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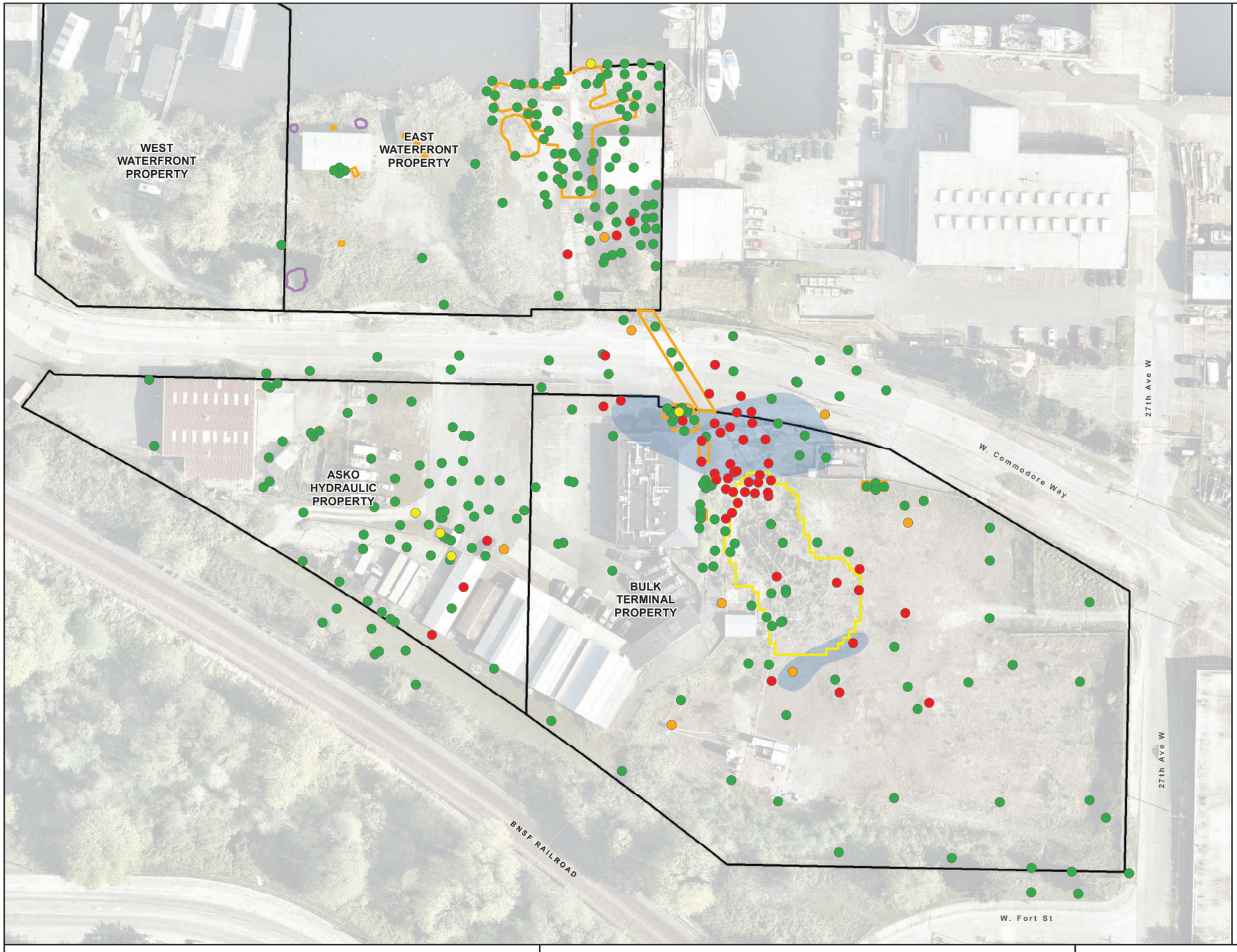
Supplemental Upland RI/FS
Time Oil Bulk Terminal PPA
Seattle, Washington

Figure 7.18
Total Petroleum Hydrocarbons Distribution in Soil (with data)—
East Waterfront Property

I:\GIS\Projects\Cantera-TOC\MXD\RIFS\RI 2019\Figure 7.18 TPH in Soil (with data)-East Waterfront.mxd
9/11/2020



Legend

Soil Sample Results

- All Results Less Than Criteria
- One or More Results Greater Than Criteria by ≤ 2 times
- One or More Results Greater Than Criteria by > 2 to < 5 times
- One or More Results Greater Than Criteria by ≥ 5 times

Extent of Historical Excavations

- 1991–2016: TPH Excavations
- 2002–2012: Penta and Dioxin/Furan Excavations
- 1992: Metals and Sandblast Grit Excavations

Other Site Features

- Approximate LNAPL Extent
- Property Boundary for the Seattle Terminal Properties

Proposed Cleanup Level
Benzene: 0.020 mg/kg

Notes:
· Refer to Figures 3.3 and 3.4 for details about individual historical excavation areas.
· Parcel boundaries obtained from King County Geographic Information Systems Center, 2011. Lot lines are approximate. Not for legal use.
· Orthoimagery obtained from Nearmap, 2018.

Abbreviations:
LNAPL = Light non-aqueous-phase liquid
mg/kg = Milligrams per kilogram
Penta = Pentachlorophenol
TPH = Total petroleum hydrocarbons

N

0 45 90 180
Scale in Feet

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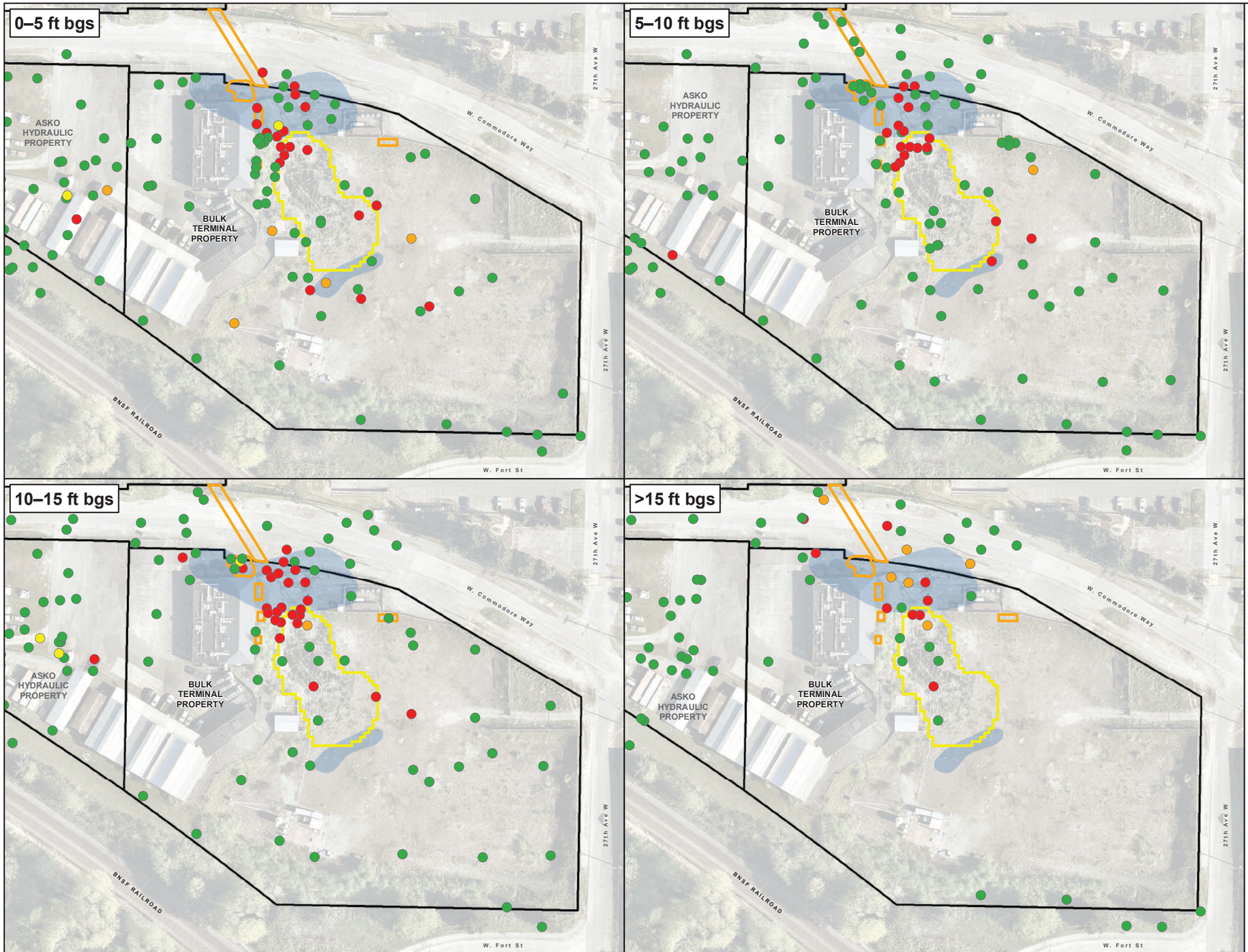
Supplemental Upland RI/FS
Time Oil Bulk Terminal PPA
Seattle, Washington

Figure 7.19
Benzene Distribution in Soil—Sitewide

I:\GIS\Projects\Cantera-TOC\MXD\RIFS\RI 2019\Figure 7.19 Benzene in Soil-Sitewide.mxd
9/11/2020



Legend

Soil Sample Results

- All Results Less Than Criteria
- One or More Results Greater Than Criteria by ≤ 2 times
- One or More Results Greater Than Criteria by > 2 to < 5 times
- One or More Results Greater Than Criteria by ≥ 5 times

Extent of Historical Excavations

- 1991–2016: TPH Excavations
- 2002–2012: Penta and Dioxin/Furan Excavations

Other Site Features

- Approximate LNAPL Extent
- Property Boundary for the Seattle Terminal Properties

Proposed Cleanup Level
Benzene: 0.020 mg/kg

Notes:
· Refer to Figure 3.3 for details about individual historical excavation areas.
· Parcel boundaries obtained from King County Geographic Information Systems Center, 2011. Lot lines are approximate. Not for legal use.
· Orthoimagery obtained from Nearmap, 2018.

Abbreviations:
ft bgs = Feet below ground surface
LNAPL = Light non-aqueous-phase liquid
mg/kg = Milligrams per kilogram
Penta = Pentachlorophenol
TPH = Total petroleum hydrocarbons

N

0 60 120 240
Scale in Feet

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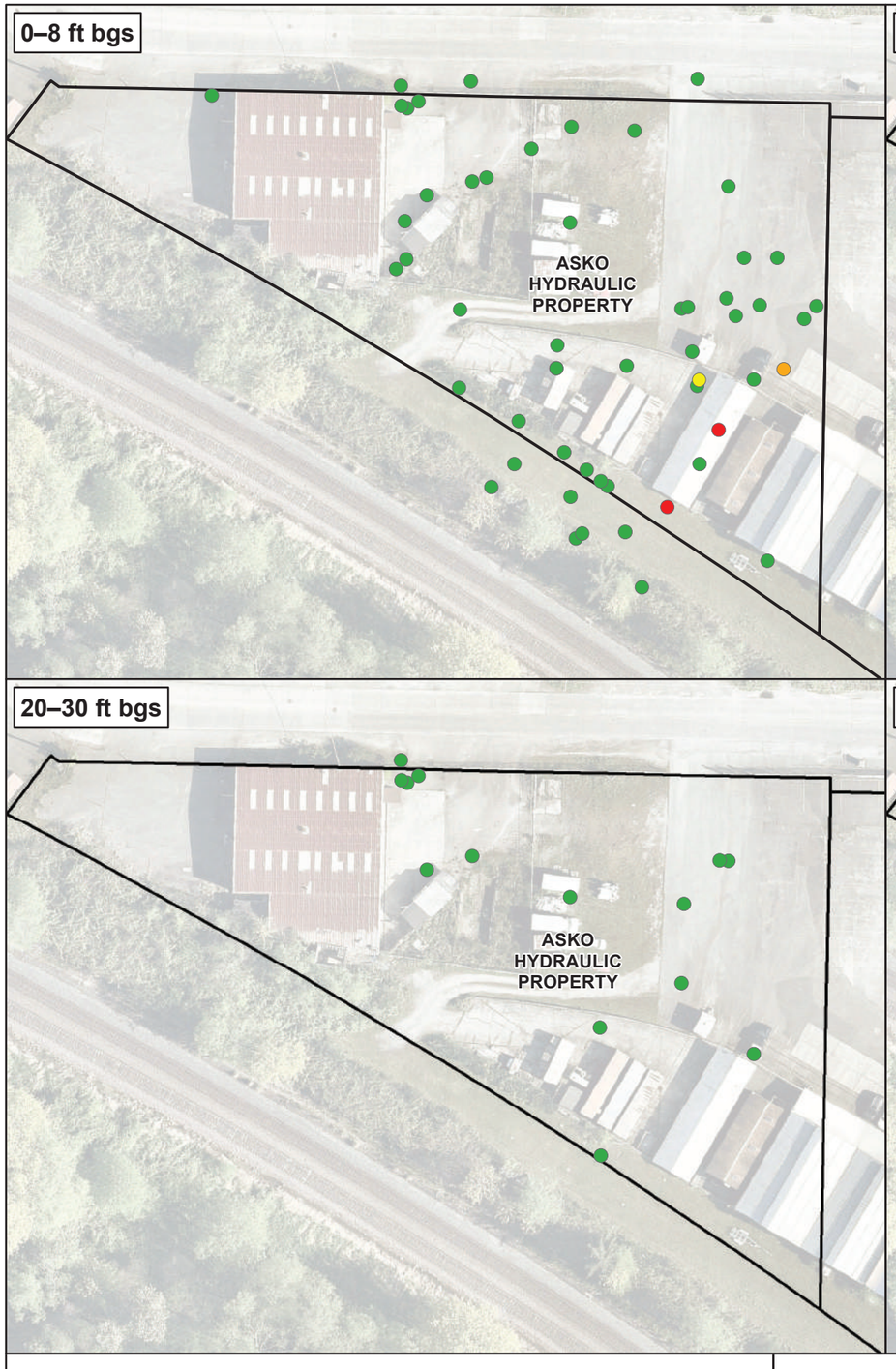
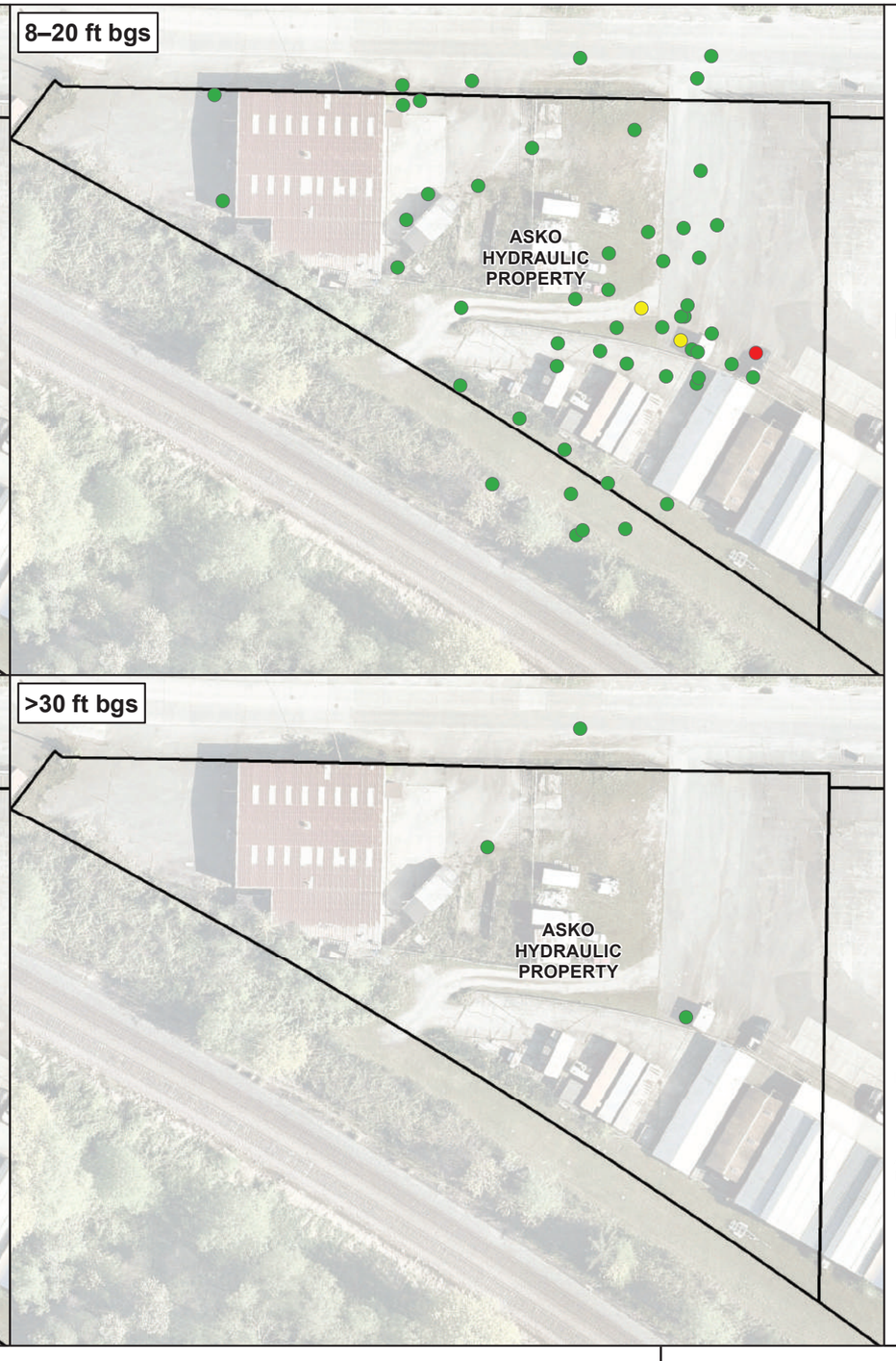
Supplemental Upland RI/FS
Time Oil Bulk Terminal PPA
Seattle, Washington

Figure 7.20
Benzene Distribution in Soil—
Bulk Terminal Property

I:\GIS\Projects\Cantera-TOC\MXD\RIFS\RI 2019\Figure 7.20 Benzene in Soil-Bulk Terminal.mxd
9/11/2020





Legend

Soil Sample Results

- All Results Less Than Criteria
- One or More Results Greater Than Criteria by ≤ 2 times
- One or More Results Greater Than Criteria by > 2 to < 5 times
- One or More Results Greater Than Criteria by ≥ 5 times

Other Site Features

- Property Boundary for the Seattle Terminal Properties

Proposed Cleanup Level
Benzene: 0.020 mg/kg

Notes:
· Parcel boundaries obtained from King County Geographic Information Systems Center, 2011. Lot lines are approximate. Not for legal use.
· Orthoimagery obtained from Nearmap, 2018.

Abbreviations:
ft bgs = Feet below ground surface
mg/kg = Milligrams per kilogram

N

0 40 80 160
Scale in Feet

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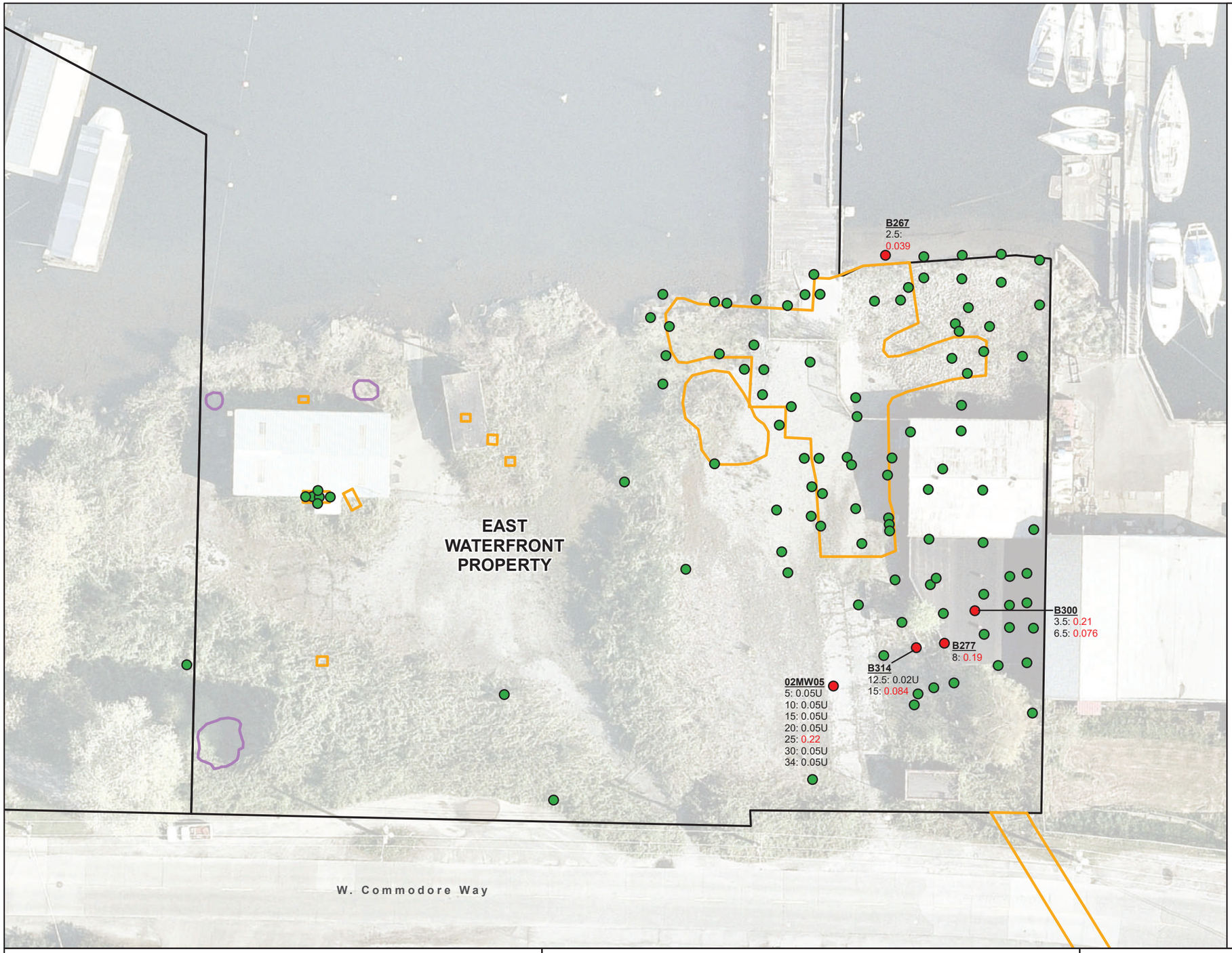
Time Oil Bulk Terminal PPA
Seattle, Washington

Figure 7.21
Benzene Distribution in Soil—
ASKO Property

I:\GIS\Projects\Cantera-TOC\MXD\RIFS\RI 2019\Figure 7.21 Benzene in Soil-ASKO.mxd
9/11/2020



Legend

Soil Sample Results

- All Results Less Than Criteria
- One or More Results Greater Than Criteria

Extent of Historical Excavations

- 1991–2016: TPH Excavations
- 1992: Metals and Sandblast Grit Excavations

Other Site Features

- Property Boundary for the Seattle Terminal Properties

Proposed Cleanup Level
Benzene: 0.020 mg/kg

Notes:
- Results shown in RED indicate exceedances exceedance of criteria.
- Chemical results are presented only at locations where a result exceeds the criterion.
- Results presented in mg/kg.
- Refer to Figure 3.4 for details about individual historical excavation areas.
- Parcel boundaries obtained from King County Geographic Information Systems Center, 2011. Lot lines are approximate. Not for legal use.
- Orthoimagery obtained from Nearmap, 2018.

Abbreviations:
mg/kg = Milligrams per kilogram
TPH = Total petroleum hydrocarbons

Qualifier:
U Analyte was not detected at the given reporting limit.

N

0 20 40 80
Scale in Feet

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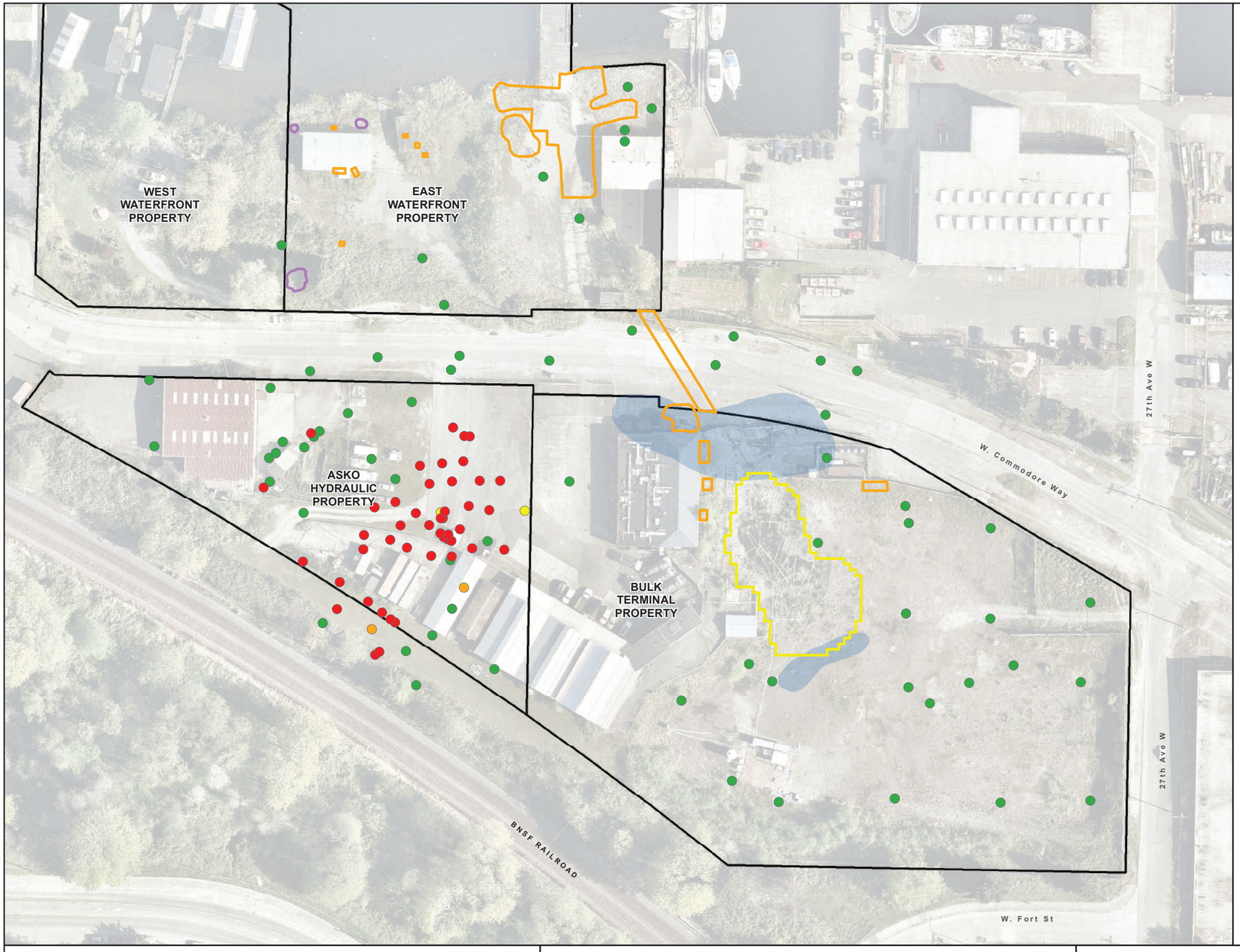
Supplemental Upland RI/FS
Time Oil Bulk Terminal PPA
Seattle, Washington

Figure 7.22
Benzene Distribution in Soil (with data)—
East Waterfront Property

I:\GIS\Projects\Cantera-TOC\MXD\RIFS\RI 2019\Figure 7.22 Benzene in Soil (with data)-East Waterfront.mxd
9/11/2020



Legend

Soil Sample Results

- All Results Less Than Criteria
- One or More Results Greater Than Criteria by ≤ 2 times
- One or More Results Greater Than Criteria by > 2 to < 5 times
- One or More Results Greater Than Criteria by ≥ 5 times

Extent of Historical Excavations

- 1991–2016: TPH Excavations
- 2002–2012: Penta and Dioxin/Furan Excavations
- 1992: Metals and Sandblast Grit Excavations

Other Site Features

- Approximate LNAPL Extent
- Property Boundary for the Seattle Terminal Properties

Proposed Cleanup Level
Trichloroethene: 0.020 mg/kg

Notes:
- Refer to Figures 3.3 and 3.4 for details about individual historical excavation areas.
- Parcel boundaries obtained from King County Geographic Information Systems Center, 2011. Lot lines are approximate. Not for legal use.
- Orthoimagery obtained from Nearmap, 2018.

Abbreviations:
GRO = Gasoline-range organics
LNAPL = Light non-aqueous-phase liquid
mg/kg = Milligrams per kilogram
Penta = Pentachlorophenol
TPH = Total petroleum hydrocarbons

N

0 45 90 180
Scale in Feet

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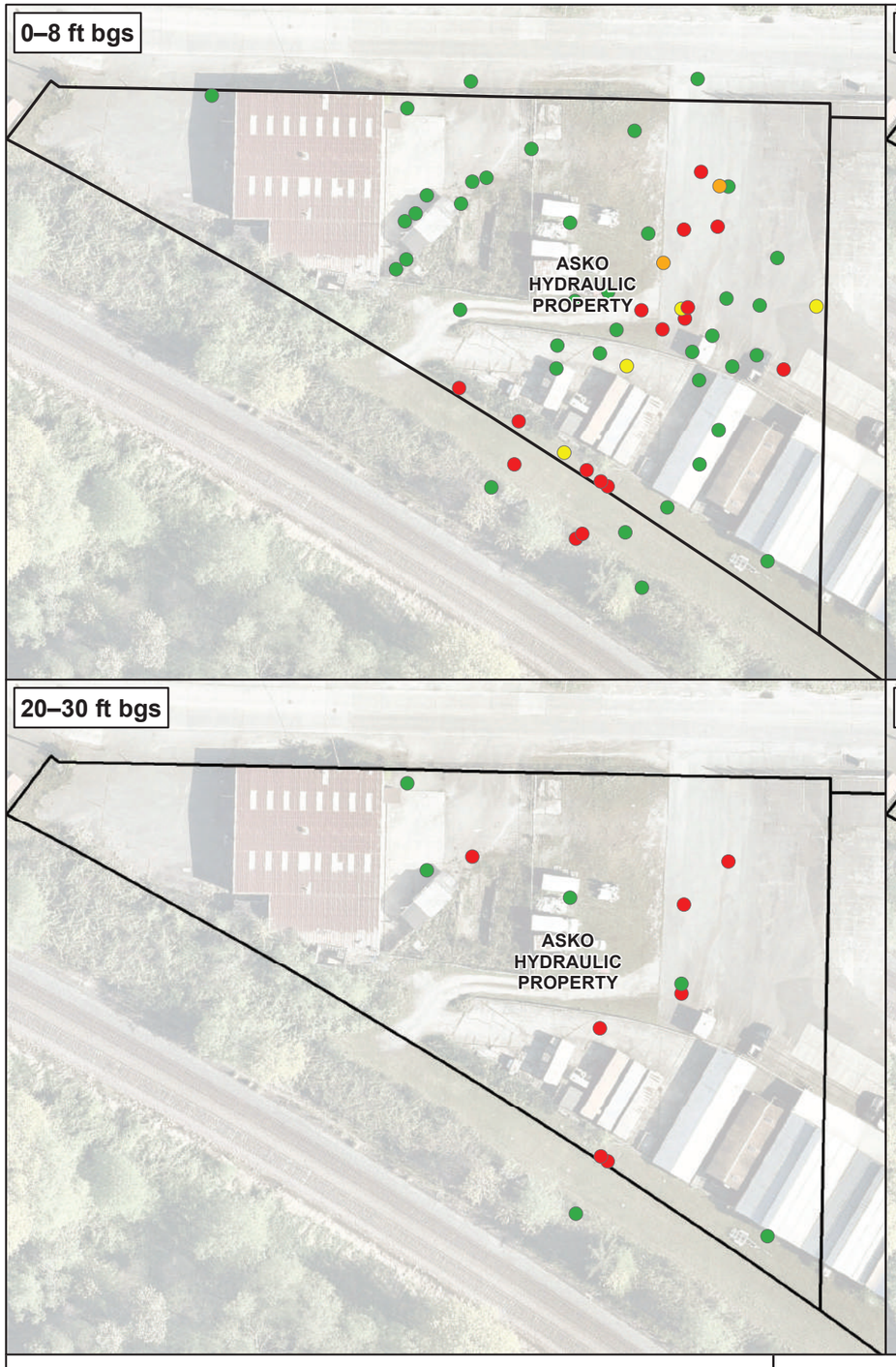
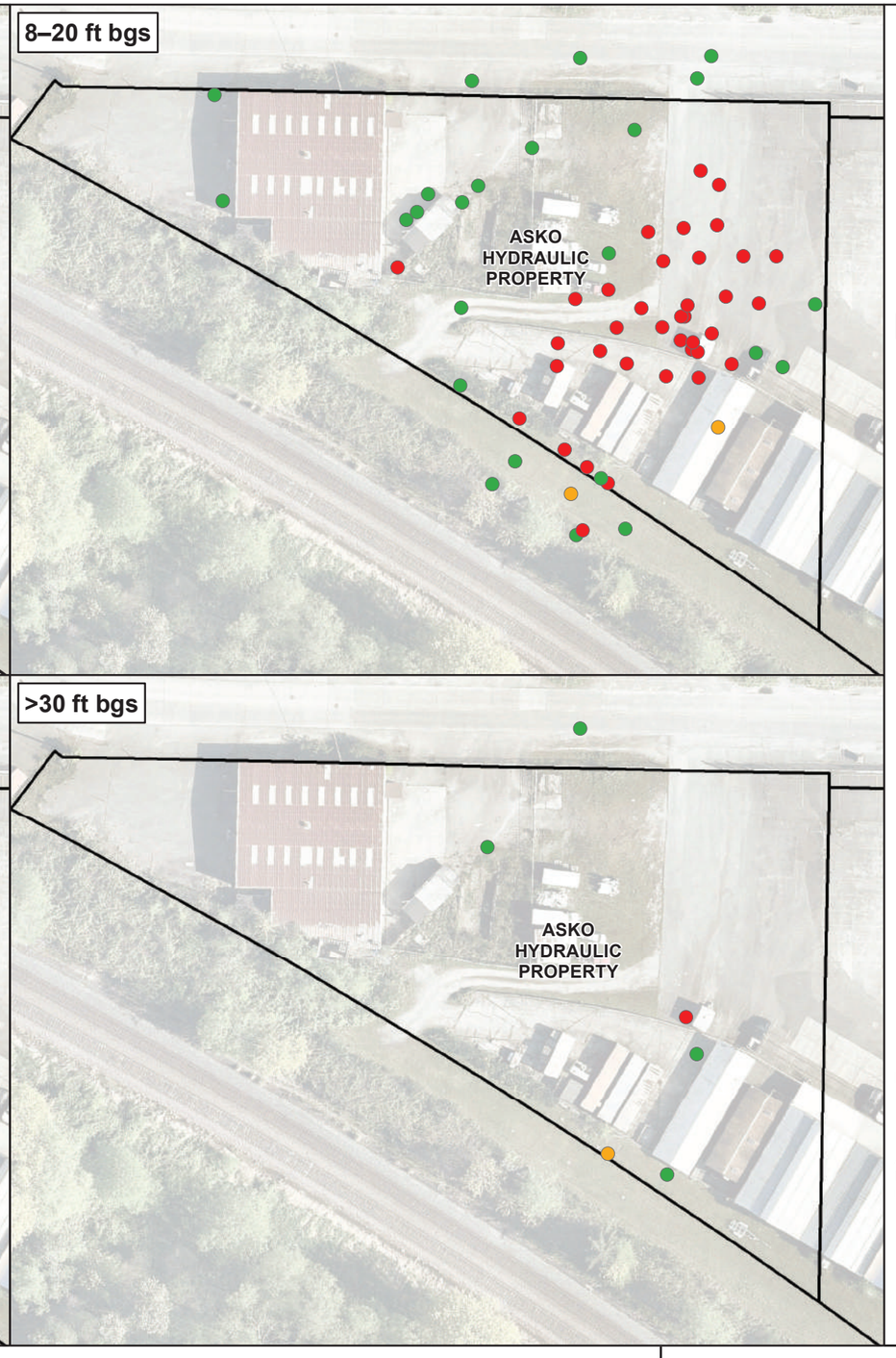
Supplemental Upland RI/FS
Time Oil Bulk Terminal PPA
Seattle, Washington

Figure 7.23
Trichloroethene Distribution in Soil—Sitewide

I:\GIS\Projects\Cantera-TOC\MXD\RIFS\RI 2019\Figure 7.23 TCE in Soil-Sitewide.mxd
9/11/2020





Legend

Soil Sample Results

- All Results Less Than Criteria
- One or More Results Greater Than Criteria by ≤ 2 times
- One or More Results Greater Than Criteria by > 2 to < 5 times
- One or More Results Greater Than Criteria by ≥ 5 times

Other Site Features

- Property Boundary for the Seattle Terminal Properties

Proposed Cleanup Level
Trichloroethene: 0.020 mg/kg

Notes:
· Parcel boundaries obtained from King County Geographic Information Systems Center, 2011. Lot lines are approximate. Not for legal use.
· Orthoimagery obtained from Nearmap, 2018.

Abbreviations:
ft bgs = Feet below ground surface
mg/kg = Milligrams per kilogram

N

0 40 80 160
Scale in Feet

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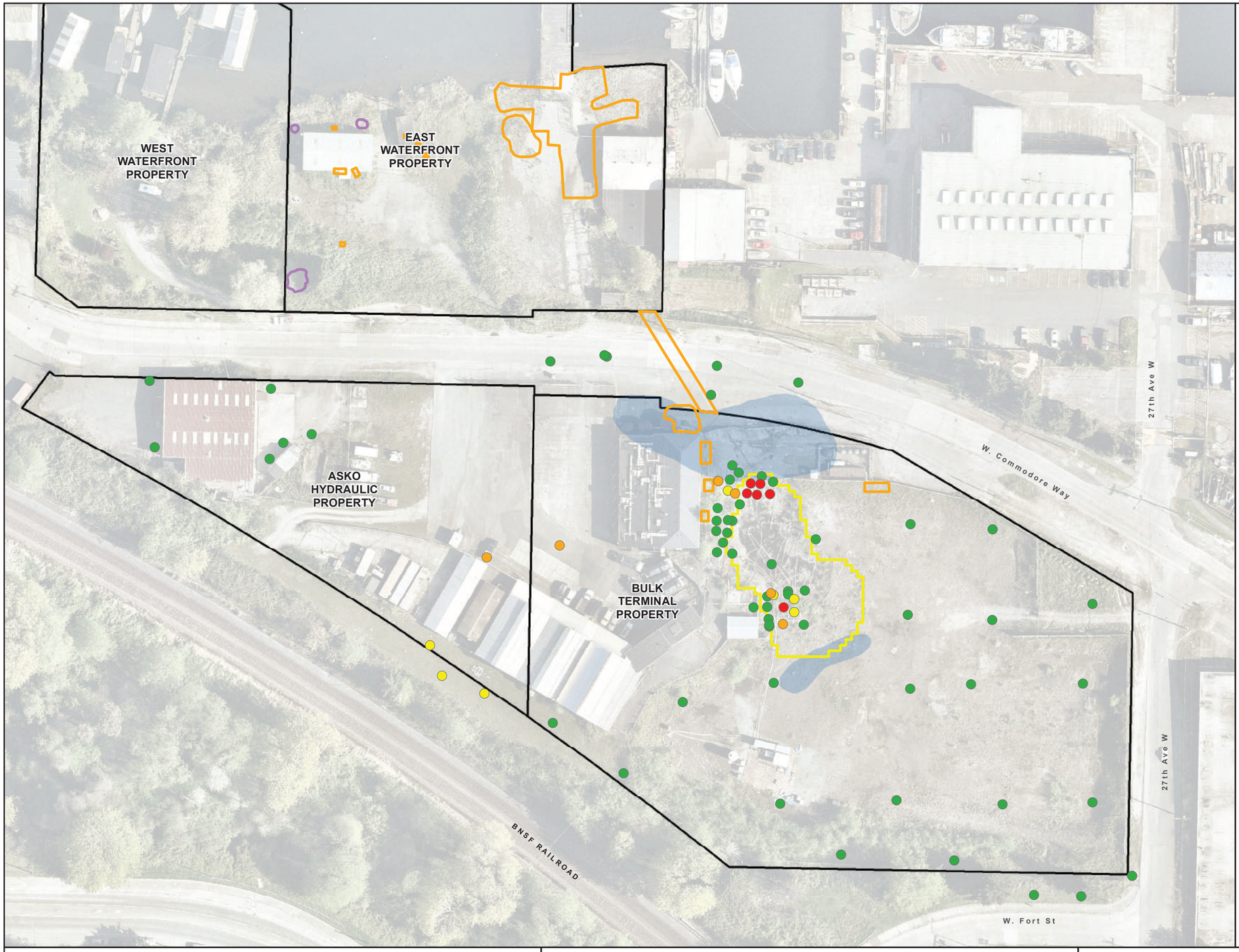
Supplemental Upland RI/FS
Time Oil Bulk Terminal PPA
Seattle, Washington

Figure 7.24
Trichloroethene Distribution in Soil—
ASKO Property

I:\GIS\Projects\Cantera-TOC\MXD\RIFS\RI 2019\Figure 7.24 TCE in Soil-ASKO.mxd
9/11/2020



Legend

Soil Sample Results

- All Results Less Than Criteria
- One or More Results Greater Than Criteria by ≤ 2 times
- One or More Results Greater Than Criteria by > 2 to < 5 times
- One or More Results Greater Than Criteria by ≥ 5 times

Extent of Historical Excavations

- 1991–2016: TPH Excavations
- 2002–2012: Penta and Dioxin/Furan Excavations
- 1992: Metals and Sandblast Grit Excavations

Other Site Features

- Approximate LNAPL Extent
- Property Boundary for the Seattle Terminal Properties

Proposed Cleanup Level
Penta: 0.050 mg/kg

Notes:
- Refer to Figures 3.3 and 3.4 for details about individual historical excavation areas.
- Parcel boundaries obtained from King County Geographic Information Systems Center, 2011. Lot lines are approximate. Not for legal use.
- Orthoimagery obtained from Nearmap, 2018.

Abbreviations:
LNAPL = Light non-aqueous-phase liquid
mg/kg = Milligrams per kilogram
Penta = Pentachlorophenol
TPH = Total petroleum hydrocarbons

N

0 45 90 180
Scale in Feet

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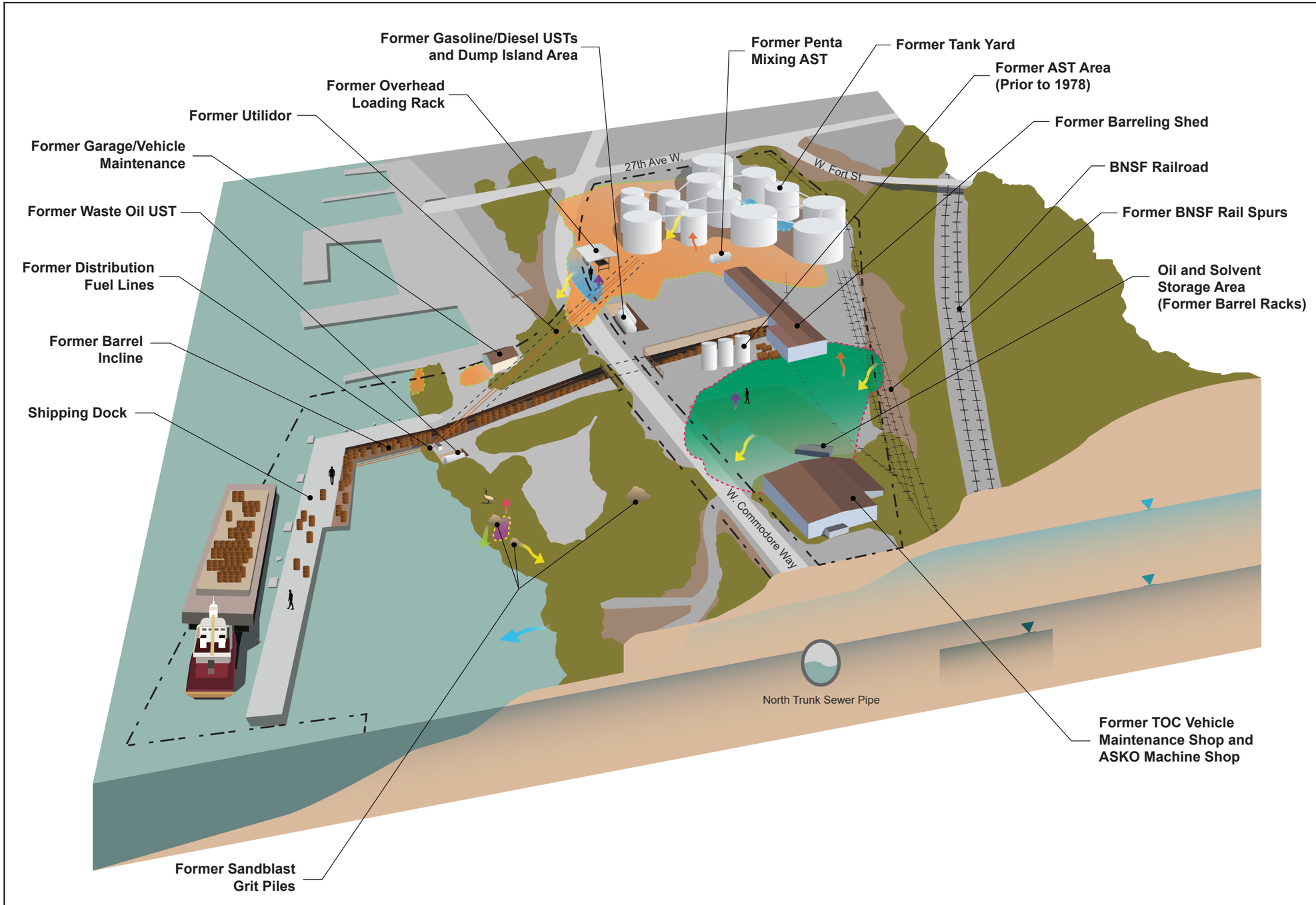
Figure 7.25
Pentachlorophenol in Soil—Sitewide

I:\GIS\Projects\Cantera-TOC\MXD\RIFS\RI 2019\Figure 7.25 Pentachlorophenol in Soil-Sitewide.mxd
9/11/2020



Legend

Site Features

- Property Boundary for the Seattle Terminal Properties
- Former Belowground Feature
- LNAPL Area (approximate)
- Paved Areas
- Unpaved Areas
- Vegetated Areas
- Surface Water
- Observed Shallow Groundwater (April/May 2019)
- Observed Intermediate Groundwater (July 2019)
- Observed Deep Groundwater (April/May 2019)

IHS Distribution

- cVOCs in Soil and/or Groundwater (approximate)
- TPH in Soil and/or Groundwater (approximate)
- Arsenic in Soil and/or Groundwater (approximate)

Migration and Exposure Pathways

- Groundwater to Surface Water Discharge
- Leaching to Groundwater
- Stormwater Runoff
- Worker Direct Contact
- Ecological Direct Contact
- Soil Vapor

Note:
- Model not to scale.

Abbreviations:
AST = Aboveground storage tank
BNSF = BNSF Railway Company
cVOC = Chlorinated volatile organic compound
LNAPL = Light non-aqueous-phase liquid
Penta = Pentachlorophenol
TOC = TOC Holdings Co.
TPH = Total petroleum hydrocarbons
UST = Underground storage tank

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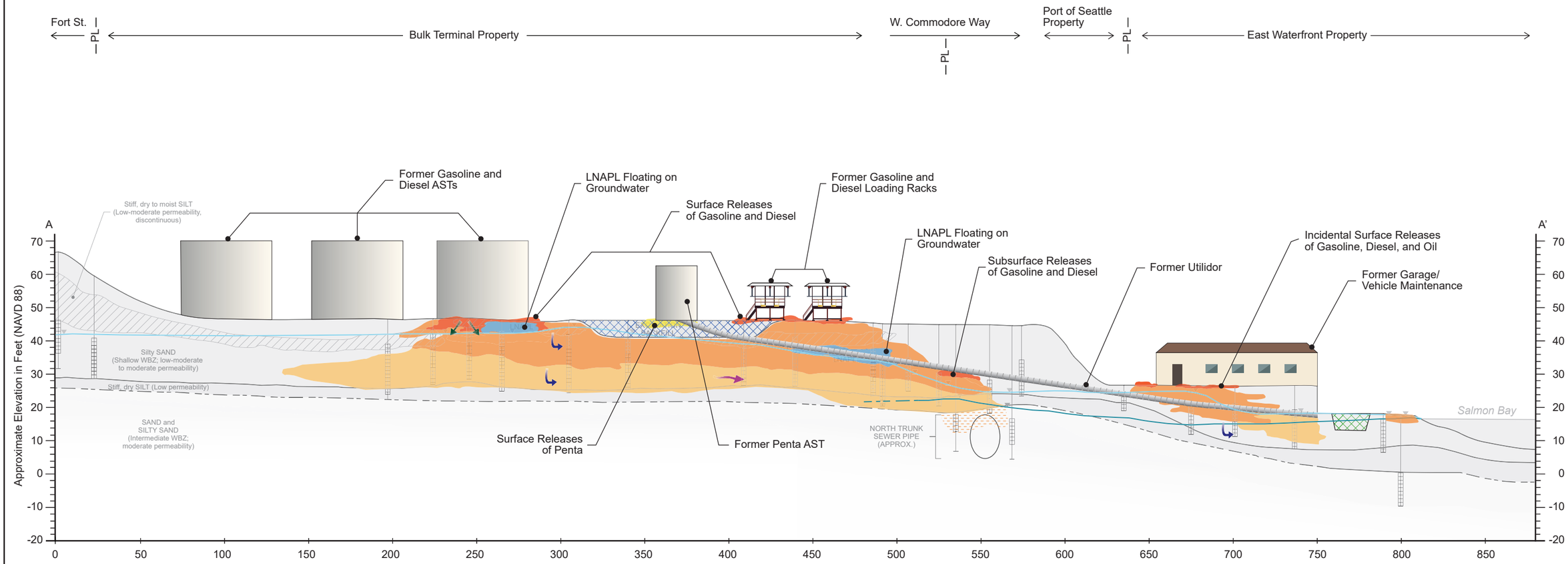
Figure 8.1
Conceptual Site Model

I:\GIS\Projects\Cantera-TOC\AI\RI CSM\Figure 8.1 Conceptual Site Model_2020-0402.ai
04/02/2020



Legend

Site Features

- Shallow WBZ Potentiometric Surface
- Intermediate WBZ Potentiometric Surface (dashed where inferred)
- Contact Boundary Between Lithologies (dashed where inferred)
- LNAPL Area (approximate)
- Interim Action Excavation to Remove Penta in Soil
- Interim Action Excavation to Remove TPH and Benzene in Soil

IHS Distribution

- TPH and Benzene in Soil and/or Groundwater > proposed CULs (approximate)
- TPH and Benzene in Groundwater > proposed CULs (approximate)
- Limited Migration Through Low Permeability Silt (approximate)

Migration and Exposure Pathways

- Downward and Outward Migration in Vadose Zone
- Dissolution
- Downgradient Migration in Groundwater

Notes:
-- Indicates that proposed CUL is not established.
- Lithology based on soil borings installed by IT Corporation, SoundEarth Strategies, and Floyd|Snider.
- Well location IDs are shown on Figure 5.6.

Abbreviations:
AST = Aboveground storage tank
CUL = Cleanup level
DRO = Diesel-range organics
GRO = Gasoline-range organics
IHS = Indicator hazardous substance
LNAPL = Light non-aqueous-phase liquid
µg/L = Micrograms per liter
mg/kg = Milligrams per kilogram
NAVD 88 = North American Vertical Datum of 1988
ORO = Oil-range organics
Penta = Pentachlorophenol
PL = Property line (approximate)
TCE = Trichloroethene
TPH = Total petroleum hydrocarbons
WBZ = Water-bearing zone

Horizontal Scale in Feet
0 60 120
0 30 60
Vertical Scale in Feet
Vertical Exageration X 2

Proposed Cleanup Levels

Indicator Hazardous Substance	Groundwater	Soil
Arsenic	5 µg/L	7.3 mg/kg
GRO	800 µg/L	30 mg/kg
DRO+ORO	500 µg/L	2,000 mg/kg
Benzene	0.44 µg/L	0.02 mg/kg
TCE	0.5 µg/L	0.02 mg/kg
Vinyl chloride	0.2 µg/L	--
Penta	0.2 µg/L	0.05 mg/kg

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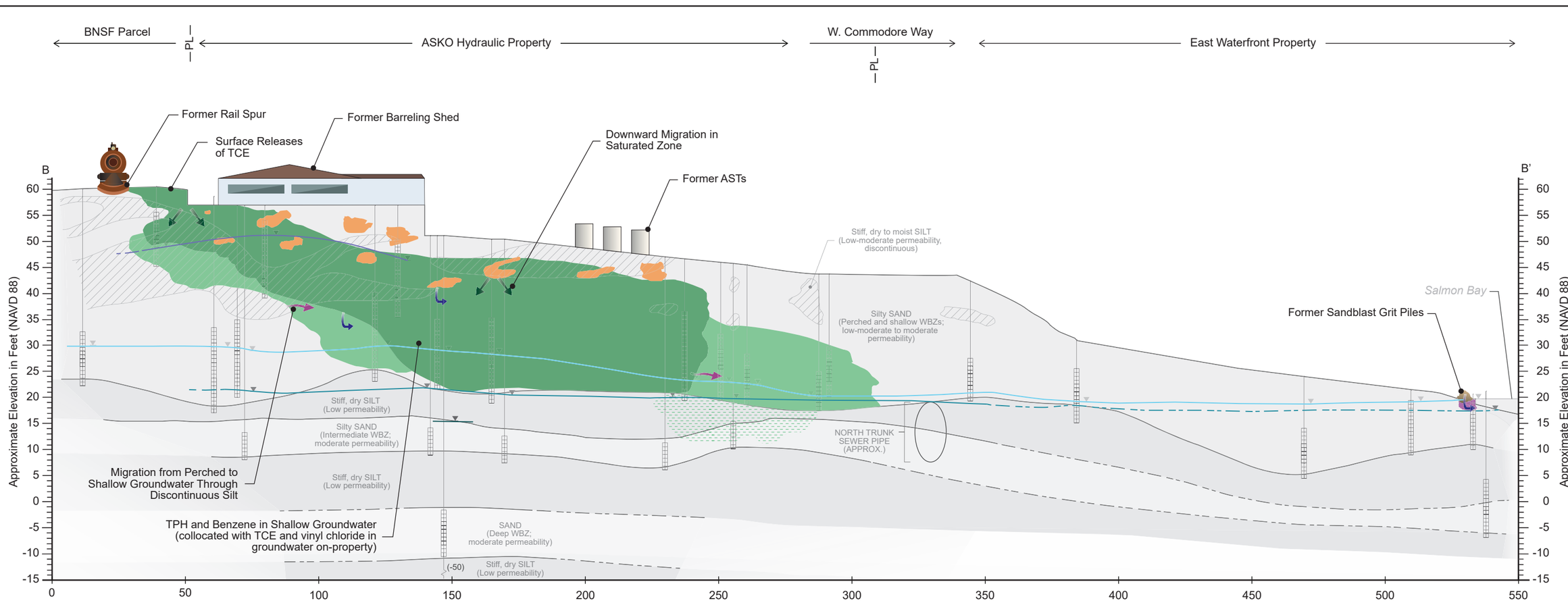
Figure 8.2
Conceptual Site Model Cross-Section A-A'

I:\GIS\Projects\Cantera-TOC\AI\RI Cross-Sections\Figure 8.2 Conceptual Site Model Cross-Section A-A'_2020-0402.ai
04/02/2020



Legend

Site Features

- Perched WBZ Potentiometric Surface (dashed where inferred)
- Shallow WBZ Potentiometric Surface
- Intermediate WBZ Potentiometric Surface (dashed where inferred)
- Deep WBZ Potentiometric Surface
- Contact Boundary Between Lithologies (dashed where inferred)

IHS Distribution

- TPH and Benzene in Soil > Proposed CULs (approximate)
- Arsenic in Soil and/or Groundwater > Proposed CULs (approximate)
- TCE in Soil and/or Groundwater > Proposed CULs (approximate)
- TCE and Breakdown Products (Vinyl Chloride) in Groundwater > Proposed CULs (approximate)
- Limited Migration Through Low Permeability Silt > Proposed CULs (approximate)

Migration and Exposure Pathways

- Downward and Outward Migration in Vadose Zone
- Dissolution
- Downgradient Migration in Groundwater

Notes:
-- Indicates that proposed CUL is not established.
- Lithology based on soil borings installed by IT Corporation, SoundEarth Strategies, and Floyd|Snider.
- Well location IDs are shown on Figure 5.7.

Abbreviations:
AST = Aboveground storage tank
CUL = Cleanup level
DRO = Diesel-range organics
GRO = Gasoline-range organics
IHS = Indicator hazardous substance
LNAPL = Light non-aqueous-phase liquid
µg/L = Micrograms per liter
mg/kg = Milligrams per kilogram
NAVD 88 = North American Vertical Datum of 1988
ORO = Oil-range organics
Penta = Pentachlorophenol
PL = Property line (approximate)
TCE = Trichloroethene
TPH = Total petroleum hydrocarbons
WBZ = Water-bearing zone

Horizontal Scale in Feet
0 40 80
0 20 40
Vertical Scale in Feet
Vertical Exaggeration X 2

Proposed Cleanup Levels		
Indicator Hazardous Substance	**Groundwater**	**Soil**
Arsenic	5 µg/L	7.3 mg/kg
GRO	800 µg/L	30 mg/kg
DRO+ORO	500 µg/L	2,000 mg/kg
Benzene	0.44 µg/L	0.02 mg/kg
TCE	0.5 µg/L	0.02 mg/kg
Vinyl chloride	0.2 µg/L	--
Penta	0.2 µg/L	0.05 mg/kg

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Figure 8.3
Conceptual Site Model Cross-Section B-B'

I:\GIS\Projects\Cantera-TOC\AI\RI Cross-Sections\Figure 8.3 Conceptual Site Model Cross-Section B-B'_2020-0402.ai
04/02/2020

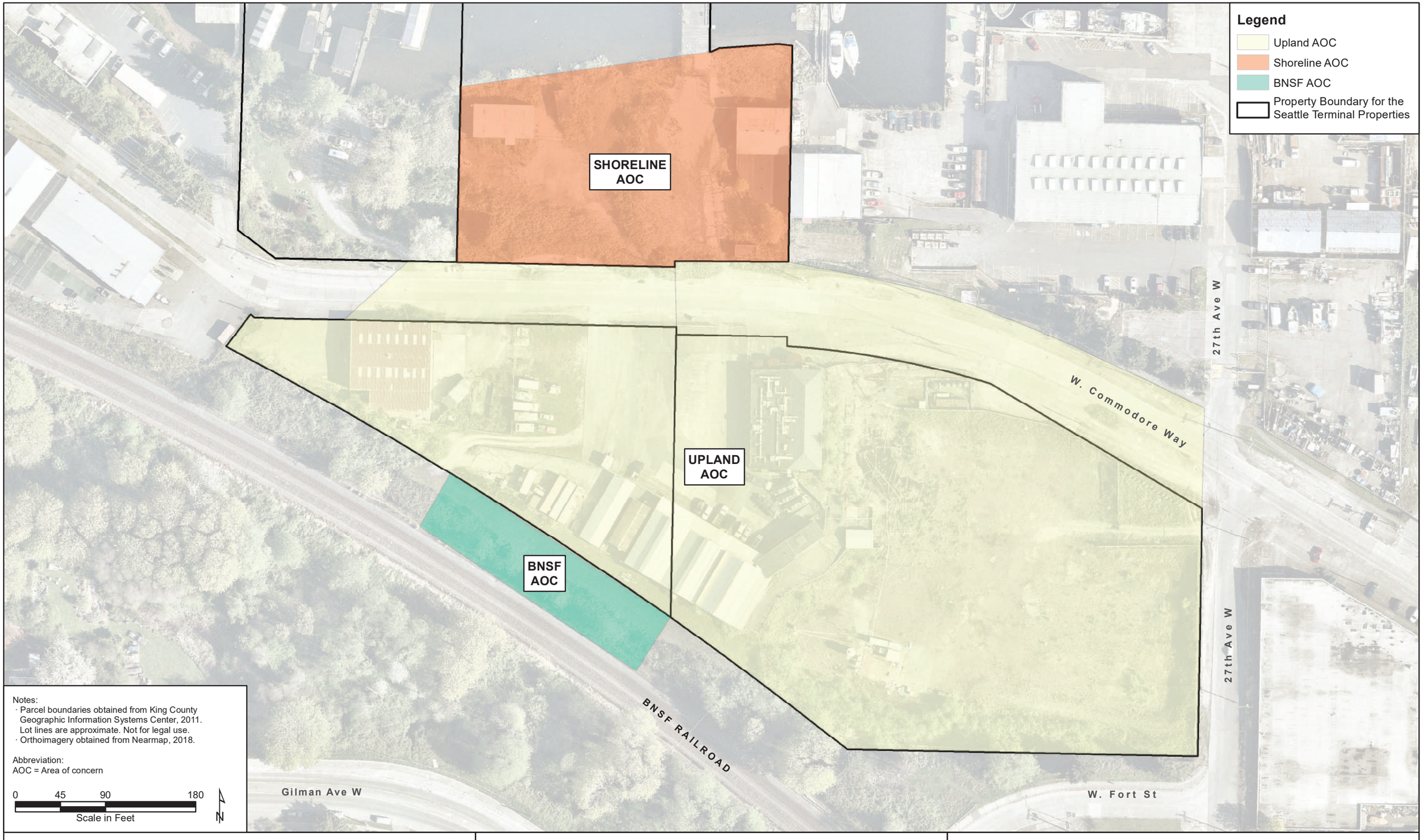

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Figure 8.4
Areas of Concern

I:\GIS\Projects\Cantera-TOC\MXD\RIFS\RI 2019\Figure 8.4 Areas of Concern.mxd
9/11/2020

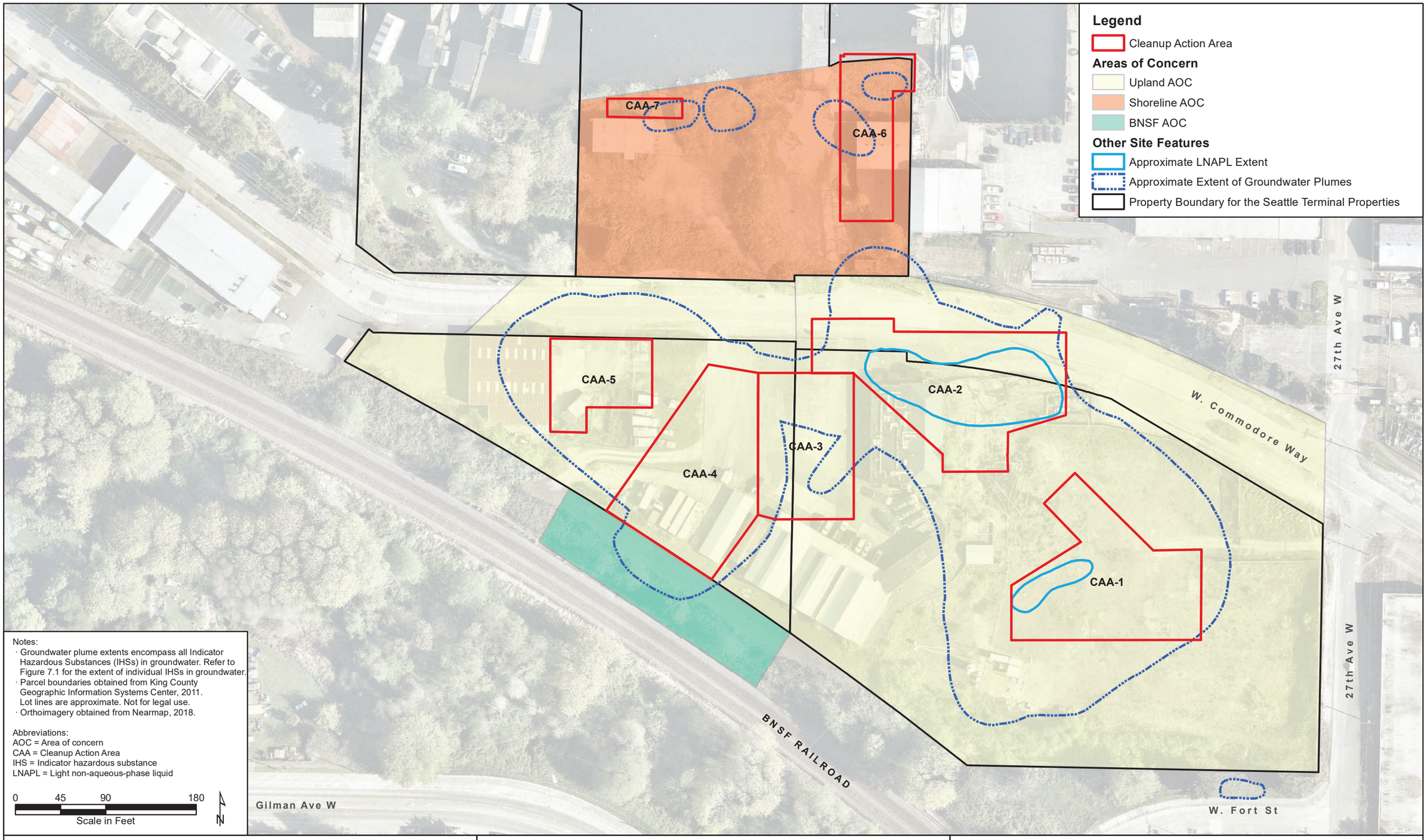

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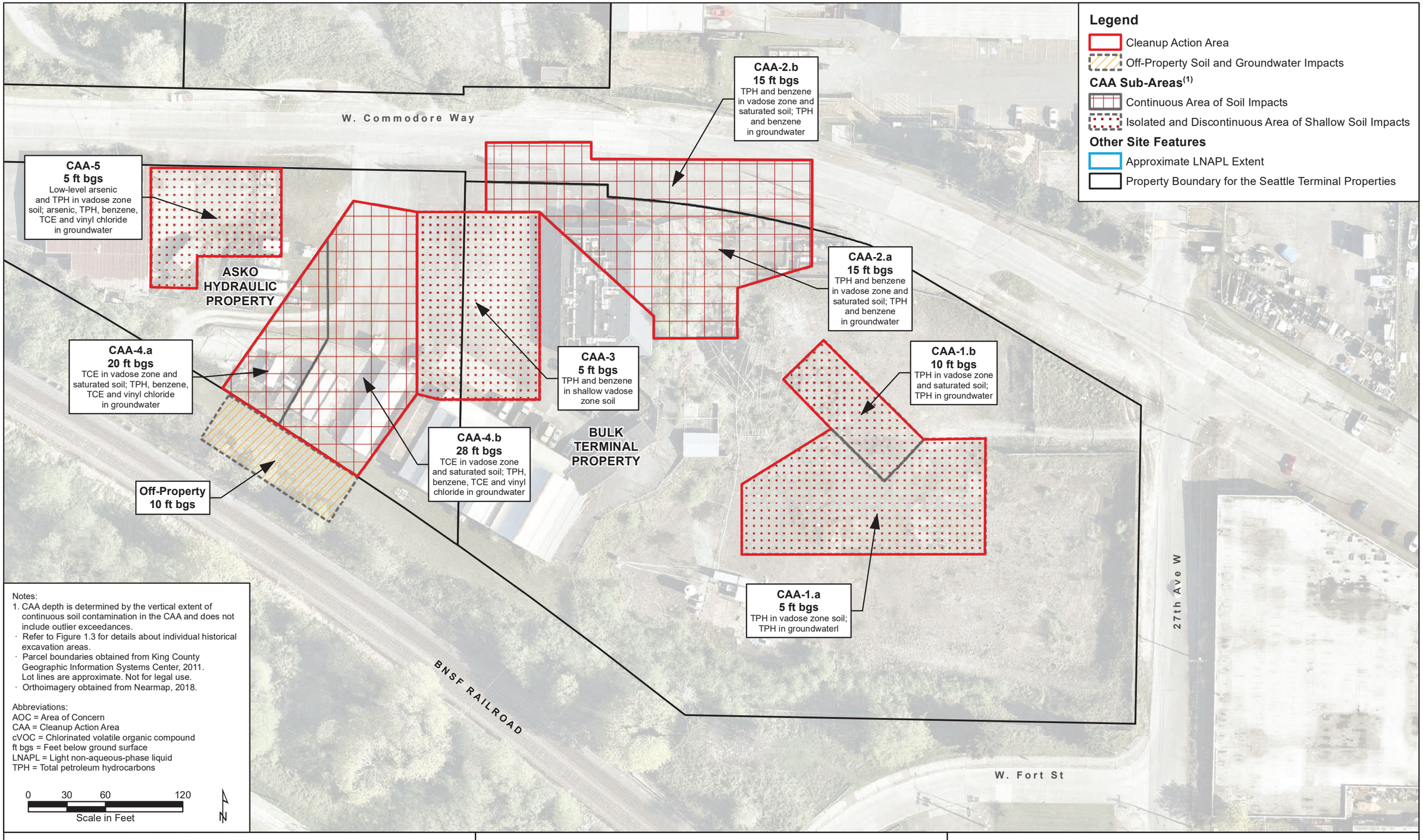
Figure 9.1
Cleanup Action Areas

I:\GIS\Projects\Cantera-TOC\MXD\RIFS\FS 2019\Figure 9.1 Cantera CAAs.mxd
9/11/2020



Notes:
1. CAA depth is determined by the vertical extent of continuous soil contamination in the CAA and does not include outlier exceedances.
- Refer to Figure 1.3 for details about individual historical excavation areas.
- Parcel boundaries obtained from King County Geographic Information Systems Center, 2011. Lot lines are approximate. Not for legal use.
- Orthoimagery obtained from Nearmap, 2018.

Abbreviations:
AOC = Area of Concern
CAA = Cleanup Action Area
cVOC = Chlorinated volatile organic compound
ft bgs = Feet below ground surface
LNAPL = Light non-aqueous-phase liquid
TPH = Total petroleum hydrocarbons

0 30 60 120
Scale in Feet

N

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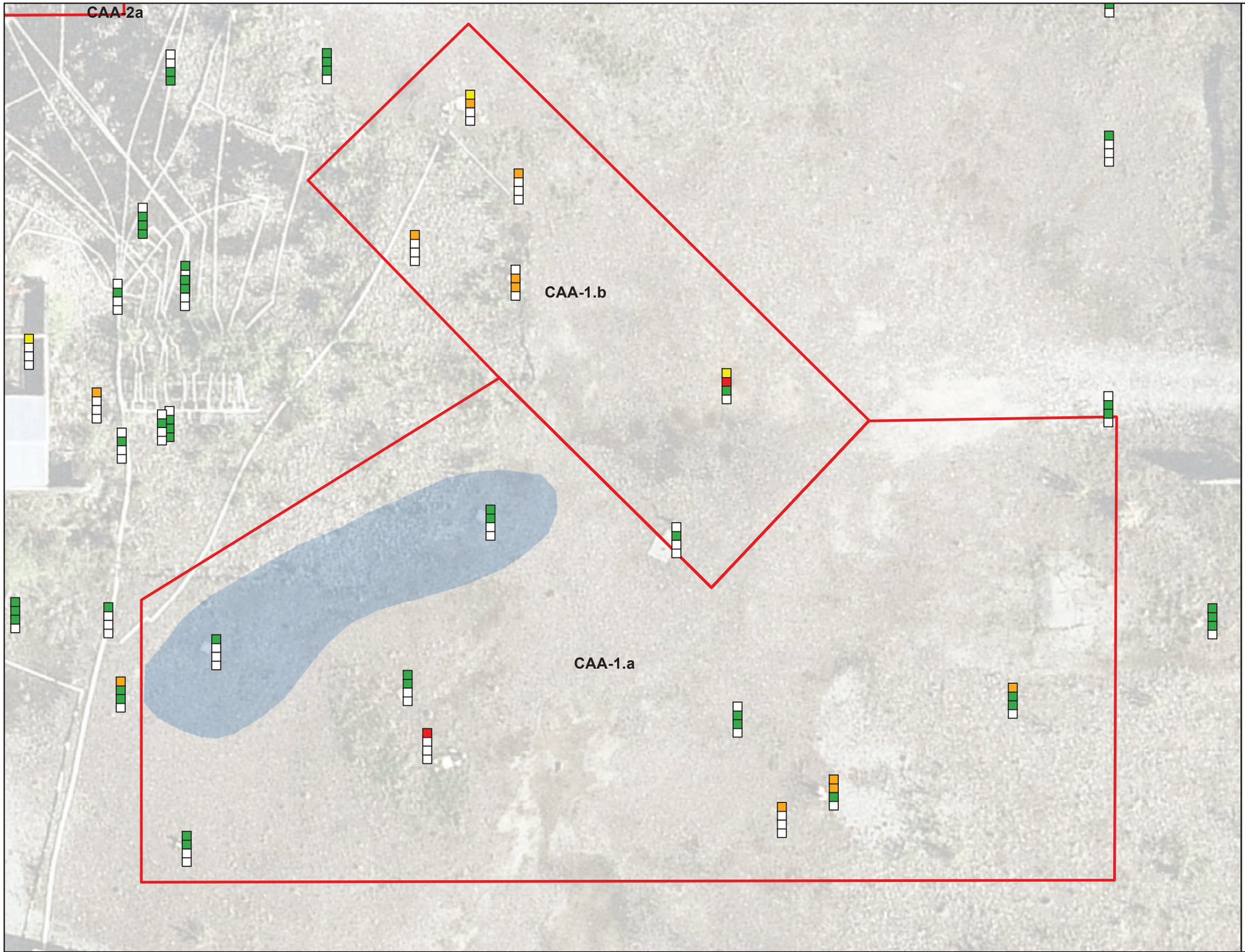
Figure 9.2
Upland AOC Cleanup Action Areas

I:\GIS\Projects\Cantera-TOC\MXD\RIFS\FS 2019\Figure 9.2 Upland AOC Cleanup Action Areas.mxd
9/11/2020



Legend

- Cleanup Action Area
- Approximate LNAPL Extent
- Property Boundary for the Seattle Terminal Properties

Soil Label

Bulk Terminal
Sample Depth
Interval (ft bgs)

- 0–5
- 5–10
- 10–15
- >15

Boxes are colored according to the highest concentration detected within that depth interval.

- All Results Less Than CUL
- One or More Results Greater Than CUL by ≤2 Times
- One or More Results Greater Than CUL by >2 Times, but Less Than REL
- One or More Results Greater Than REL
- Not Analyzed for Specified Chemicals

GRO Cleanup and Remediation Levels
CUL: 30 mg/kg
REL: 5,000 mg/kg

Notes:
· Parcel boundaries obtained from King County Geographic Information Systems Center, 2011. Lot lines are approximate. Not for legal use.
· Orthoimagery obtained from Nearmap, 2018.

Abbreviations:
CUL = Cleanup level
ft bgs = Feet below ground surface
GRO = Gasoline-range organics
LNAPL = Light non-aqueous-phase liquid
mg/kg = Milligrams per kilogram
REL = Remediation level

N

0 10 20 40
Scale in Feet

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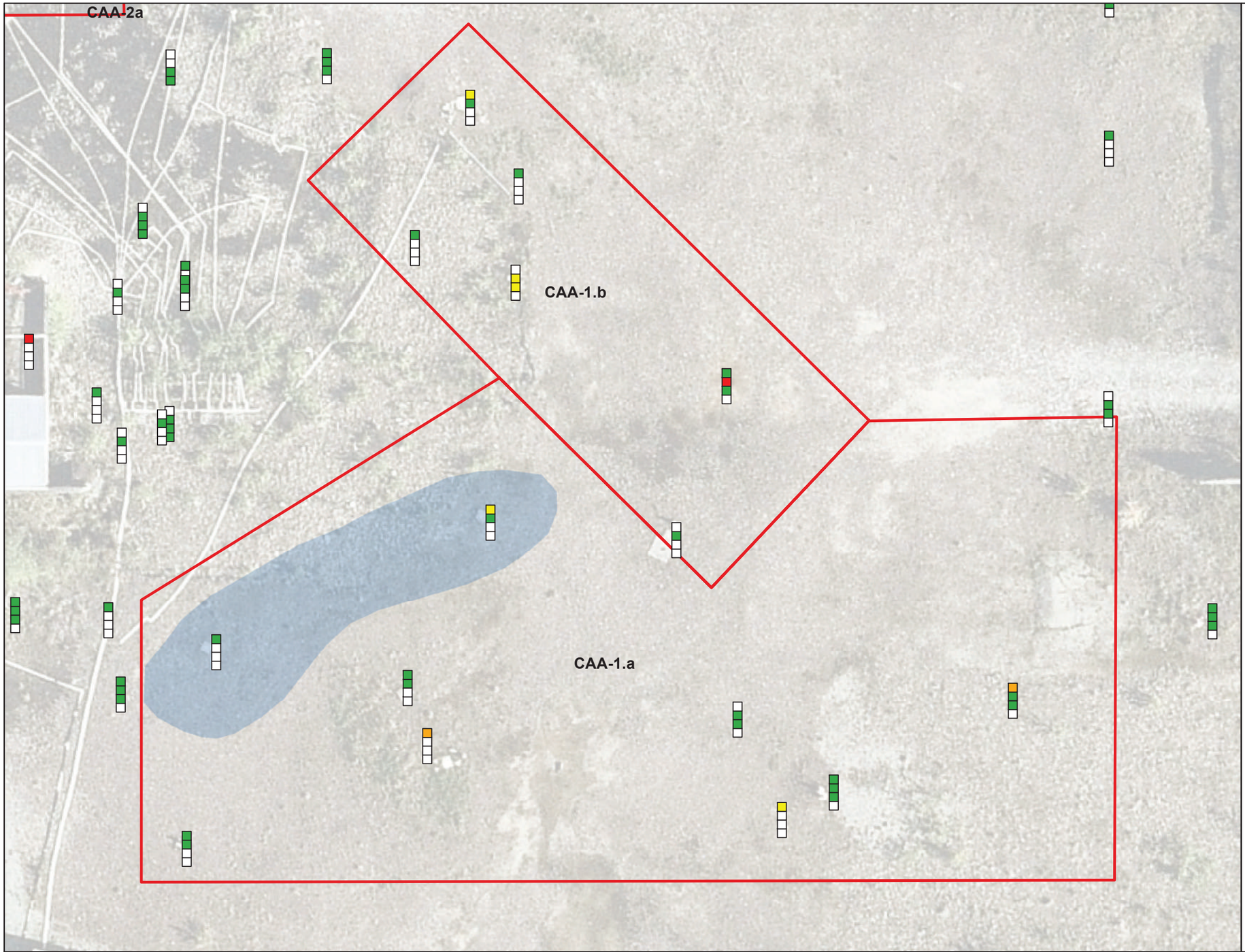
Figure 9.3
Depth Profile for Gasoline-Range Organics in Soil: CAA-1

I:\GIS\Projects\Cantera-TOC\MXD\RIFS\FS 2019\Figure 9.3 Depth Profile for GRO in Soil_CAA1.mxd
9/11/2020



Legend

- Cleanup Action Area
- Approximate LNAPL Extent
- Property Boundary for the Seattle Terminal Properties

Soil Label

Bulk Terminal Sample Depth Interval (ft bgs)

- 0–5
- 5–10
- 10–15
- >15

Boxes are colored according to the highest concentration detected within that depth interval.

- All Results Less Than CUL
- One or More Results Greater Than CUL by ≤2 Times
- One or More Results Greater Than CUL by >2 Times, but Less Than REL
- One or More Results Greater Than REL
- Not Analyzed for Specified Chemicals

DRO+ORO Cleanup and Remediation Levels
CUL: 2,000 mg/kg
REL: 12,000 mg/kg

Notes:
· Parcel boundaries obtained from King County Geographic Information Systems Center, 2011. Lot lines are approximate. Not for legal use.
· Orthoimagery obtained from Nearmap, 2018.

Abbreviations:
CUL = Cleanup level
DRO = Diesel-range organics
ft bgs = Feet below ground surface
LNAPL = Light non-aqueous-phase liquid
mg/kg = Milligrams per kilogram
ORO = Oil-range organics
REL = Remediation level

N

0 10 20 40
Scale in Feet

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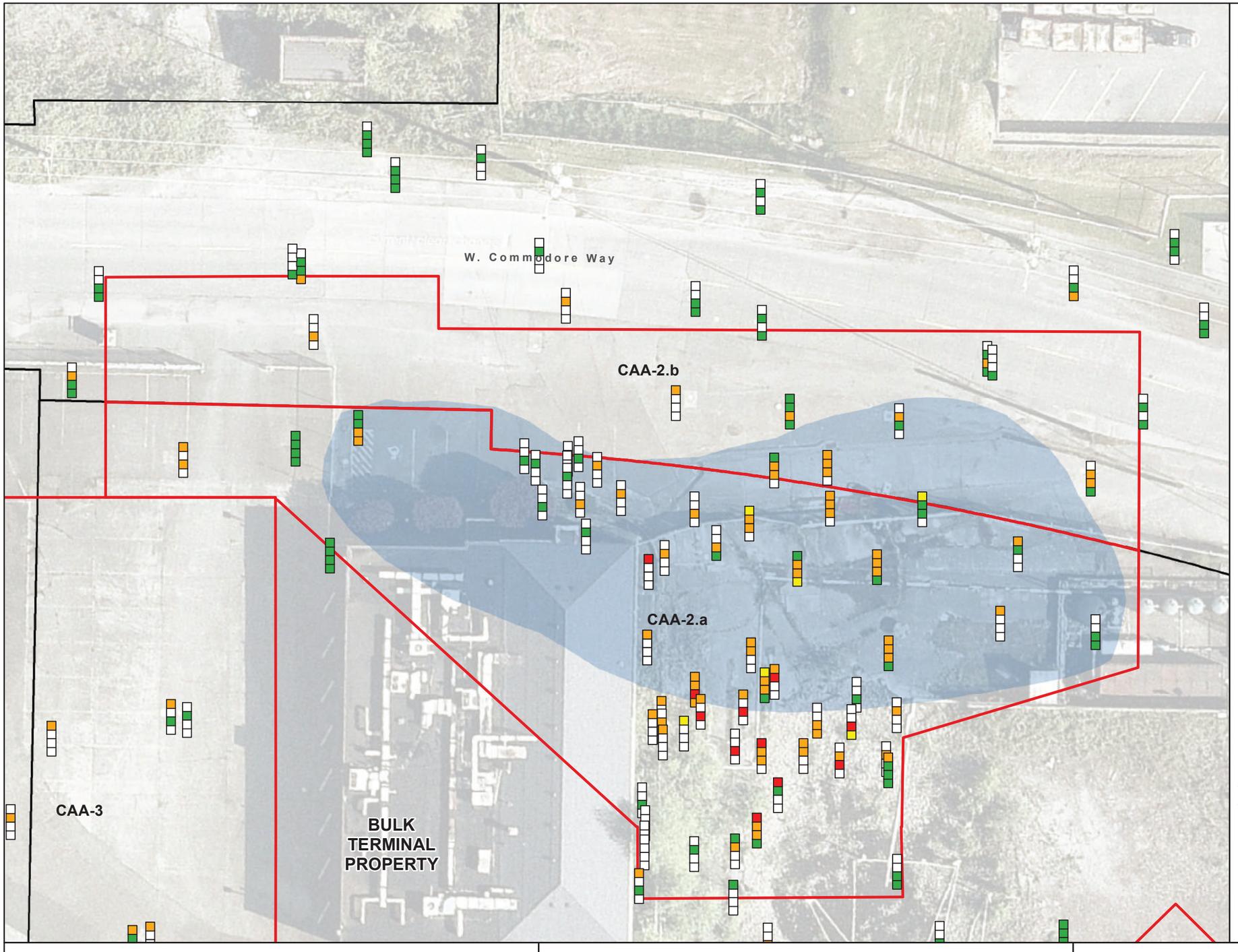
Figure 9.4
Depth Profile for Diesel- and Oil-Range Organics in Soil: CAA-1

I:\GIS\Projects\Cantera-TOC\MXD\RIFS\FS 2019\Figure 9.4 Depth Profile for DRO and ORO in Soil_CAA1.mxd
9/11/2020



Legend

- Cleanup Action Area
- Approximate LNAPL Extent
- Property Boundary for the Seattle Terminal Properties

Soil Label

Bulk Terminal
Sample Depth
Interval (ft bgs)

- 0–5 →
- 5–10 →
- 10–15 →
- >15 →

Boxes are colored according to the highest concentration detected within that depth interval.

- All Results Less Than CUL
- One or More Results Greater Than CUL by ≤2 Times
- One or More Results Greater Than CUL by >2 Times, but Less Than REL
- One or More Results Greater Than REL
- Not Analyzed for Specified Chemicals

GRO Cleanup and Remediation Levels
CUL: 30 mg/kg
REL: 5,000 mg/kg

Notes:
· Parcel boundaries obtained from King County Geographic Information Systems Center, 2011. Lot lines are approximate. Not for legal use.
· Orthoimagery obtained from Nearmap, 2018.

Abbreviations:
CUL = Cleanup level
ft bgs = Feet below ground surface
GRO = Gasoline-range organics
LNAPL = Light non-aqueous-phase liquid
mg/kg = Milligrams per kilogram
REL = Remediation level

N

0 12.5 25 50
Scale in Feet

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Figure 9.5
Depth Profile for Gasoline-Range Organics in Soil: CAA-2

I:\GIS\Projects\Cantera-TOC\MXD\RIFS\FS 2019\Figure 9.5 Depth Profile for GRO in Soil_CAA2.mxd
9/11/2020

W. Commodore Way

CAA-2.b

CAA-2.a

CAA-3

BULK TERMINAL PROPERTY

Legend

- Cleanup Action Area
- Approximate LNAPL Extent
- Property Boundary for the Seattle Terminal Properties

Soil Label

Bulk Terminal Sample Depth Interval (ft bgs)

- 0–5
- 5–10
- 10–15
- >15

Boxes are colored according to the highest concentration detected within that depth interval.

- All Results Less Than CUL
- One or More Results Greater Than CUL by ≤2 Times
- One or More Results Greater Than CUL by >2 Times, but Less Than REL
- One or More Results Greater Than REL
- Not Analyzed for Specified Chemicals

DRO+ORO Cleanup and Remediation Levels
CUL: 2,000 mg/kg
REL: 12,000 mg/kg

Notes:
· Parcel boundaries obtained from King County Geographic Information Systems Center, 2011. Lot lines are approximate. Not for legal use.
· Orthoimagery obtained from Nearmap, 2018.

Abbreviations:
CUL = Cleanup level
DRO = Diesel-range organics
ft bgs = Feet below ground surface
LNAPL = Light non-aqueous-phase liquid
mg/kg = Milligrams per kilogram
ORO = Oil-range organics
REL = Remediation level

N

0 12.5 25 50
Scale in Feet

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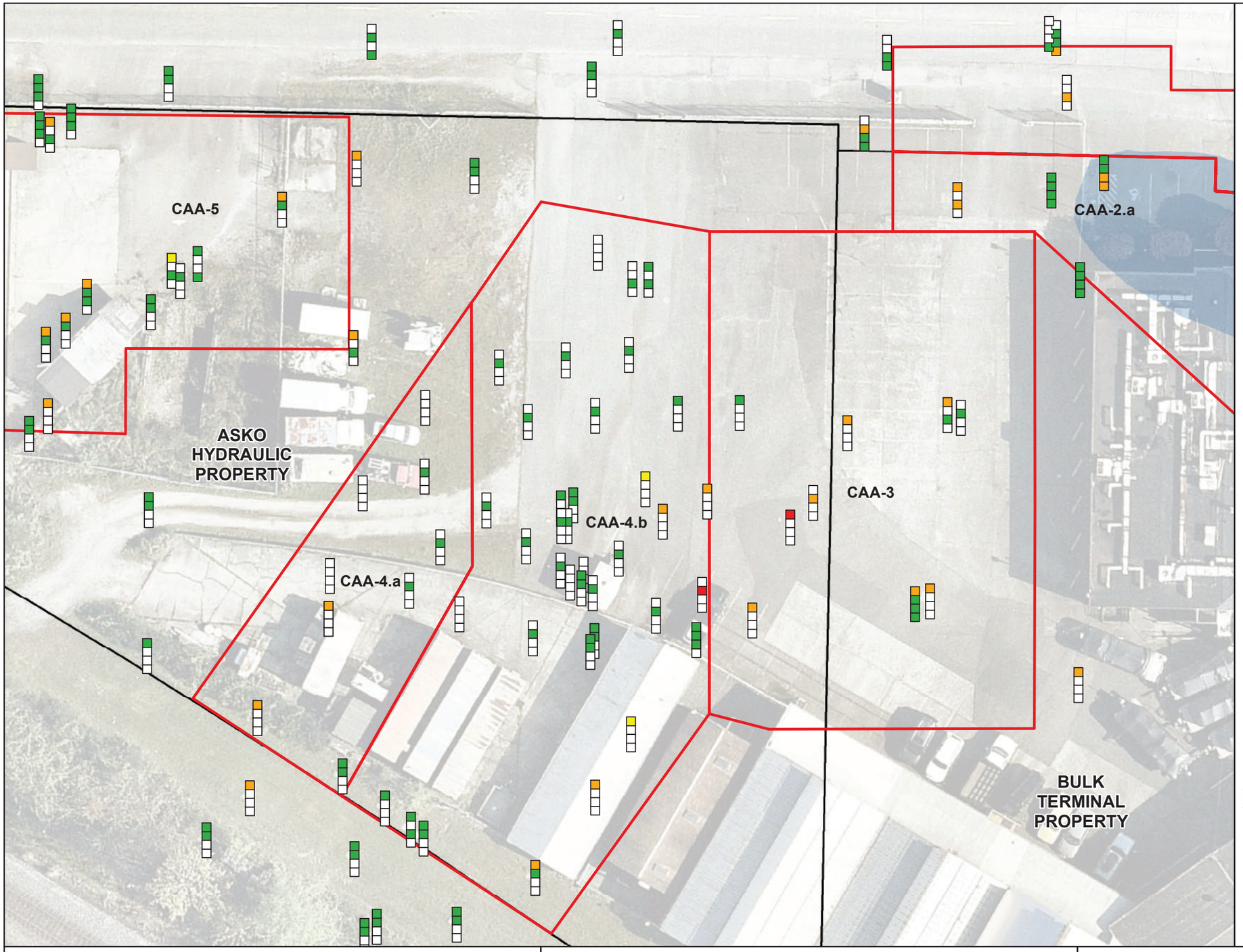
Figure 9.6
Depth Profile for Diesel- and Oil-Range Organics in Soil: CAA-2

I:\GIS\Projects\Cantera-TOC\MXD\RIFS\FS 2019\Figure 9.6 Depth Profile for DRO and ORO in Soil_CAA2.mxd
9/11/2020



Legend

- Cleanup Action Area
- Approximate LNAPL Extent
- Property Boundary for the Seattle Terminal Properties

Soil Label

Bulk Terminal Sample Depth Interval (ft bgs)	ASKO Hydraulic Property Sample Depth Interval (ft bgs)
0–5 →	0–8 →
5–10 →	8–20 →
10–15 →	20–30 →
>15 →	>30 →

Boxes are colored according to the highest concentration detected within that depth interval.

- All Results Less Than CUL
- One or More Results Greater Than CUL by ≤2 Times
- One or More Results Greater Than CUL by >2 Times, but Less Than REL
- One or More Results Greater Than REL
- Not Analyzed for Specified Chemicals

GRO Cleanup and Remediation Levels
CUL: 30 mg/kg
REL: 5,000 mg/kg

Notes:
· Parcel boundaries obtained from King County Geographic Information Systems Center, 2011. Lot lines are approximate. Not for legal use.
· Orthoimagery obtained from Nearmap, 2018.

Abbreviations:
CUL = Cleanup level
ft bgs = Feet below ground surface
GRO = Gasoline-range organics
LNAPL = Light non-aqueous-phase liquid
mg/kg = Milligrams per kilogram
REL = Remediation level

N

0 15 30 60
Scale in Feet

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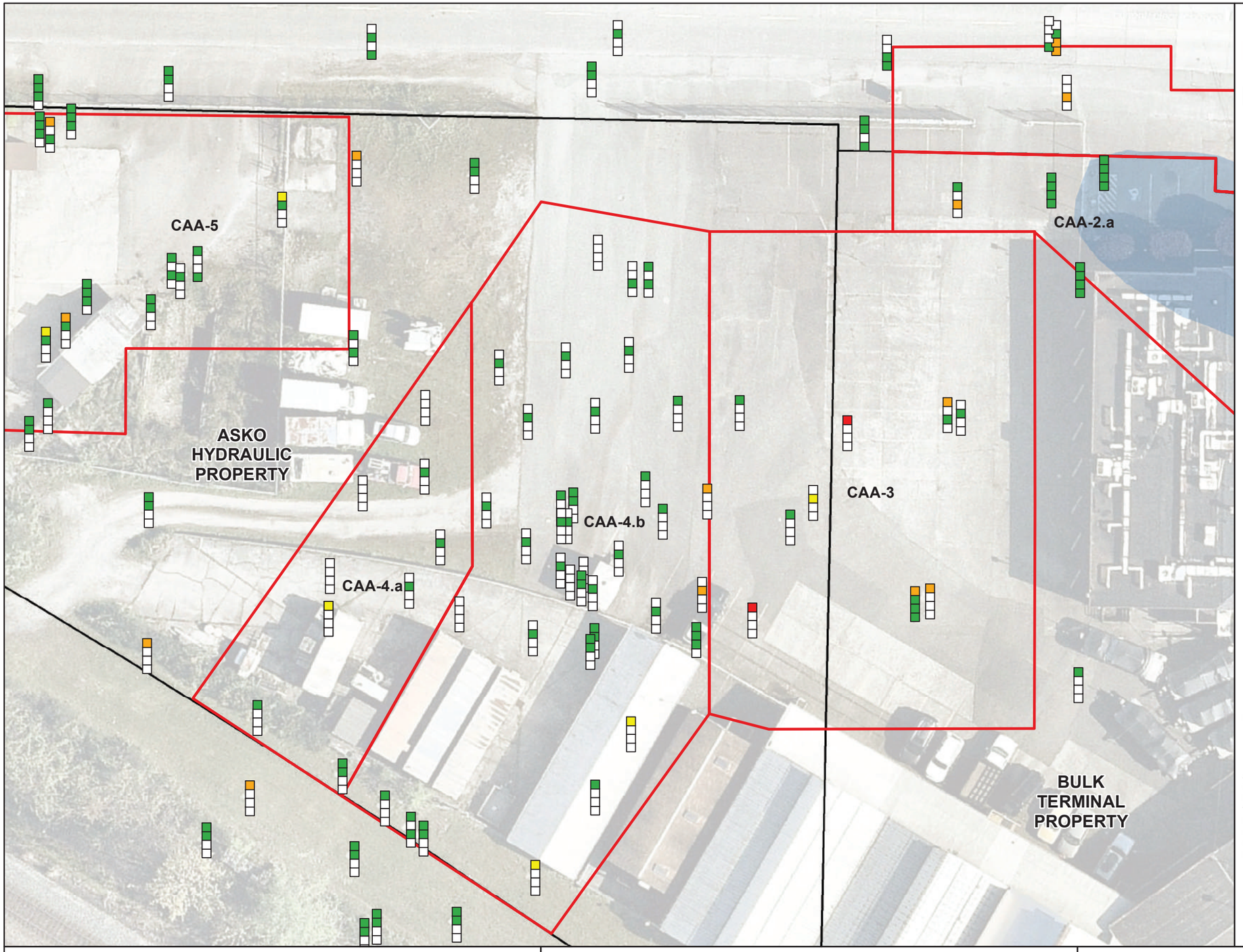
Figure 9.7
Depth Profile for Gasoline-Range Organics in Soil:
CAA-3 and CAA-4

I:\GIS\Projects\Cantera-TOC\MXD\RIFS\FS 2019\Figure 9.7 Depth Profile for GRO in Soil CAA3 and CAA4.mxd
9/11/2020



Legend

- Cleanup Action Area
- Approximate LNAPL Extent
- Property Boundary for the Seattle Terminal Properties

Soil Label

Bulk Terminal Sample Depth Interval (ft bgs)	ASKO Hydraulic Property Sample Depth Interval (ft bgs)
0–5	0–8
5–10	8–20
10–15	20–30
>15	>30

Boxes are colored according to the highest concentration detected within that depth interval.

- All Results Less Than CUL
- One or More Results Greater Than CUL by ≤2 Times
- One or More Results Greater Than CUL by >2 Times, but Less Than REL
- One or More Results Greater Than REL
- Not Analyzed for Specified Chemicals

DRO+ORO Cleanup and Remediation Levels
CUL: 2,000 mg/kg
REL: 12,000 mg/kg

Notes:
· Parcel boundaries obtained from King County Geographic Information Systems Center, 2011. Lot lines are approximate. Not for legal use.
· Orthoimagery obtained from Nearmap, 2018.

Abbreviations:
CUL = Cleanup level
DRO = Diesel-range organics
ft bgs = Feet below ground surface
LNAPL = Light non-aqueous-phase liquid
mg/kg = Milligrams per kilogram
ORO = Oil-range organics
REL = Remediation level

N

0 12.5 25 50
Scale in Feet

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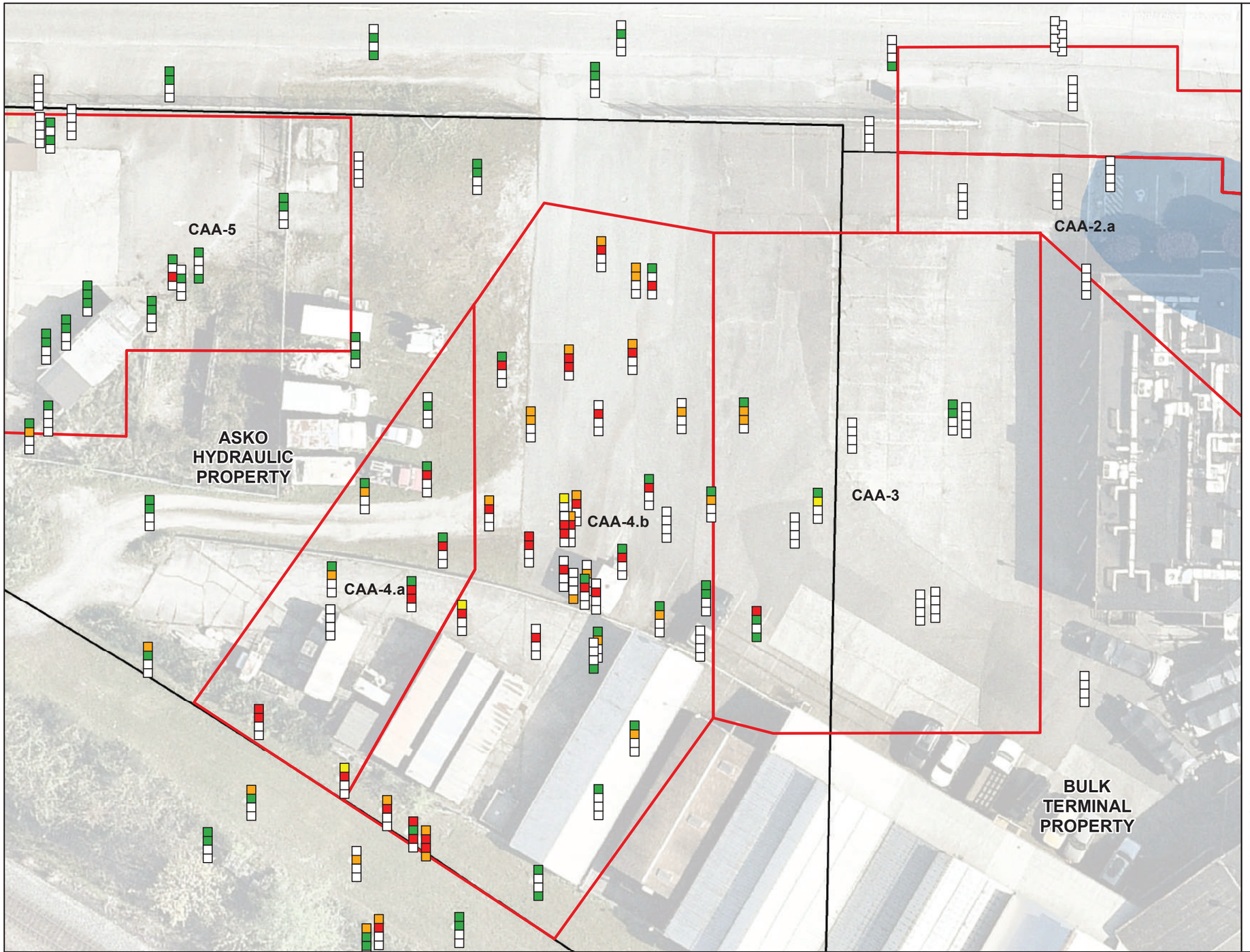
Figure 9.8
Depth Profile for Diesel- and Oil-Range Organics in Soil: CAA-3 and CAA-4

I:\GIS\Projects\Cantera-TOC\MXD\RIFS\FS 2019\Figure 9.8 Depth Profile for DRO and ORO in Soil CAA3 and CAA4.mxd
9/11/2020



Legend

- Cleanup Action Area
- Approximate LNAPL Extent
- Property Boundary for the Seattle Terminal Properties

Soil Label

Bulk Terminal Sample Depth Interval (ft bgs)	ASKO Hydraulic Property Sample Depth Interval (ft bgs)
0–5	0–8
5–10	8–20
10–15	20–30
>15	>30

Boxes are colored according to the highest concentration detected within that depth interval.

- All Results Less Than CUL
- One or More Results Greater Than CUL by ≤2 Times
- One or More Results Greater Than CUL by >2 Times, but Less Than REL
- One or More Results Greater Than REL
- Not Analyzed for Specified Chemicals

TCE Cleanup and Remediation Levels
CUL: 0.020 mg/kg
REL: 1 mg/kg

Notes:
· Parcel boundaries obtained from King County Geographic Information Systems Center, 2011. Lot lines are approximate. Not for legal use.
· Orthoimagery obtained from Nearmap, 2018.

Abbreviations:
CUL = Cleanup level
ft bgs = Feet below ground surface
LNAPL = Light non-aqueous-phase liquid
mg/kg = Milligrams per kilogram
REL = Remediation level
TCE = Trichloroethene

N

0 12.5 25 50
Scale in Feet

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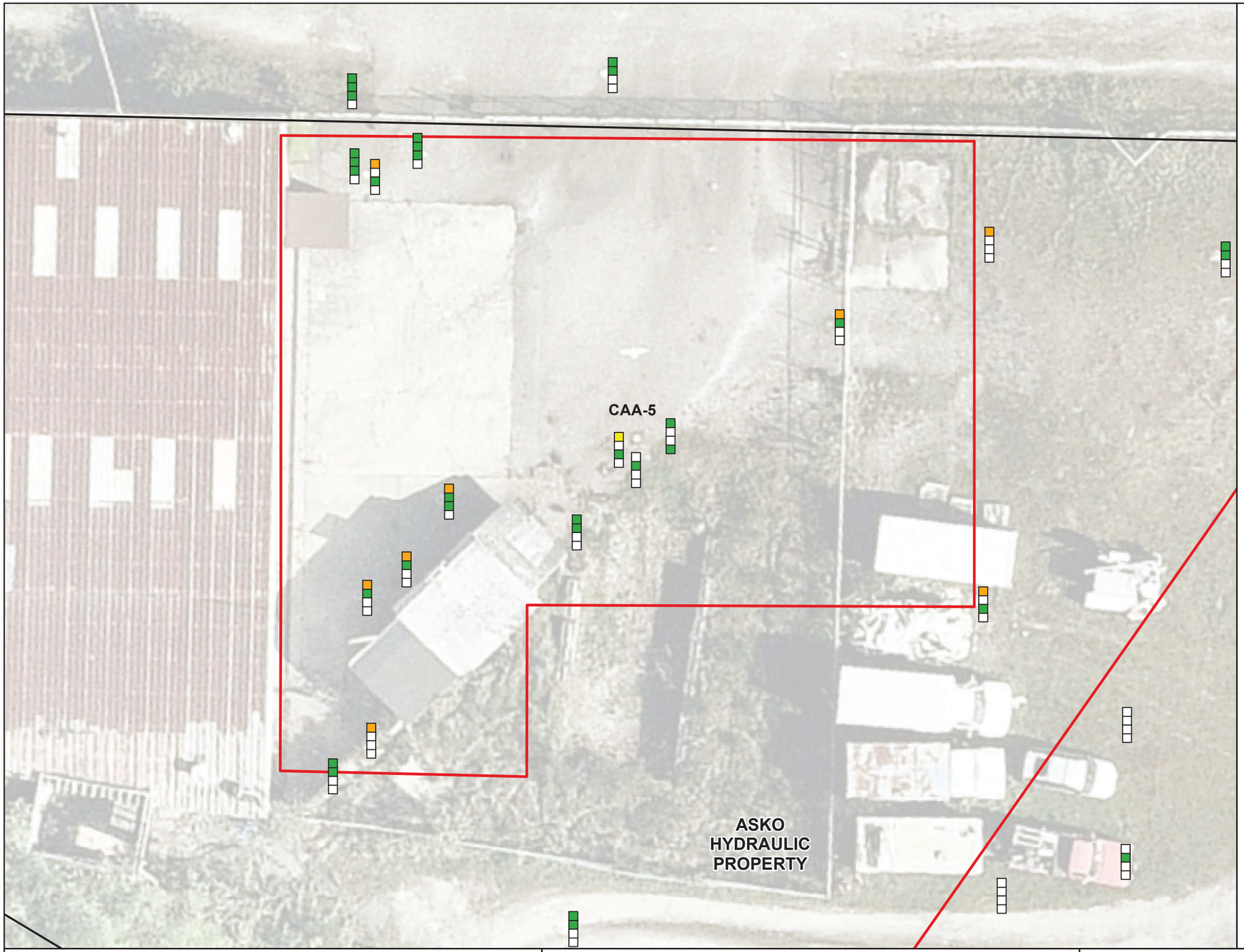
Figure 9.9
Depth Profile for Trichloroethene in Soil:
CAA-3 and CAA-4

I:\GIS\Projects\Cantera-TOC\MXD\RIFS\FS 2019\Figure 9.9 Depth Profile for TCE in Soil CAA3 and CAA4.mxd
9/11/2020



Legend

- Cleanup Action Area
- Property Boundary for the Seattle Terminal Properties

Soil Label

ASKO Hydraulic Property Sample Depth Interval (ft bgs)

0–8 →
8–20 →
20–30 →
>30 →

Boxes are colored according to the highest concentration detected within that depth interval.

- All Results Less Than CUL
- One or More Results Greater Than CUL by ≤2 Times
- One or More Results Greater Than CUL by >2 Times, but Less Than REL
- One or More Results Greater Than REL
- Not Analyzed for Specified Chemicals

GRO Cleanup and Remediation Levels
CUL: 30 mg/kg
REL: 5,000 mg/kg

Notes:
· Parcel boundaries obtained from King County Geographic Information Systems Center, 2011. Lot lines are approximate. Not for legal use.
· Orthoimagery obtained from Nearmap, 2018.

Abbreviations:
CUL = Cleanup level
ft bgs = Feet below ground surface
GRO = Gasoline-range organics
mg/kg = Milligrams per kilogram
REL = Remediation level

N

0 7.5 15 30
Scale in Feet

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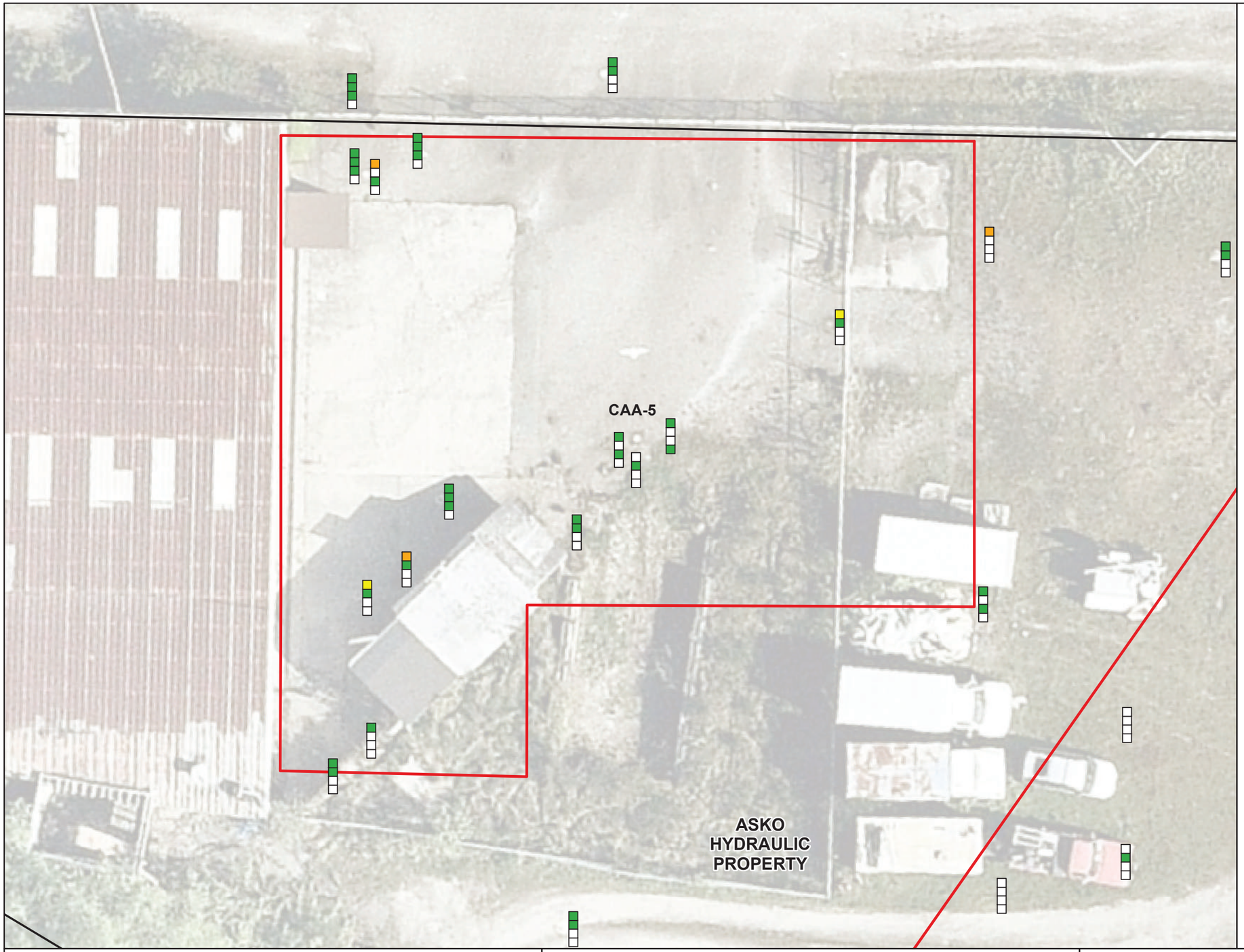
Figure 9.10
Depth Profile for Gasoline-Range Organics in Soil: CAA-5

I:\GIS\Projects\Cantera-TOC\MXD\RIFS\FS 2019\Figure 9.10 Depth Profile for GRO in Soil CAA5.mxd
9/11/2020



Legend

Cleanup Action Area

Property Boundary for the Seattle Terminal Properties

Soil Label

ASKO Hydraulic Property Sample Depth Interval (ft bgs)

0–8 →
8–20 →
20–30 →
>30 →

Boxes are colored according to the highest concentration detected within that depth interval.

- All Results Less Than CUL
- One or More Results Greater Than CUL by ≤2 Times
- One or More Results Greater Than CUL by >2 Times, but Less Than REL
- One or More Results Greater Than REL
- Not Analyzed for Specified Chemicals

DRO+ORO Cleanup and Remediation Levels
CUL: 2,000 mg/kg
REL: 12,000 mg/kg

Notes:
· Parcel boundaries obtained from King County Geographic Information Systems Center, 2011. Lot lines are approximate. Not for legal use.
· Orthoimagery obtained from Nearmap, 2018.

Abbreviations:
CUL = Cleanup level
DRO = Diesel-range organics
ft bgs = Feet below ground surface
mg/kg = Milligrams per kilogram
ORO = Oil-range organics
REL = Remediation level

N

0 7.5 15 30
Scale in Feet

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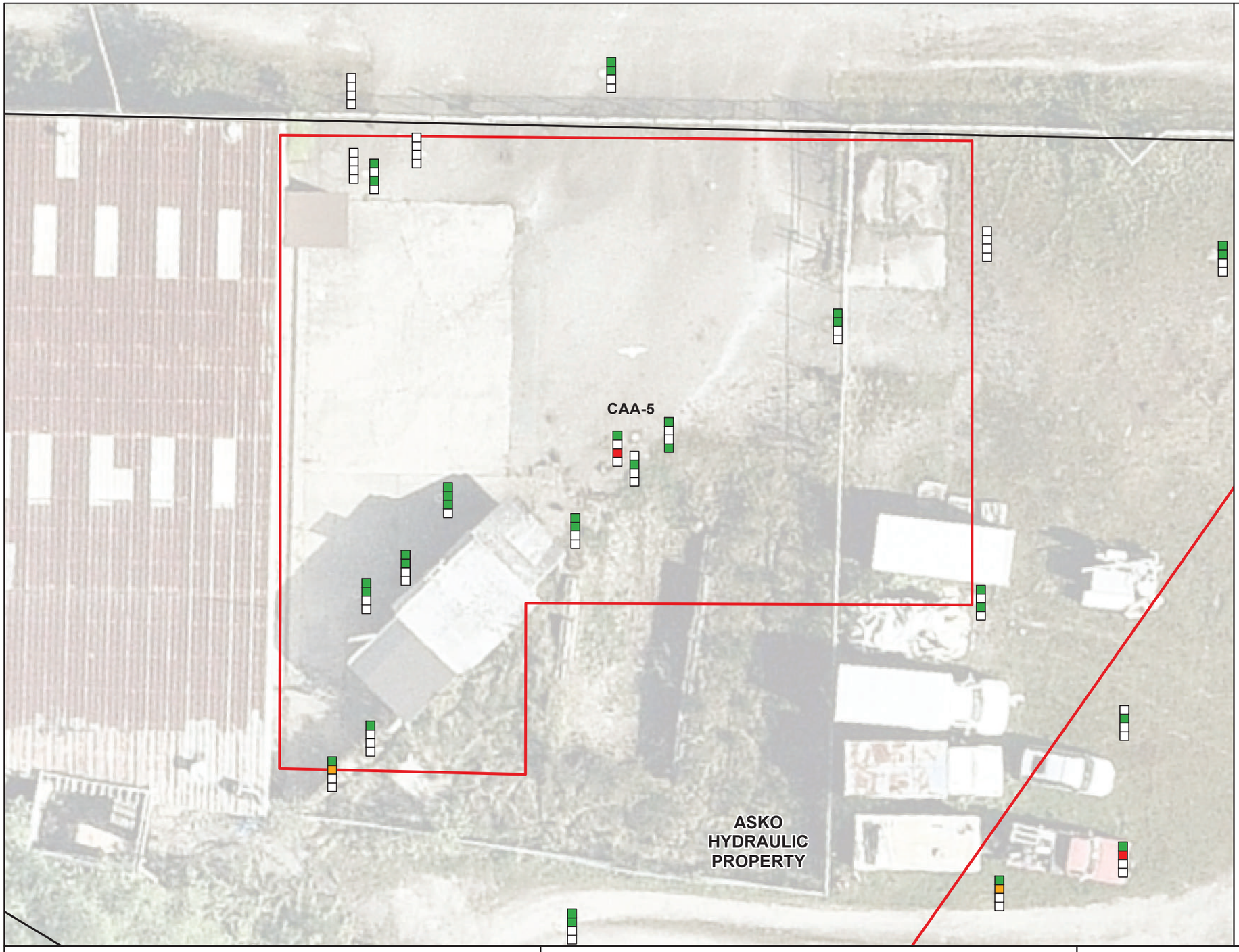
Time Oil Bulk Terminal PPA
Seattle, Washington

Figure 9.11
Depth Profile for Diesel- and Oil-Range Organics in Soil: CAA-5

I:\GIS\Projects\Cantera-TOC\MXD\RIFS\FS 2019\Figure 9.11 Depth Profile for DRO and ORO in Soil CAA5.mxd
9/11/2020



Legend

Cleanup Action Area

Property Boundary for the Seattle Terminal Properties

Soil Label

ASKO Hydraulic Property Sample Depth Interval (ft bgs)

0–8 →
8–20 →
20–30 →
>30 →

Boxes are colored according to the highest concentration detected within that depth interval.

- All Results Less Than CUL
- One or More Results Greater Than CUL by ≤2 Times
- One or More Results Greater Than CUL by >2 Times, but Less Than REL
- One or More Results Greater Than REL
- Not Analyzed for Specified Chemicals

TCE Cleanup and Remediation Levels
CUL: 0.020 mg/kg
REL: 1 mg/kg

Notes:
· Parcel boundaries obtained from King County Geographic Information Systems Center, 2011. Lot lines are approximate. Not for legal use.
· Orthoimagery obtained from Nearmap, 2018.

Abbreviations:
CUL = Cleanup level
ft bgs = Feet below ground surface
mg/kg = Milligrams per kilogram
REL = Remediation level
TCE = Trichloroethene

N

0 7.5 15 30
Scale in Feet

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Figure 9.12
Depth Profile for Trichloroethene in Soil:
CAA-5

I:\GIS\Projects\Cantera-TOC\MXD\RIFS\FS 2019\Figure 9.12 Depth Profile for TCE in Soil CAA5.mxd
9/11/2020

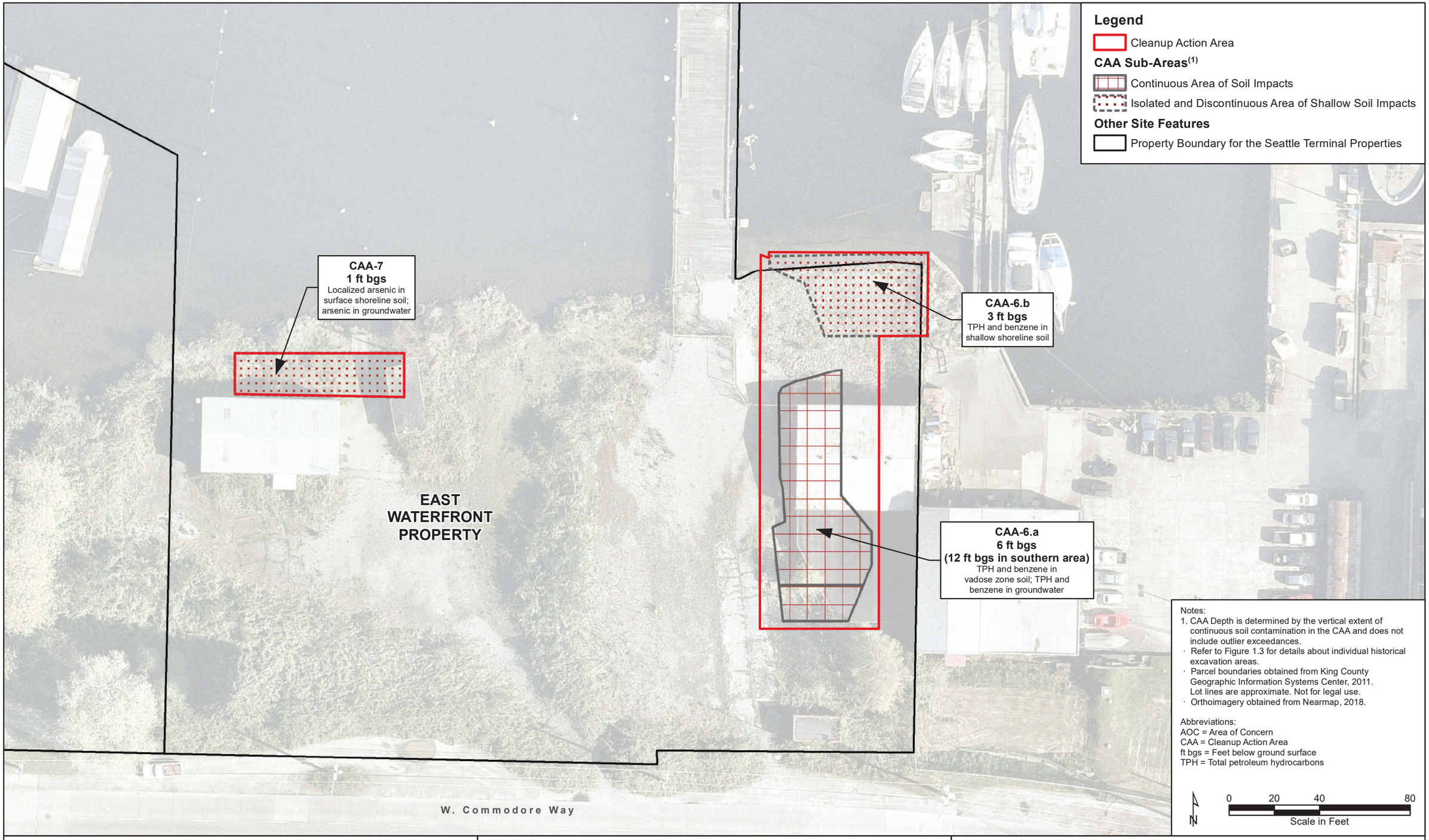

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Figure 9.13
Shoreline AOC Cleanup Action Areas

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9/11/2020

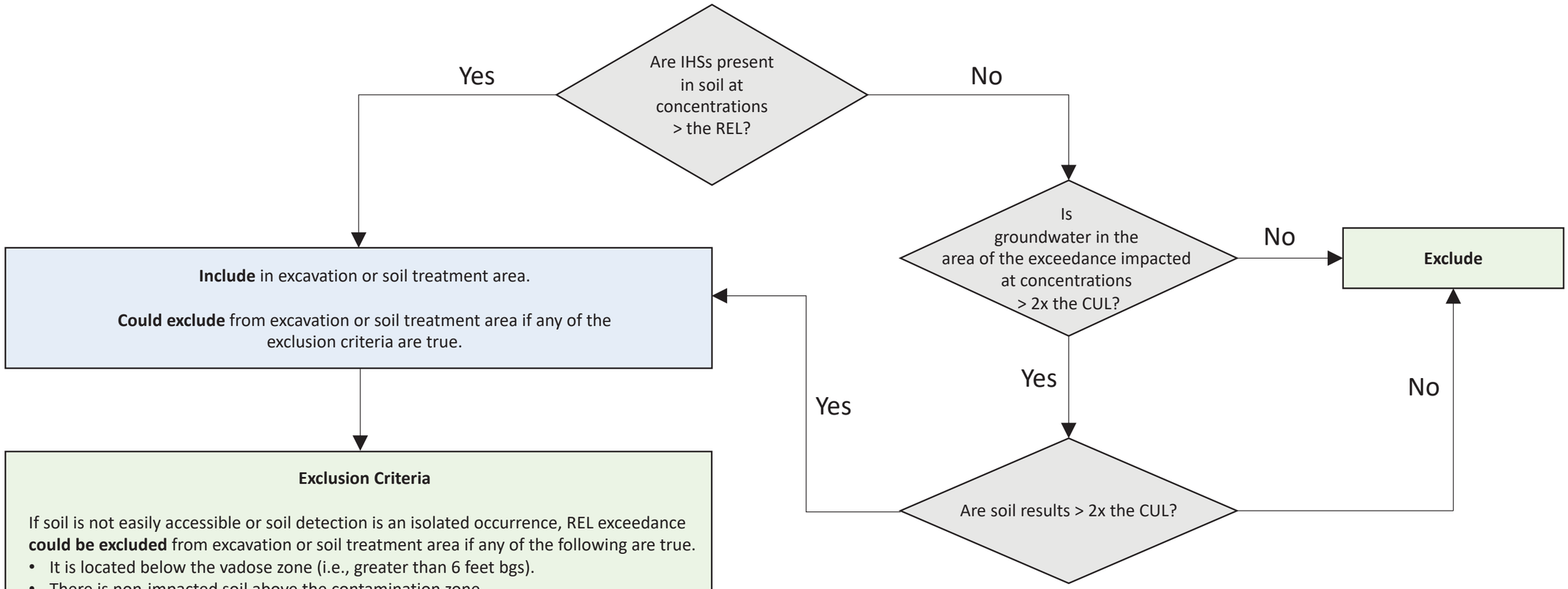

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Figure 11.1
Decision Criteria for Alternatives Evaluation

04/06/2020

Alternative A.1

Capping with Pavement or Buildings
Upland AOC

Excavation to CULs

CAA-1.a
5 ft bgs (2,800 CY)
LNAPL Removal

CAA-1.b
10 ft bgs (1,900 CY)

CAA-2
15 ft bgs (13,400 CY)
LNAPL Removal

CAA-3
5 ft bgs (2,600 CY)

CAA-4.a
20 ft bgs (4,000 CY)

CAA-4.b
28 ft bgs (14,800 CY)

CAA-5
5 ft bgs (1,300 CY)

CAA-6.a
6 ft bgs (700 CY)
12 ft bgs (300 CY)

CAA-6.b
3 ft bgs (300 CY)

CAA-7
1 ft bgs (60 CY)

Total Volume Addressed
42,160 CY

PRB Wall with ZVI
CAA-4

Legend

- Cleanup Action Area
- Approximate LNAPL Extent
- Property Boundary for the Seattle Terminal Properties

CAA-7
1 ft bgs

CAA-6.b
3 ft bgs

CAA-6.a
6 ft bgs
(12 ft bgs in southern area)

CAA-5
5 ft bgs

CAA-2
15 ft bgs

CAA-4.a
20 ft bgs

CAA-3
5 ft bgs

CAA-4.b
28 ft bgs

PRB Wall
15 ft bgs

CAA-1.b
10 ft bgs

CAA-1.a
5 ft bgs

W. Commodore Way

27th Ave W

BNSF RAILROAD

Gilman Ave W

W. Fort St

Notes:
· Parcel boundaries obtained from King County Geographic Information Systems Center, 2011. Lot lines are approximate. Not for legal use.
· Orthoimagery obtained from Nearmap, 2018.

Abbreviations:
AOC = Area of concern
CAA = Cleanup Action Area
CUL = Cleanup level
CY = Cubic yard
ft bgs = Feet below ground surface
LNAPL = Light non-aqueous-phase liquid
PRB = Permeable Reactive Barrier
ZVI = Zero-valent iron

0 45 90 180
Scale in Feet

N

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Figure 11.2
Alternative A.1

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Alternative A.2

Capping with Pavement or Buildings
Upland AOC

Excavation to CULs
- **CAA-6.a**
  - 6 ft bgs (700 CY)
  - 12 ft bgs (300 CY)
- **CAA-6.b**
  - 3 ft bgs (300 CY)
- **CAA-7**
  - 1 ft bgs (60 CY)
- **Total Volume Addressed**
  - 1,360 CY

Excavation to RELs
- **CAA-1.a**
  - 5 ft bgs (2,200 CY)
  - LNAPL Removal
- **CAA-1.b**
  - 10 ft bgs (1,600 CY)
- **CAA-2**
  - 15 ft bgs (8,800 CY)
  - LNAPL Removal
- **CAA-3**
  - 5 ft bgs (1,700 CY)
- **CAA-4.a**
  - 20 ft bgs (4,000 CY)
- **CAA-4.b**
  - 28 ft bgs (10,500 CY)
- **Total Volume Addressed**
  - 28,800 CY

No Action[1]
CAA-5

PRB Wall with ZVI
CAA-4

Notes:
1. Areas of no action consist of isolated and discontinuous areas of shallow soil impacts and will be addressed by capping with pavement or buildings and institutional controls to protect human health and the environment from direct contact with contaminated soil.

- Parcel boundaries obtained from King County Geographic Information Systems Center, 2011. Lot lines are approximate. Not for legal use.
- Orthoimagery obtained from Nearmap, 2018.

Abbreviations:
AOC = Area of concern
CAA = Cleanup Action Area
CUL = Cleanup level
CY = Cubic yards
ft bgs = Feet below ground surface
LNAPL = Light non-aqueous-phase liquid
PRB = Permeable Reactive Barrier
REL = Remediation level
ZVI = Zero-valent iron

0 45 90 180
Scale in Feet

N

Legend
- Cleanup Action Area
- Approximate LNAPL Extent
- Property Boundary for the Seattle Terminal Properties

CAA-7
1 ft bgs

CAA-6.b
3 ft bgs

CAA-6.a
6 ft bgs
(12 ft bgs in southern area)

CAA-5

CAA-2
15 ft bgs

CAA-4.a
20 ft bgs

CAA-3
5 ft bgs

CAA-4.b
28 ft bgs

PRB Wall
15 ft bgs

CAA-1.b
10ft bgs

CAA-1.a
5 ft bgs

W. Commodore Way

27th Ave W

BNSF RAILROAD

Gilman Ave W

W. Fort St

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Figure 11.3
Alternative A.2

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Alternative B

Capping with Pavement or Buildings
Upland AOC

Excavation to CULs
- **CAA-5**
  - 5 ft bgs (1,300 CY)
- **CAA-6.a**
  - 6 ft bgs (700 CY)
  - 12 ft bgs (300 CY)
- **CAA-6.b**
  - 3 ft bgs (300 CY)
- **CAA-7**
  - 1 ft bgs (60 CY)
- **Total Volume Addressed**
  - 2,660 CY

Excavation to RELs
- **CAA-1.a**
  - 5 ft bgs (2,200 CY)
  - LNAPL Removal
- **CAA-1.b**
  - 10 ft bgs (1,600 CY)
- **CAA-2.b**
  - 15 ft bgs (2,100 CY)
  - LNAPL Removal
- **CAA-3**
  - 5 ft bgs (800 CY)
- **Total Volume Addressed**
  - 6,700 CY

In Situ Stabilization/Solidification
- **CAA-2.a**
  - 23 ft bgs (10,200 CY)
- **CAA-4.a**
  - 30 ft bgs (5,900 CY)
- **CAA-4.b**
  - 30 ft bgs (11,300 CY)
- **Total Volume Addressed**
  - 27,400 CY

Interceptor Trench
CAA-4

PRB Wall with ZVI
CAA-4

Notes:
· Parcel boundaries obtained from King County Geographic Information Systems Center, 2011. Lot lines are approximate. Not for legal use.
· Orthoimagery obtained from Nearmap, 2018.

Abbreviations:
AOC = Area of concern
CAA = Cleanup Action Area
CUL = Cleanup level
CY = Cubic yards
ft bgs = Feet below ground surface
LNAPL = Light non-aqueous-phase liquid
PRB = Permeable Reactive Barrier
REL = Remediation level

0 45 90 180
Scale in Feet

N

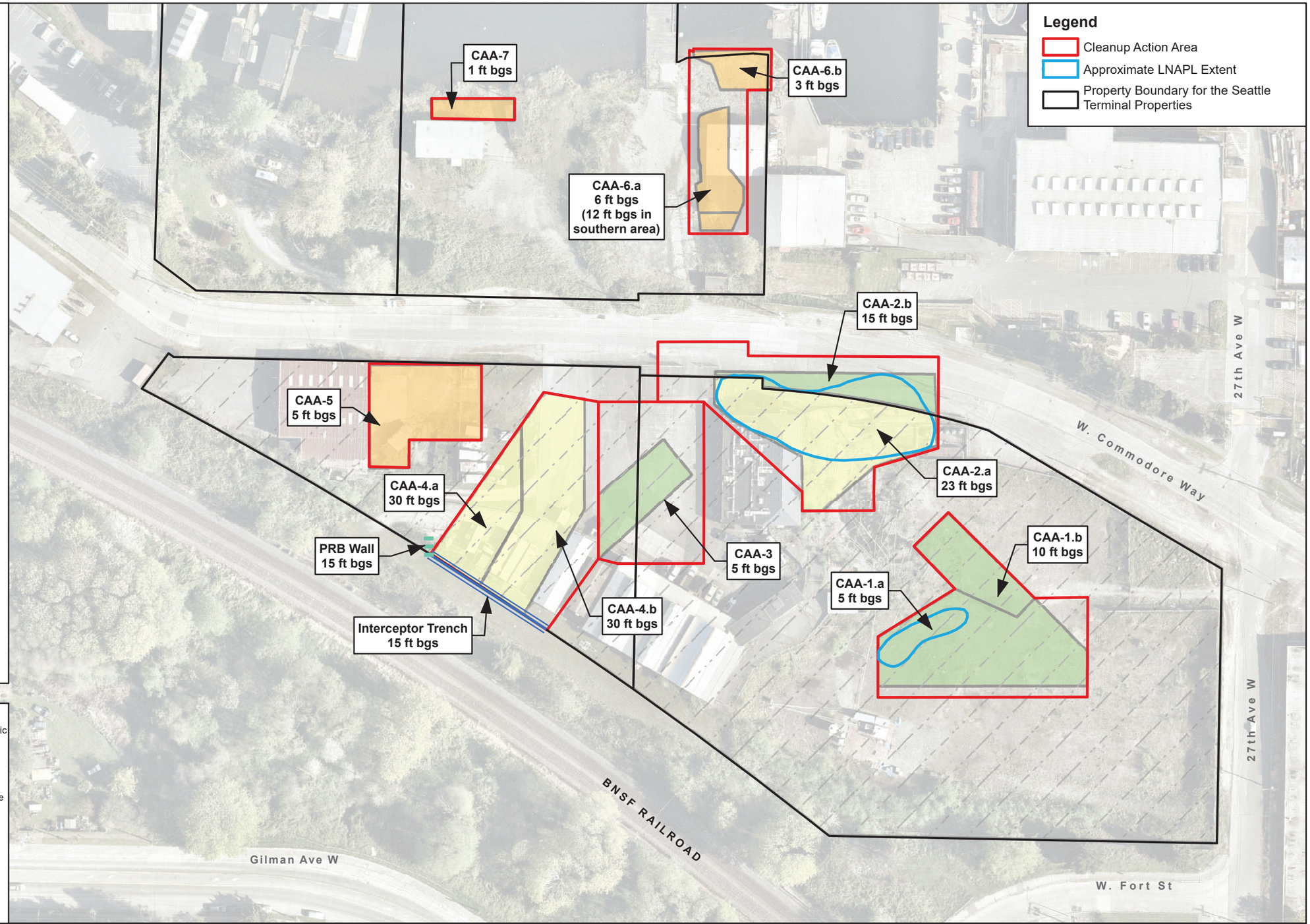

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Figure 11.4
Alternative B

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Alternative C

Capping with Pavement or Buildings
Upland AOC

Excavation to CULs
CAA-5 Hotspot
5 ft bgs (200 CY)
CAA-6.a
6 ft bgs (700 CY)
12 ft bgs (300 CY)
CAA-6.b
3 ft bgs (300 CY)
CAA-7
1 ft bgs (60 CY)
Total Volume Addressed
1,560 CY

Excavation to RELs
CAA-1.a
5 ft bgs (1,300 CY)
LNAPL Removal
CAA-1.b
10 ft bgs (800 CY)
CAA-2.b
15 ft bgs (2,100 CY)
LNAPL Removal
CAA-3
5 ft bgs (800 CY)
Total Volume Addressed
5,000 CY

In Situ Stabilization/Solidification
CAA-2.a
23 ft bgs (10,200 CY)
CAA-4.a
30 ft bgs (5,900 CY)
CAA-4.b
30 ft bgs (11,300 CY)
Total Volume Addressed
27,400 CY

In Situ Groundwater Treatment[1]
CAA-5

Interceptor Trench
CAA-4

PRB Wall with ZVI
CAA-4

Notes:
1. In situ groundwater treatment includes enhanced reductive dichlorination of the TCE and vinyl chloride groundwater plume using a trademarked colloidal biomatrix and sulfidated micro zero-valent iron mixture (PlumeStop and S-MicroZVI) to create a passive treatment zone of chemical reduction and bioremediation in the Shallow WBZ and the addition of an enriched natural microbial consortium (BDI Plus) to stimulate rapid dichlorination of TCE.

· Parcel boundaries obtained from King County Geographic Information Systems Center, 2011. Lot lines are approximate. Not for legal use.
· Orthoimagery obtained from Nearmap, 2018.

Abbreviations:
AOC = Area of concern
BDI = Bio-Dechlor INOCULUM
CAA = Cleanup Action Area
CUL = Cleanup level
CY = Cubic yards
ft bgs = Feet below ground surface
LNAPL = Light non-aqueous-phase liquid
PRB = Permeable Reactive Barrier
REL = Remediation level
TCE = Trichloroethene
WBZ = Water-bearing zone

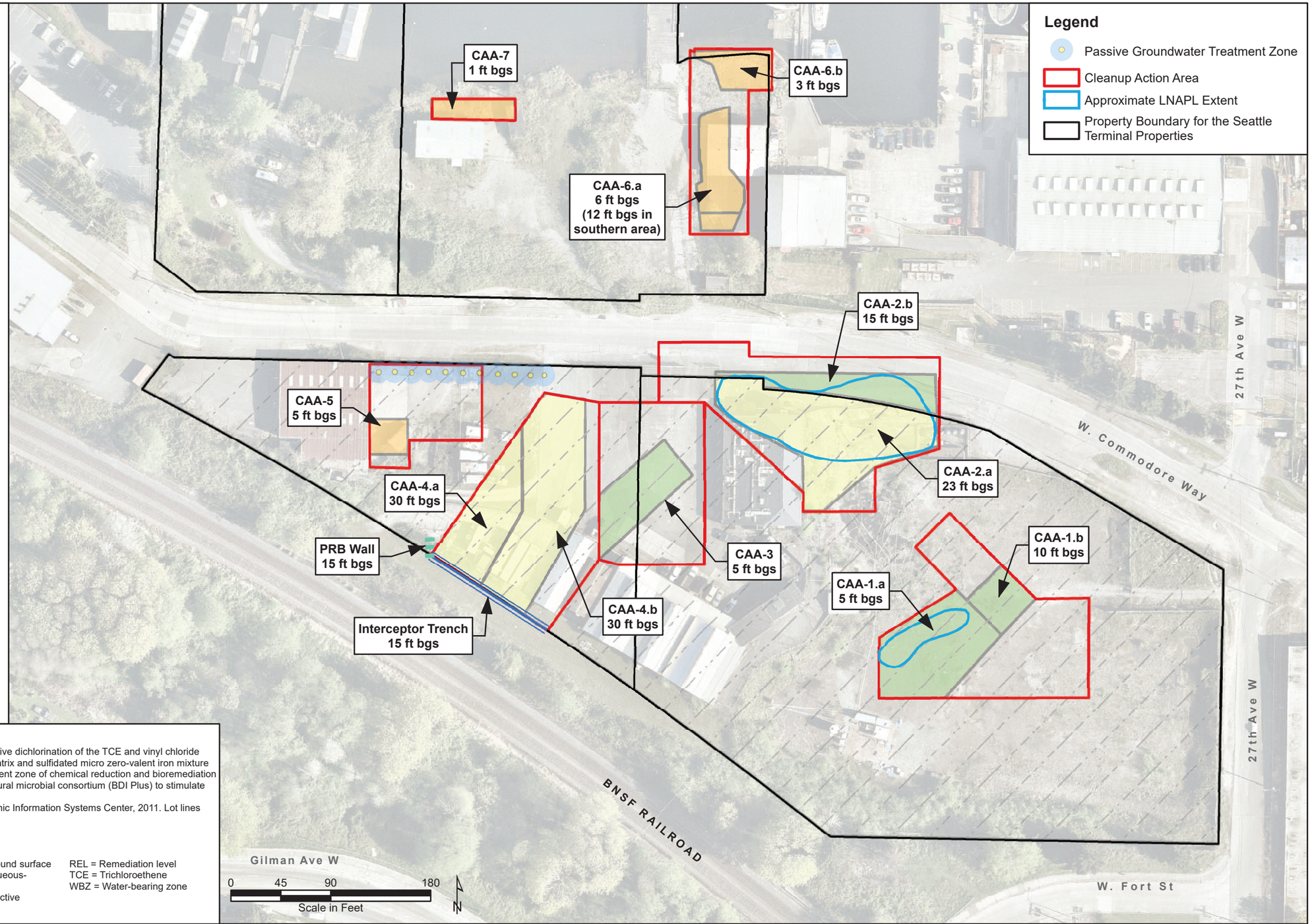

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Figure 11.5
Alternative C

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Alternative D

Capping with Pavement or Buildings
Upland AOC

Excavation to CULs
- **CAA-6.a**
  - 6 ft bgs (700 CY)
  - 12 ft bgs (300 CY)
- **CAA-6.b**
  - 3 ft bgs (300 CY)
- **CAA-7**
  - 1 ft bgs (60 CY)
- **Total Volume Addressed**
  - 1,360 CY

Excavation to RELs
- **CAA-1.a**
  - 5 ft bgs (600 CY)
  - LNAPL Removal
- **CAA-2**
  - 15 ft bgs (7,900 CY)
  - LNAPL Removal
- **Total Volume Addressed**
  - 8,500 CY

ERH Treatment[1]
- **CAA-4.a**
  - 20 ft bgs (4,000 CY)
- **CAA-4.b**
  - 20 ft bgs (7,500 CY)
- **Total Volume Addressed**
  - 11,500 CY

No Action[2]
- **CAA-1.b**
- **CAA-3**
- **CAA-5**

PRB Wall with ZVI
- **CAA-4**

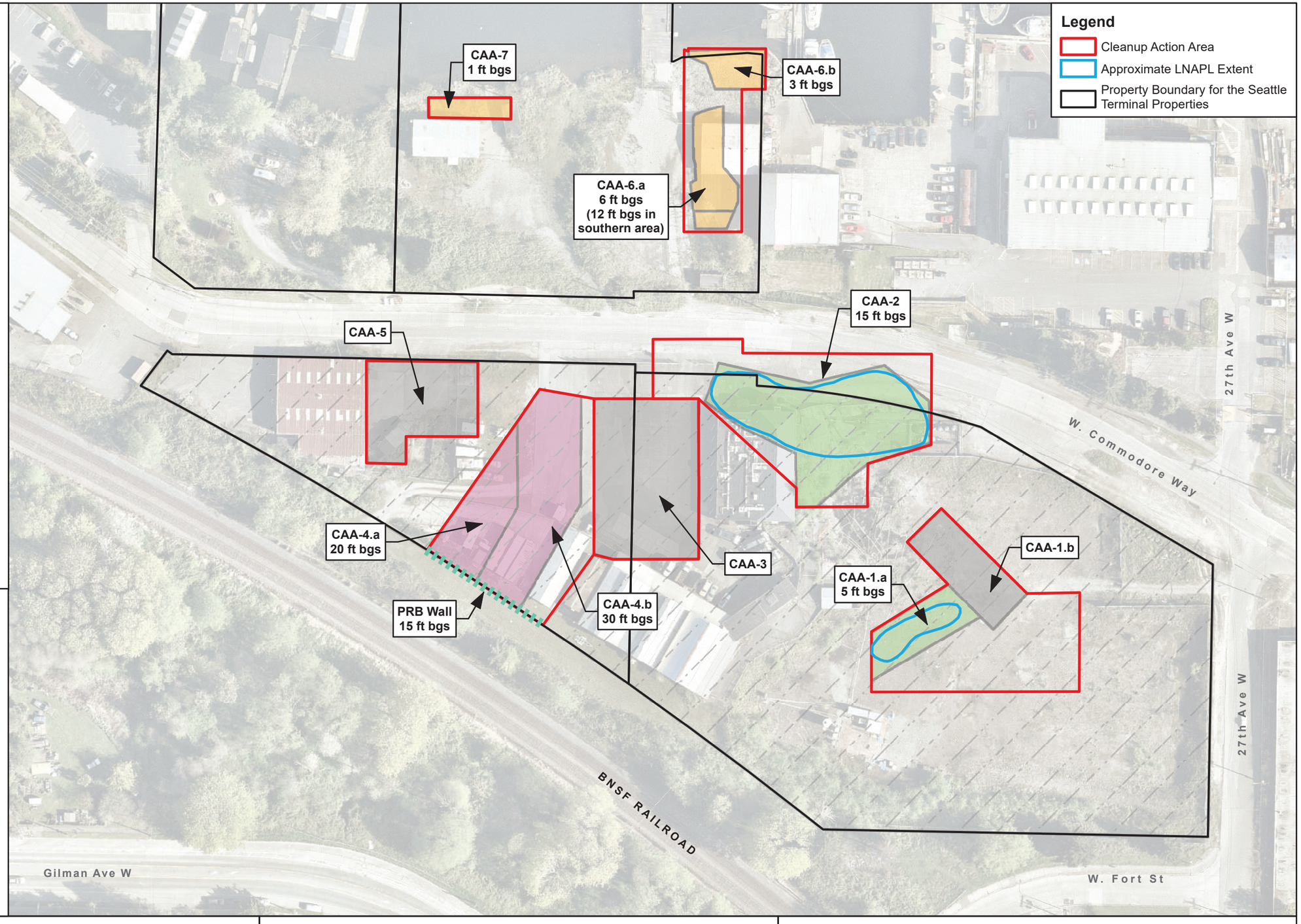
Notes:
1. Assumes the installation of 69 electrodes spaced 16 feet apart throughout the remediation zone.
2. Areas of no action consist of isolated and discontinuous areas of shallow soil impacts and will be addressed by capping with pavement or buildings and institutional controls to protect human health and the environment from direct contact with contaminated soil.

· Parcel boundaries obtained from King County Geographic Information Systems Center, 2011. Lot lines are approximate. Not for legal use.
· Orthoimagery obtained from Nearmap, 2018.

Abbreviations:
AOC = Area of concern
CAA = Cleanup Action Area
CUL = Cleanup level
CY = Cubic yards
ERH = Electrical Resistance Heating
ft bgs = Feet below ground surface
LNAPL = Light non-aqueous-phase liquid
PRB = Permeable Reactive Barrier
REL = Remediation level
ZVI = Zero-valent iron

0 45 90 180
Scale in Feet

N



Legend
- Cleanup Action Area
- Approximate LNAPL Extent
- Property Boundary for the Seattle Terminal Properties

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Figure 11.6
Alternative D

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Alternative E

Capping with Pavement or Buildings
Upland AOC

Excavation to CULs
- **CAA-6.a**
  - 6 ft bgs (700 CY)
  - 12 ft bgs (300 CY)
- **CAA-6.b**
  - 3 ft bgs (300 CY)
- **CAA-7**
  - 1 ft bgs (60 CY)
- **Total Volume Addressed**
  - 1,360 CY

Excavation to RELs
- **CAA-1.a**
  - 5 ft bgs (600 CY)
  - LNAPL Removal
- **CAA-2.b**
  - 15 ft bgs (2,100 CY)
  - LNAPL Removal
- **Total Volume Addressed**
  - 2,700 CY

In Situ Stabilization/Solidification
- **CAA-2.a**
  - 23 ft bgs (10,200 CY)
- **CAA-4.a**
  - 30 ft bgs (5,900 CY)
- **CAA-4.b**
  - 30 ft bgs (11,300 CY)
- **Total Volume Addressed**
  - 27,400 CY

No Action[1]
- **CAA-1.b**
- **CAA-3**
- **CAA-5**

Interceptor Trench
- **CAA-4**

PRB Wall with ZVI
- **CAA-4**

Notes:
1. Areas of no action consist of isolated and discontinuous areas of shallow soil impacts and will be addressed by capping with pavement or buildings and institutional controls to protect human health and the environment from direct contact with contaminated soil.

· Parcel boundaries obtained from King County Geographic Information Systems Center, 2011. Lot lines are approximate. Not for legal use.

· Orthoimagery obtained from Nearmap, 2018.

Abbreviations:

AOC = Area of concern
CAA = Cleanup Action Area
CUL = Cleanup level
CY = Cubic yards
ft bgs = Feet below ground surface
LNAPL = Light non-aqueous-phase liquid
PRB = Permeable Reactive Barrier
REL = Remediation level
ZVI = Zero-valent iron

0 45 90 180
Scale in Feet

N

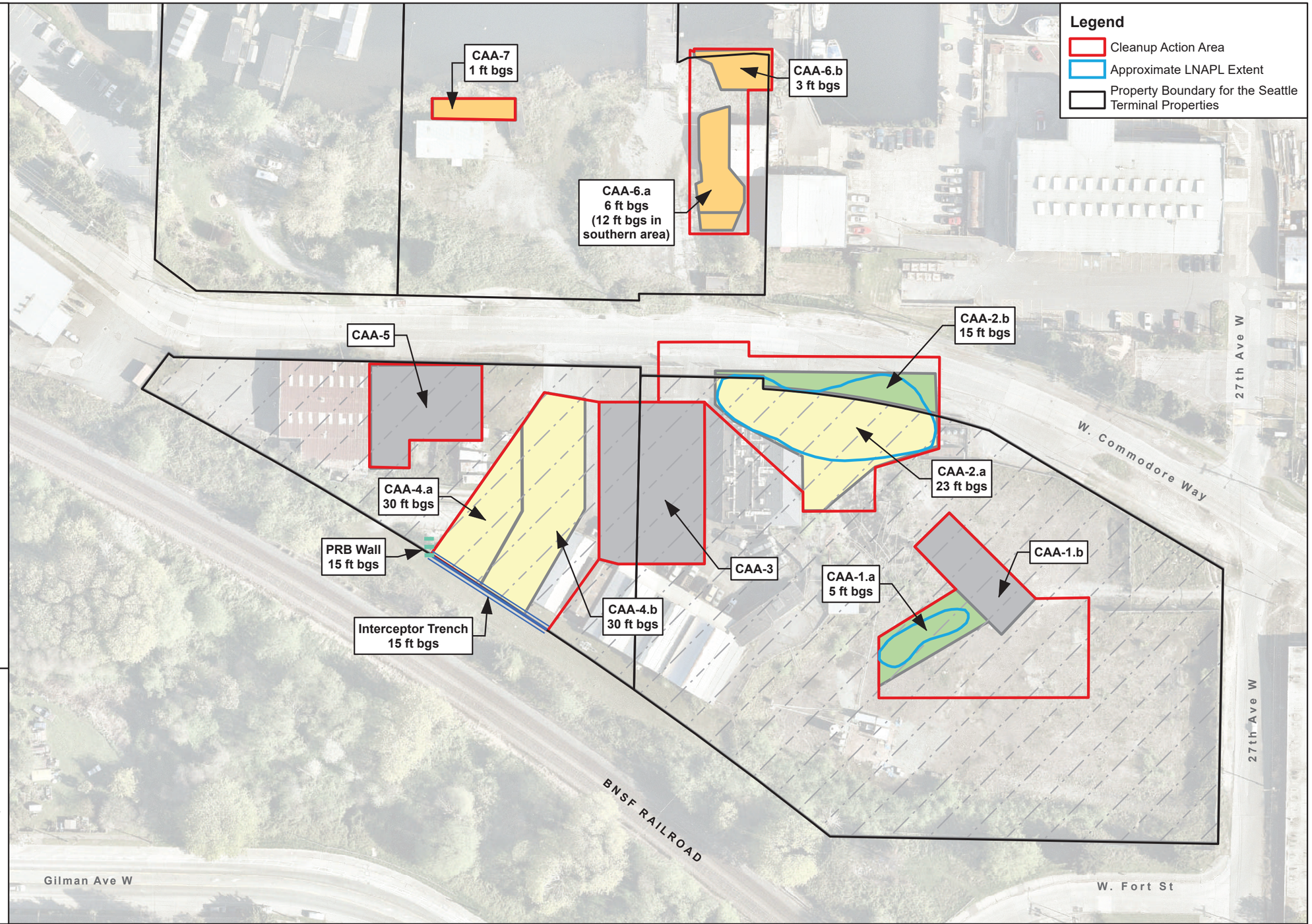

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Figure 11.7
Alternative E

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Preferred Remedial Alternative

Capping with Pavement or Buildings
Upland AOC

Excavation to CULs
CAA-5 Hotspot
5 ft bgs (200 CY)
CAA-6.a
6 ft bgs (700 CY)
12 ft bgs (300 CY)
CAA-6.b
3 ft bgs (300 CY)
CAA-7
1 ft bgs (60 CY)
Total Volume Addressed
1,560 CY

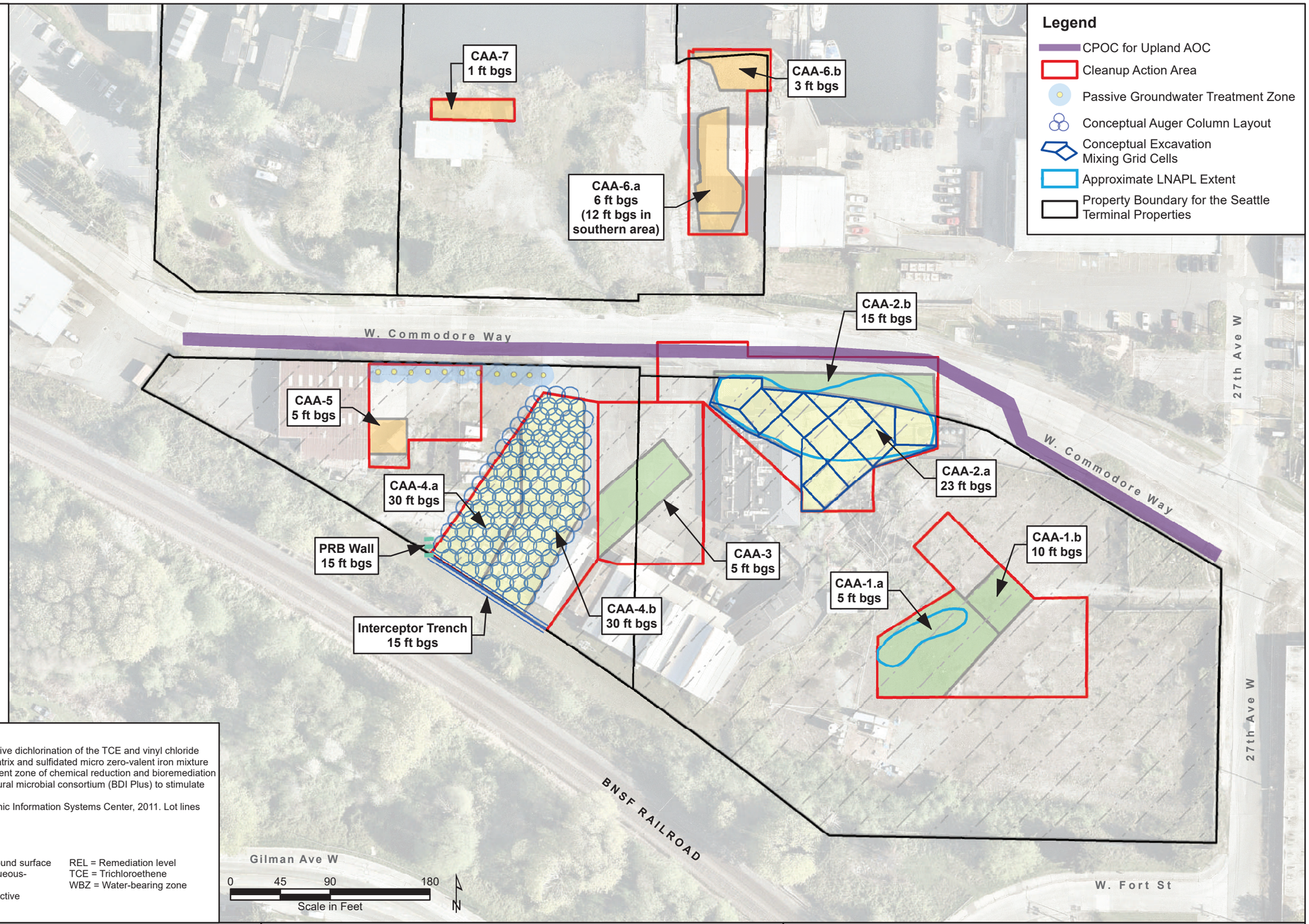
Excavation to RELs
CAA-1.a
5 ft bgs (1,300 CY)
LNAPL Removal
CAA-1.b
10 ft bgs (800 CY)
CAA-2.b
15 ft bgs (2,100 CY)
LNAPL Removal
CAA-3
5 ft bgs (800 CY)
Total Volume Addressed
5,000 CY

In Situ Stabilization/Solidification
CAA-2.a
23 ft bgs (10,200 CY)
CAA-4.a
30 ft bgs (5,900 CY)
CAA-4.b
30 ft bgs (11,300 CY)
Total Volume Addressed
27,400 CY

In Situ Groundwater Treatment[1]
CAA-5

Interceptor Trench
CAA-4

PRB Wall with ZVI
CAA-4



Legend

- CPOC for Upland AOC
- Cleanup Action Area
- Passive Groundwater Treatment Zone
- Conceptual Auger Column Layout
- Conceptual Excavation Mixing Grid Cells
- Approximate LNAPL Extent
- Property Boundary for the Seattle Terminal Properties

Notes:
1. In situ groundwater treatment includes enhanced reductive dichlorination of the TCE and vinyl chloride groundwater plume using a trademarked colloidal biomatrix and sulfidated micro zero-valent iron mixture (PlumeStop and S-MicroZVI) to create a passive treatment zone of chemical reduction and bioremediation in the Shallow WBZ and the addition of an enriched natural microbial consortium (BDI Plus) to stimulate rapid dichlorination of TCE.

· Parcel boundaries obtained from King County Geographic Information Systems Center, 2011. Lot lines are approximate. Not for legal use.
· Orthoimagery obtained from Nearmap, 2018.

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CAA = Cleanup Action Area
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CY = Cubic yards
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LNAPL = Light non-aqueous-phase liquid
PRB = Permeable Reactive Barrier
REL = Remediation level
TCE = Trichloroethene
WBZ = Water-bearing zone

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Figure 13.1
Preferred Remedial Alternative

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