SoundEarth Strategies, Inc.
2811 Fairview Avenue East, Suite 2000
Seattle, Washington 98102

FEASIBILITY STUDY

BULK TERMINAL PROPERTY

Property:

Bulk Terminal Property
2737 West Commodore Way
Seattle, Washington

Prepared for:

TOC Holdings Co.
2737 West Commodore Way
Seattle, Washington

Report Date:

June 17, 2014

Feasibility Study

Prepared for:

TOC Holdings Co.
2737 West Commodore Way
Seattle, Washington 98199

Bulk Terminal Property
2737 West Commodore Way
Seattle, Washington

Project No.: 0440-004

Prepared by:

Jessica Brown, LG
Project Hydrogeologist

Tyler G. Oester, PE
Project Engineer

Reviewed by:

Timothy S. Brown, LHG
Senior Hydrogeologist

State of Washington Licensed Geologist — Hydrogeologist — Timothy Scott Brown

Terry Montoya, PE
Principal Engineer

Terry W. Montoya — State of Washington — Registered Professional Engineer — EXPIRES

June 17, 2014

SoundEarth Strategies

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ACRONYMS AND ABBREVIATIONS

the 2003 BINMIC Report	North Ballard Interbay North Manufacturing Industrial Center (BINMIC) Hydrogeologic and Environmental Settings Report, prepared by The Floyd Snider McCarthy Team, 2003
°F	degrees Fahrenheit
API	American Petroleum Institute
ARAR	applicable or relevant and appropriate requirement
AST	aboveground storage tank
ASTM	American Society for Testing and Materials
bcy	bank cubic yards
bgs	below ground surface
BINMIC	Ballard Interbay North Manufacturing Industrial Center
BNSF	Burlington Northern Santa Fe
BTEX	benzene, toluene, ethylbenzene, and total xylenes
Bulk Terminal Property	located at 2737 West Commodore Way, and is part of King County Tax Parcel No. 112503-9050
CFR	Code of Federal Regulations
cm/sec	centimeters per second
COPC	chemicals of potential concern
CSM	conceptual site model
CPGV	critical pore gas velocity
DPD	City of Seattle Department of Planning and Development
DNR	Washington State Department of Natural Resources
DRPH	diesel-range petroleum hydrocarbon
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
ft/day	feet per day
ft/min	feet per minute
ft^3/min	cubic feet per minute
FS	feasibility study
FS Report	Feasibility Study report, prepared by SoundEarth Strategies, Inc.
GAC	granular activated carbon

ACRONYMS AND ABBREVIATIONS (CONTINUED)

gpm	gallons per minute
g/cm^3	grams per cubic centimeter
GRPH	gasoline-range petroleum hydrocarbon
Hdf	Holocene Depression Fillings
Hf	Holocene Fill
iow	inches of water (vacuum or pressure)
LEL	lower explosive limit
LNAPL	light, nonaqueous phase liquid
LPGAC	liquid phase granular activated carbon
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
MNA	monitored natural attenuation
MPE	multiphase extraction
MTCA	Washington State Model Toxics Control Act
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NFA	No Further Action
O&M	operation and maintenance
OMB	Office of Management and Budget
ORPH	oil-range petroleum hydrocarbon
PAH	polycyclic aromatic hydrocarbon
PCP	pentachlorophenol
PSCAA	Puget Sound Clean Air Agency
Qpf	pre-Frasier age glacial deposits
Qpfc	pre-Frasier coarse-grained deposits
Qpff	pre-Frasier fine deposits
RAO	remedial action objective
RCRA	Resource Conservation and Recovery Act
RCW	Revised Code of Washington
RI	remedial investigation
RI Report	Remedial Investigation Report prepared by SoundEarth Strategies, Inc., dated June 13, 2014
ROW	right-of-way

ACRONYMS AND ABBREVIATIONS (CONTINUED)

RP	Recommended Practice
scfm	standard cubic feet per minute
the Site	The north, central, and south portions of the Bulk Terminal Property, extending into the north-adjoining West Commodore right-of-way
SoundEarth	SoundEarth Strategies, Inc., formerly known as Sound Environmental Strategies Corporation
SVE	soil vapor extraction
TCE	trichloroethylene
TOC	TOC Holdings Co.
TPH	total petroleum hydrocarbons
USACE	United States Army Corps of Engineers
USC	United States Code
UST	underground storage tank
VCP	Voluntary Cleanup Program
VOC	volatile organic compound
WAC	Washington Administrative Code
ZOI	zone of vacuum influence

1.0 INTRODUCTION

SoundEarth Strategies, Inc. (SoundEarth, formerly Sound Environmental Strategies Corporation) has prepared this Feasibility Study Report (FS Report) on behalf of TOC Holdings Co. (TOC; formerly named Time Oil Co.) for the Bulk Terminal Property. The Bulk Terminal Property is located at 2737 West Commodore Way in Seattle, Washington (Figure 1). The Bulk Terminal Property is part of the Seattle Terminal Properties. The Seattle Terminal Properties include four real properties (King County Tax Parcel Numbers 112503-9050 [Bulk Terminal Property], 112503-9120, 423790-0405, and 112503-9081) and one parcel leased from the Washington State Department of Natural Resources (DNR; King County Tax Parcel Number 112503-9113). The Seattle Terminal Properties are identified as the Bulk Terminal Property, East Waterfront Property, ASKO Hydraulic Property, West Waterfront Property, and the Washington State DNR Aquatic Lease Land Property. The Seattle Terminal Properties and West Commodore Way are located in Section 11, Township 25 North, Range 3 East. The latitude and longitude of the Seattle Terminal Properties is approximately 47°39'41−51"North and 122°23'28−41"West. The layout of the Seattle Terminal Properties is shown on Figure 2. The City of Seattle West Commodore Way right-of-way (ROW) runs from east to west and separates the Bulk Terminal Property and ASKO Hydraulic Property from the East Waterfront Property and West Waterfront Property. The Seattle Terminal Properties and West Commodore Way are located within the Ballard Interbay North Manufacturing Industrial Center (BINMIC) designated by the City of Seattle in 1994.

SoundEarth conducted a remedial investigation (RI) to address data gaps identified from the data presented in previous subsurface investigations and interim actions conducted by SoundEarth and others that had confirmed releases of the chemicals of potential concern (COPC) to the environment at the Bulk Terminal Property. The releases of COPCs resulted in the migration of contamination in soil and groundwater. The confirmed and suspected sources of COPCs are associated with historical facility operations; however, the release mechanisms are unknown. The previous investigations and interim actions conducted at the Bulk Terminal Property are summarized in the Remedial Investigation Report (RI Report) prepared by SoundEarth in 2014.

The feasibility study (FS) was performed as part of an ongoing cleanup action in accordance with Washington State Model Toxics Control Act (MTCA) Cleanup Regulations as established in Chapter 173-340 of the Washington Administrative Code (WAC 173-340). In accordance with WAC 173-340-360(2), the final cleanup action will meet the cleanup standards at the defined points of compliance, protect human health and the environment, comply with applicable state and federal laws, provide for compliance monitoring, and provide a permanent solution to the maximum extent practicable.

1.1 PURPOSE

The objective of this FS is to develop and evaluate cleanup action alternatives to facilitate selection of a final cleanup action for the Sites in accordance with WAC 173-340-350(8). A FS includes the development, screening, and evaluation process for numerous remedial alternatives.

The FS Report has been prepared to develop and evaluate cleanup action alternatives for the site and to select the most appropriate alternative based on the evaluation criteria as defined by MTCA WAC 173-340-350 through 173-340-390. According to MTCA, a cleanup action alternative must satisfy all of the following threshold criteria as specified in WAC 173-340-360(2):

- Protect human health and the environment.
- Comply with applicable state and federal laws.
- Comply with cleanup standards.
- Provide for compliance monitoring.

While these criteria represent the minimum standards for an acceptable cleanup action, WAC 173-340-360(2b) also recommends that the cleanup action alternative satisfy the following criteria:

- Use permanent solutions to the maximum extent practicable.
- Provide for a reasonable restoration time frame.
- Consider public concerns.

1.2 PRELIMINARY SITE DEFINITION

According to Washington State Department of Ecology's (Ecology) *Guidelines for Property Cleanups under the Voluntary Cleanup Program* dated July 2008, a site is defined by the nature and extent of contamination associated with one or more releases of hazardous substances (such as the release of gasoline from a leaking underground storage tank [UST]) prior to any cleanup of that contamination (Ecology 2008). Based on the information gathered to date, the site encompasses the north, central, and south portions of the Bulk Terminal Property and extends into the north-adjoining West Commodore Way ROW (the Site), as shown on Figure 3.

1.3 PRELIMINARY CLEANUP LEVELS

Preliminary cleanup levels were established for individual hazardous substances in each medium during the scoping of the RI based on various phases of investigation performed by others. The preliminary cleanup levels were refined during the RI. The final cleanup levels will be defined in the subsequent Cleanup Action Plan, as additional information becomes available on the potential future land use.

The Bulk Terminal Property is zoned industrial. However, the City of Seattle will permit commercial uses in industrial areas to the extent that they reinforce the industrial character of the region and new residential uses will not be permitted except for special types of dwellings that are related to the industrial area or that would not restrict or disrupt industrial activity.

Total petroleum hydrocarbons (TPH) are the primary suspected source(s) of potential releases of hazardous substances at the Bulk Terminal Property, based on the historical land use as a petroleum bulk storage facility. Based on the results of the RI, the primary COPC at the Site is TPH and associated volatile petroleum compounds (benzene, toluene, ethylbenzene, and total xylenes [BTEX]) and pentachlorophenol (PCP). Concentrations of secondary COPCs are encompassed by the larger TPH plumes that define the Site and include the following: lead in soil; polycyclic aromatic hydrocarbons (PAH) in soil; and naphthalene, 1-methyl-naphthalene, and 2-methyl-naphthalene in soil. The preliminary cleanup levels for individual hazardous substances including TPH are based on established MTCA Method A cleanup levels in accordance with WAC 173-340-720 through WAC 173-340-760. MTCA Method B cleanup levels are used for hazardous substances where MTCA Method A cleanup levels were not established, for example, PCP. The preliminary cleanup levels for COPCs confirmed or suspected in environmental media of potential concern are provided in Table 1.

The final cleanup standards will be determined based on the selected cleanup action(s) and the current and potential future land and resource uses. The final cleanup standards for the Site including cleanup levels, points of compliance, and remediation levels, if applicable, will be defined in the Cleanup Action Plan presented under separate cover, in accordance with WAC 173-340-700.

1.4 REPORT ORGANIZATION

This FS Report is organized into the following sections:

- **Section 2.0, Background.** This section provides a description of general facility information and conditions for the Bulk Terminal Property, a description of current and historical land uses for Bulk Terminal Property and the West Commodore Way ROW, where portions of the site are located. This section also provides a summary of the environmental setting for the Bulk Terminal Property.
- **Section 3.0, Summary of the Conceptual Site Model.** This section provides a summary of the conceptual site model (CSM) developed for the Site based on the completion of the RI conducted by SoundEarth, and previous investigations performed by others.
- **Section 4.0, Field Pilot Tests and Treatability Studies.** This section summarizes field tests and treatability studies that were performed to evaluate the effectiveness of potential candidate remedial technologies and to obtain preliminary design data used to evaluate the cost-effectiveness of the technology.
- **Section 5.0, Remedial Alternatives Assessment.** This section lists the remedial action objectives (RAO) developed for the Site which were used to define the technical elements for the screening evaluation and to select a cleanup action alternative. The technical elements include applicable or relevant and appropriate requirements (ARAR), COPCs, media of concern, and preliminary cleanup standards. This section provides the comparative evaluation of cleanup action alternatives and disproportionate cost analysis, and presents the recommended cleanup action alternative.
- **Section 6.0, Bibliography.** This section lists reference used to develop this document.
- **Section 7.0, Limitations.** This section presents SoundEarth's standard limitations associated with conducting the work reported herein and preparing this FS Report.

2.0 BACKGROUND

This section provides a description of general facility information and conditions for the Bulk Terminal Property, a description of current and historical land uses for the Bulk Terminal Property and the West Commodore Way ROW, and a summary of the environmental settings, including topography, surface water and sediments, soil and geology, hydrogeology, and air.

2.1 PROPERTY DESCRIPTION

The Bulk Terminal Property is located at 2737 West Commodore Way, Seattle, Washington. The Bulk Terminal Property is comprised of a single tax parcel (King County Tax Parcel Number 112503-9050) with a total area of 4.08 acres (177,688 square feet).

The Bulk Terminal Property extends from West Commodore Way to the Burlington Northern Santa Fe (BNSF) railroad to the south. Several buildings exist on the western portion of the parcel, including a 13,662-square-foot office building (TOC's current Headquarters Office Building); a portion of a 7,200-square-foot Warehouse Building; and three smaller shop buildings encompassing 660 square feet (the Foamite Shed), 528 square feet (the Boiler Room), and 892 square feet (the Pump Shed). The western portion of the Warehouse Building extends onto the ASKO Hydraulic Property. The eastern portion of the Bulk Terminal Property is currently undeveloped and primarily covered with 4 to 6 inches of 2- to 4-inch-diameter gravel. The south end of the Upper Tank Yard banks steeply upward to the existing fence line and former rail spur.

The Bulk Terminal Property is serviced by overhead electrical, cable, and telephone utilities and by underground communications and municipal water and sewer utilities. These utilities generally come on to the Bulk Terminal Property at the northeast corner of the TOC Headquarters Office Building from the West Commodore Way ROW. An additional overhead electric line runs from the southeast corner of the TOC headquarters building to the southeast corner of the Warehouse Building.

The Bulk Terminal Property is bounded to the north by the West Commodore Way ROW. Located farther to the north of the Bulk Terminal Property are the East Waterfront Property to the northwest and a Port of Seattle parcel to the northeast. The eastern portion of the Bulk Terminal Property is bounded by 27^{th} Avenue West and beyond by a warehouse building owned by Century Twenty-One Promotions; the southern portion is bounded by the BNSF Parcel; and the western portion is bounded by the ASKO Hydraulic Property (Figure 2).

2.2 PROPERTY LAND USE AND HISTORY

The current and historical use information presented in this FS Report for the Bulk Terminal Property and the West Commodore Way ROW is compiled from reviewed sources, including City of Seattle Department of Planning and Development (DPD), King County Assessor's website, historical assessor records obtained from Puget Sound Regional Archives, Sanborn Fire Insurance Maps; Kroll and Baist Atlases; Polk and Cole City Directories; aerial photographs, historical records provided by Ecology and TOC, and previous reports prepared by others. Historical documentation referenced in this section is provided in the RI Report.

According to the *Ballard Interbay North Manufacturing Industrial Center (BINMIC) Hydrogeologic and Environmental Settings Report* (the 2003 BINMIC Report) prepared by The Floyd Snider McCarthy Team, the Bulk Terminal Property is located within the BINMIC (Figure 2 of the 2003 BINMIC Report). The current land use of the Bulk Terminal Property is a mix of industrial and commercial.

The Bulk Terminal Property is zoned as Industrial General 2 Unlimited/65 and Industrial Buffer Unlimited/45 according to the City of Seattle's zoning map. The Industrial General 2 Unlimited/65 zoning classification allows for a broad range of industrial and commercial uses. Typical land use includes general and heavy manufacturing, commercial, entertainment, transportation and utility services, and salvage and recycling. The intent of the Industrial Buffer Unlimited/45 zoning classification is to provide an appropriate transition between industrial areas and adjacent residential and/or commercial zones. Typical land use includes general and light manufacturing, commercial, limited transportation services, entertainment, and salvage and recycling. The City of Seattle will reportedly permit commercial uses in industrial areas to the extent that they reinforce the industrial character of the region. New residential uses will not be permitted by the City of Seattle except for special types of dwellings that are related to the industrial area and that would not restrict or disrupt industrial activity. In addition, the City of Seattle has designated portions of Bulk Terminal Property as environmentally critical areas for Heron Habitat and Wildlife Preservation Areas, 40 Percent Steep Slope, and Potential Slide Area.

TOC operated the petroleum bulk storage facility at the Bulk Terminal Property between 1941 and October 2001 (Foster Wheeler 2003). Operations of the petroleum bulk storage facility included distribution of retail petroleum products, including gasoline, diesel, kerosene, and mineral spirits between transport ships, railroad tank cars, and trucks. Petroleum products were transported at the Seattle Terminal Properties by drums and distribution pipelines. Piping ran from the bulk aboveground storage tanks (AST) on the Bulk Terminal Property to barreling sheds where 5-gallon containers and 55-gallon drums were filled with petroleum products, which were then transported beneath the West Commodore Way ROW to the East Waterfront Property using inclined gravity conveyors (Former West and East Barrel Inclines).

Historical records indicated that as many as three configurations of barreling sheds were formerly located at the Seattle Terminal Properties. The first configuration was located west of the Headquarters Office Building (Former Barreling Shed #1), the second configuration was located on the southwest portion of the Bulk Terminal Property extending onto the ASKO Hydraulic Property (Former Barreling Shed #2), and the third configuration was operated on the southeast portion of the ASKO Hydraulic Property (Former Barreling Shed #3). Former Barreling Shed #2 was operated from approximately 1941 to 1952. Former Barreling Shed #3 was constructed after 1952 to replace Former Barreling Shed #2. The full extent of operations conducted at the barreling sheds is unknown.

Additional structures on the Bulk Terminal Property included two 1941-vintage Former Overhead Fuel Loading Racks, each with 300-square-foot canopies located directly north of the Lower Tank Yard; the southern end of the East Barrel Incline which extended from Former Barreling Shed #2 to the East Waterfront Property; a Pipeline Utilidor which extended north from the Lower Tank Yard beneath the West Commodore Way ROW and angled toward the Shipping Terminal Dock; and five Former Rail Spurs extending off the main BNSF railroad. One rail spur ran to the north of the Warehouse Building, three rail spurs ran to the southeast corner of the Warehouse Building, and the fifth rail spur extended to the southeast corner of the Upper Tank Yard.

Petroleum products were delivered to the Bulk Terminal Property via rail cars from the BNSF railroad, barges, and tankers, and stored in 14 bulk ASTs located in the Lower and Upper Tank Yards, formerly on the central and eastern portions of the Bulk Terminal Property. The 14 bulk ASTs were constructed between 1941 and 1944. The Lower Tank Yard contained six bulk ASTs, while the Upper Tank Yard contained eight bulk ASTs that were larger in volume. The approximate capacities of the bulk ASTs ranged from 5,225 to 23,000 blue barrels. A blue barrel is estimated to contain 42 gallons. The bulk ASTs and associated piping and support systems were decommissioned in 2006.

Distribution piping ran between the Bulk Terminal Property, East Waterfront Property, and BNSF railroad where petroleum products were pumped between ASTs, transport ships, and railroad tank cars. Fuel distribution lines connected the ASTs to a manifold system that connected to the Former Overhead Fuel Loading Racks and to the Pipeline Utilidor. Petroleum products were transported off the Bulk Terminal Property by pumping the fuel into tanker trucks through the Former Overhead Fuel Loading Racks or by fueling ships via the Pipeline Utilidor. In addition to the 14 bulk fuel ASTs on the Bulk Terminal Property, a Former PCP Mixing AST was located southeast of the Pump Shed; three USTs containing leaded and unleaded gasoline and diesel and two sets of fuel-dispensing pumps were located northeast of the Headquarters Office Building; two USTs were located at the north end of the Lower Tank Yard, with one UST containing ethanol and toluene and the second with unknown petroleum contents; and two USTs were located east of the Headquarters Office Building, both containing heating oil.

According to TOC employees, wood preservative was prepared near the west wall of the Lower Tank Yard by mixing PCP crystals into heated diesel fuel in the Former PCP Mixing AST located south of the Pump Shed for 3 to 4 months in 1967, as part of a military contract. The PCP mixture was transferred through underground pipelines to the New Barrel Shed located on the ASKO Hydraulic Property, where 5-gallon containers and 55-gallon drums were filled and loaded onto rail cars for shipment overseas. The duration of the PCP mixing operations at the Bulk Terminal Property is unknown. According to a letter dated July 11, 1967, an order for 55,250 five-gallon pails of wood preservative was to be shipped to Vietnam. The material would be made in a 270-gallon "storage vessel" and manufactured in one mix using the approximately 10,000-gallon Former PCP Mixing AST on the Bulk Terminal Property. The solvent known as B-6 used in the proposed mixing process may have been mineral spirits; however, based on the known fuel products stored at the Bulk Terminal Property, it is likely that TOC used diesel or stove oil to make the wood preservative.

A summary table, including reference sources and development description based on available current and historical information for the Bulk Property, is provided in the RI Report. Historical property features discussed below are also presented on Figure 4.

2.3 LAND USE HISTORY OF WEST COMMODORE WAY ROW

The West Commodore Way ROW was completed by 1912. West Commodore Way ROW runs from east to west and is located directly north of the Bulk Terminal Property. The West Commodore Way ROW consists of a concrete and asphalt roadway with gravel easement. The North Trunk Sewer, operated by the King County Wastewater Treatment Division, was constructed beneath West Commodore Way by the City of Seattle between 1909 and 1913. The tunneled portions of the North Trunk Sewer located within West Commodore Way were reportedly constructed as brick crown within a timber set and lagging tunnel. The North Trunk Sewer continues to the West Point Treatment Plant. The top of the North Trunk Sewer is at an approximate elevation of 8 to 20 feet above the North American Vertical Datum 1988. The diameter of the North Trunk Sewer section running beneath the West Commodore Way ROW is reportedly 144 inches (12 feet).

Sanitary sewer and stormwater lines servicing TOC Headquarters Office Building connect to the North Trunk Sewer beneath West Commodore Way. Additional utilities located within the West Commodore Way ROW that service the Bulk Terminal Property include a natural gas main beneath the south shoulder of West Commodore Way, which approaches from the west and terminates with a service connection to the ASKO Hydraulic Property. A water main located beneath the north shoulder of West Commodore Way supplies potable water to the Bulk Terminal Property. TOC records identified a tunnel beneath the West Commodore Way ROW in 1944 used to deliver drums from the Bulk Terminal Property to the East Waterfront Property. The Pipeline Utilidor was also identified running under the West Commodore Way ROW from the Bulk Terminal Property to the East Waterfront Property.

A summary table, including dates, reference sources, and development description based on available current and historical information, is provided in the RI Report. The East Waterfront Property is located northwest of the West Commodore Way ROW, and the Port of Seattle property is located northwest of the West Commodore Way ROW, relative to the Bulk Terminal Property. Additional information regarding the northwest- and northeast-adjoining properties is provided in the RI Report.

2.4 ENVIRONMENTAL SETTING AND REGULATORY CLASSIFICATIONS

A summary of the environmental setting, including topography, surface water, soils and geology, hydrogeology, and air, for the Bulk Terminal Property and vicinity is provided below. Further background and references of the environmental setting and regulatory classifications for the Bulk Terminal Property are provided in the RI Report.

2.4.1 Regional Topography

The Bulk Terminal Property lies within the Puget Trough or Lowland portion of the Pacific Border Physiographic Province. The Puget Lowland is a broad, low-lying region situated between the Cascade Range to the east and the Olympic Mountains and Willapa Hills to the west. In the north, the San Juan Islands form the division between the Puget Lowland and the Strait of Georgia in British Columbia. The province is characterized by roughly north to south-oriented valleys and ridges, with the ridges that locally form an upland plain at elevations of up to about 500 feet above sea level. The moderately to steeply sloped ridges are separated by swales, which are often occupied by wetlands, streams, and lakes. The physiographic nature of the Puget Lowland was prominently formed by the last retreat of the Vashon Stade of the Fraser Glaciation, which is estimated to have occurred between 14,000 and 18,000 years before present.

The Bulk Terminal Property is situated near the base of the northeast hillside of the Magnolia Bluff neighborhood within Seattle. The general topography of the upland surface slopes gently to the north from the north portion of the BNSF Parcel to the Bulk Terminal Property towards the shoreline of Salmon Bay. The upland surfaces of the Former Tank Yards were lower in elevation to accommodate the 14 ASTs and associated piping systems and control stormwater runoff for the former bulk fuel facility operations. The upland surface of the BNSF Parcel was cut to accommodate the main railroad lines. This resulted in two steep, vegetated slopes on the north and south sides of the main railroad lines. The elevation of the Bulk Terminal Property ranges from approximately 44 feet above mean sea level at the West Commodore Way ROW to 51 feet above mean sea level at the southwest of the Bulk Terminal Property.

2.4.2 Surface Water and Sediments

Salmon Bay is located approximately 110 feet north of the Bulk Terminal Property. Salmon Bay is a man-made marine waterway located between the Hiram M. Chittenden Locks, operated by U.S. Army Corps of Engineers, to the west and Lake Union to the east. The Hiram M. Chittenden Locks were constructed to move boats between the freshwater Lake Washington Ship Canal to the east and the saltwater Elliot Bay to the west. Upstream of the Hiram M. Chittenden Locks, a submarine barrier was constructed to minimize the mixing of fresh water and saltwater and to limit the movement of saltwater upstream.

2.4.2.1 Surface Water

Saltwater intrudes into Salmon Bay as a result of the operation of the Hiram M. Chittenden Locks, which connect the Lake Washington Ship Canal with Puget Sound. Depending on the levels of salinity present, sediments in certain areas may be classified as marine, low-salinity, or freshwater. It is unlikely that Salmon Bay would be used as a drinking water source because it is known to be mildly saline as a result of mixing with seawater at the Hiram M. Chittenden Locks.

Groundwater from Salmon Bay and the Lake Washington Ship Canal upland areas moves primarily laterally from topographically higher elevations towards the lower elevations adjacent where it discharges to these surface water bodies. Locally, variations in soil conditions and engineering of shallow soils may cause groundwater to flow for short distances in other directions; however, eventually the groundwater discharges to the main surface water bodies.

Stormwater runoff from the Former Tank Yards, the paved area between the Headquarters Office Building, and the Former Overhead Fuel Loading Racks is intercepted by a series of zipper drains that route stormwater to the system influent sump. Stormwater is pumped from the sump into the oil/water separator. The accumulated water within the oil/water separator drains by gravity to a transfer tank. Mechanical float switches control the fluid level in this transfer tank through the operation of a process pump that pumps water from the transfer tank through a series of bag filters before it is routed through two liquid-phase granular activated carbon (GAC) treatment vessels. The system is designed to operate with a pair of GAC units in series with a second pair of GAC units on standby if breakthrough occurs in the primary units. When the two GAC units in service become exhausted, they are taken off-line and the flow is routed through the clean standby units that are also operated in series. Effluent water from the GAC vessels discharges to the King County Metro Storm Sewer, and a data logger records flow rate and total cumulative flow data from the flowmeter located on the discharge line.

The majority of the Bulk Terminal Property is unpaved. Runoff from the building roof tops is captured in gutters and flows down spouts that discharge to the stormwater piping system or to the surface.

2.4.2.2 Sediments

General deposition processes for Salmon Bay include eroded soils and discharged outfall sediments from Salmon Bay and the Lake Washington Ship Canal upland areas and associated sediment transport from the Lake Washington Ship Canal. The rate of sediment deposition for Salmon Bay is unknown.

The ground surface at the Bulk Terminal Property is paved, covered with a thick layer of gravel, or densely vegetated. These control measures prevent the erosion of soil at the Bulk Terminal Property and minimize the potential migrations of sediments to Salmon Bay.

2.4.3 Soils and Geology

According to the Geologic Map of Northwestern Seattle, the surficial geology in the vicinity of the Bulk Terminal Property consists of deposits corresponding to the Vashon Stade of the Fraser Glaciation and pre-Fraser glacial and interglacial periods. In the immediate vicinity of the Bulk Terminal Property, surficial deposits consist of pre-Fraser Olympia beds and of modified land characterized as fill and/or graded natural deposits that obscure or alter the original deposit.

The youngest pre-Fraser deposits in the Seattle area, known as the Olympia beds, were deposited during the last interglacial period, approximately 18,000 to 70,000 years ago. The Olympia beds consist of very dense, fine to medium, clean to silty sands and intermittent gravel channel deposits, interbedded with hard silts and peat (Booth et al. 2005, Galster and Laprade 1991). Organic matter and localized iron-oxide horizons are common. The Olympia beds have known thicknesses of up to 80 feet. Beneath the Olympia beds are various older deposits of glacial and nonglacial origin. In general, deposits from older interglacial and glacial periods are similar to deposits from the most recent glacial cycle, due to similar topographic and climactic conditions (Booth et al. 2005).

The Vashon ice-contact deposits are located on the hillside above the Bulk Terminal Property and are generally discontinuous, highly variable in thickness and lateral extent, and consist of loose to very dense, intermixed glacial till and glacial outwash deposits. The till typically consists of sandy silts with gravel. The outwash consists of sands and gravels, with variable amounts of silt (Booth et al. 2005).

The Vashon advance outwash deposits are located on the hillside above the Bulk Terminal Property and are generally discontinuous and consist of loose to very dense, layered sands and gravels, which are generally well-sorted (poorly graded). Layers of silty sands and silts are less common. The Vashon recessional lacustrine deposits consist of layered silts and clays, which range in plasticity from low to high, and may contain localized intervals of sand or peat. The recessional lacustrine deposits may grade into recessional outwash deposits (Booth et al. 2005).

The undeveloped portions of the Bulk Terminal are either covered with grasses, small shrubs, or gravel. According to geologic cross sections in the 2003 BINMIC Report, Booth et al (2005), Galster and Laprade (1991), boring logs and cross sections in the Fort Lawton Parallel Tunnel Project, Geotechnical Report (Municipality of Metropolitan Seattle 1989), and subsurface investigations conducted at the Seattle Terminal Properties, the uppermost soil layer in the vicinity of the Seattle Terminal Properties and the West Commodore Way ROW typically consists of fine- to coarse-grained soils classified as the Holocene Fill (Hf) geologic unit. The Hf geologic unit ranges from approximately 5 to greater than 20 feet thick, and consists of very loose to very dense, highly variable engineered and non-engineered fill material. Underlying the Hf geologic unit is the Holocene Depression Fillings (Hdf) geologic unit that consists of very soft to medium stiff, fine-grained sand, silt, and clay, with scattered organic particles and very soft peat deposits. The Hf and Hdf geologic units are not shown on the BINMIC geologic cross section B-B', which shows the Seattle Terminal Properties and the West Commodore Way ROW underlain by an approximate 35-foot thickness of "Unknown Outwash" that overlies clay or glaciolacustrine deposits; however, based on boring logs from the vicinity of the Seattle Terminal Properties, the "unknown Outwash" could be interpreted as the Hf and Hdf geologic units. Underlying the Hf and Hdf geologic units are the pre-Fraser age glacial deposits (Qpf). The Qpf geologic unit consists of dense to hard, interbedded sand, gravel, and silt. These deposits can be further subdivided into fine- (Qpff) and coarse-grained (Qpfc) deposits.

2.4.4 Hydrogeology

The glacial and nonglacial deposits beneath the Seattle area comprise the unconsolidated Puget Sound aquifer system, which can extend from ground surface to depths of more than 3,000 feet. Coarse-grained units within this sequence generally function as aquifers, and alternate at some scale with fine-grained units which function as aquitards (Vaccaro et al. 1998). Above local or regional water table aquifers, discontinuous perched groundwater may be present in coarse-grained intervals seated above fine-grained intervals. Below the regional water table, the alternating pattern of coarse- and fine-grained units results in a series of confined aquifers. Regional groundwater flow is generally from topographic highs toward major surface water bodies, such as Puget Sound, Lake Union, Lake Washington Ship Canal, and Salmon Bay. Vertical hydraulic gradients are typically upward near the major surface water bodies, and downward inland. Regional groundwater flow typically discharges to the closest major surface water body. Salmon Bay is located north of the Bulk Terminal Property.

Seasonal perched water is observed from approximately 5 to 8 feet below ground surface (bgs) in soils that consist of poorly-graded silty sand. Discontinuous thin layers of fine-grained soils, including silt and clay, that are less permeable separate the perched water from a site-wide underlying shallow water-bearing zone. A shallow water-bearing zone was observed from approximately 8 to 23 feet bgs in soils that consist of poorly-graded sand and silty sand. The shallow water-bearing zone is underlain by two semiconfined to confined water-bearing zones with characteristics similar to soils within the shallow water-bearing zone. The intermediate water-bearing zone is located from approximately 26 to 40 feet bgs. The two water-bearing zones are separated by silt and clay with silty sand layers that act as regional confining units that partially confine or confine the groundwater stored within the shallow and intermediate water-bearing zones. A third water-bearing zone identified as the deep water-bearing zone was observed at the ASKO Hydraulic Property located hydraulically crossgradient of the Bulk Terminal Property. The deep water-bearing zone is located from approximately 52 to 62 feet bgs at the ASKO Hydraulic Property. The general groundwater flow direction for the shallow water-bearing zone is to the northwest-north (Figure 5).

According to the BINMIC Hydrogeologic and Environmental Settings Report, three water supply wells were located in the BINMIC area. Two of the wells are located north of Salmon Bay and the Bulk Terminal Property, and the third was reportedly located 0.85 miles southeast of the Bulk Terminal Property. The wells were reportedly all used for industrial or commercial purposes and are thought to be abandoned.

Seattle Public Utilities provides the potable water supply to Seattle. Seattle Public Utilities' main source of water is derived from surface water reservoirs located within the Cedar and South Fork Tolt River watersheds. According to King County's Interactive Map for the County's Groundwater Program, there are no designated aquifer recharge or wellhead protection areas within several miles of the Bulk Terminal Property.

2.4.5 Air

Climate in the Seattle area is generally mild and experiences moderate seasonal fluctuations in temperature. Average temperatures range from the 60s in the summer to the 40s in the winter. The warmest month of the year is August, which has an average maximum temperature of 74.9 degrees Fahrenheit (°F), while the coldest month of the year is January, which has an average minimum temperature of 36.0 °F. The annual average rainfall in the Seattle area is 38.25 inches, with December as the wettest month of the year, when the area receives an average rainfall total of 6.06 inches. The prevailing wind direction in the Seattle area is from the south in winter and spring, from the northwest in the summer and early fall, and from the south-southeast in the fall and early winter.

The main underlying sources for ambient air pollutants in Seattle are motor vehicle traffic and residential wood burning. Airborne pollutants can reach the terrestrial surfaces and sediment directly, through the deposition of airborne chemicals, primarily in the form of particulate matter onto the water surface, and indirectly through the deposition of particulate matter on terrestrial surfaces from which they are conveyed via surface water runoff and stormwater to water bodies.

3.0 SUMMARY OF THE CONCEPTUAL SITE MODEL

A CSM identifies confirmed and suspected source areas of hazardous substances, primary release mechanisms for COPCs, affected media, transport mechanisms, fate of hazardous substances in the environment, environmental media of potential concern, and exposure pathways for potential receptors. The CSM is the basis for developing technically feasible cleanup action alternatives from which a final cleanup action approach is selected. A CSM may be refined when additional information becomes available during the implementation of the FS and the cleanup action. A schematic drawing showing the CSM based on the preliminary exposure assessment for the Site is presented in Figure 6. Preliminary exposure assessment for the Site is presented on Figure 7. This section summarizes the CSM developed for the Site based on completion of the RI conducted by SoundEarth and others. A summary of the confirmed and suspected source areas, affected media, contaminant fate and transport and the preliminary exposure assessment is presented below. A detailed summary of these technical components of the CSM is provided in the RI report.

3.1 CONFIRMED AND SUSPECTED SOURCE AREAS

A source area is the location of a release of a hazardous substance (i.e., PCP and TPH) that has affected soil, surface water, groundwater, and/or air quality at the Site. The historical distribution infrastructure and mechanical systems used for facility operations and processes, and unknown releases, including spills and leaks, are identified as confirmed and suspected sources of releases of hazardous substances. The confirmed and suspected areas are listed below:

- Former Rail Spurs
- Former underground distribution pipelines
- Former 14 ASTs located in the area of the Upper and Lower Tank Yards
- Former PCP Mixing AST
- Former stormwater influent sump area
- Former open trench area
- Former manifold pit
- Former pump shed area
- Former underground storage tanks
- Former pump island
- Former Pipeline Utilidor
- Former Barrel Inclines
- Former Barreling Sheds

Confirmed and suspected source areas for the Site are located in the vicinity of the historical distribution infrastructure and mechanical systems, and where the highest concentrations of COPCs are present at the Site (Figure 4).

Based on the results of the RI, the primary COPC at the Site is TPH and associated volatile petroleum compounds (BTEX) and PCP (groundwater only). Concentrations of secondary COPCs are encompassed by the larger TPH plumes that define the Site (Figure 3). Secondary COPCs identified for the Site include the following:

- Lead in soil.
- PAHs in soil.
- Naphthalene, 1-methyl-naphthalene, and 2-methyl-naphthalene in soil.

3.2 AFFECTED ENVIRONMENTAL MEDIA

The affected environmental media consists of soil and groundwater with COPCs that were detected at concentrations exceeding their respective preliminary cleanup levels. Soil vapor and outdoor air has been retained as a medium of potential concern based on concentrations of TPH in soil and groundwater. The cleanup of the affected soil and groundwater is expected to result in the elimination of soil vapor and outdoor air as a future medium of concern for the Site.

3.3 CONTAMINANT FATE AND TRANSPORT

Fate and transport of COPCs in affected environmental media are dependent on the physical and chemical properties of the COPC and the geochemical and hydraulic properties of the subsurface environment. Contaminants may exist in four phases in a subsurface environment from a release of a hazardous substance. The four phases include: free-phase (nonaqueous-phase liquid [NAPL]), sorbed-phase (adsorbed to organics or clay soil particles), aqueous-phase (dissolved in water) and gaseous-phase (volatilization from soil or water to air). Commonly, contaminants exist in multiple phases with some degree of partitioning between phases. The contaminant phase depends not only on the properties of the COPC and the site-specific geological properties, but also on the magnitude and extent of release. The physical and chemical properties that control the fate and transport of COPCs include specific gravity, solubility, vapor pressure, Henry's Law constant, and the octanol-water partition coefficient.

The primary indicator hazardous substances for the affected environmental media at the Site include TPH and PCP. TPH is a primary indicator hazardous substance based on historical facility operations and processes to distribute TPH and because it is pervasive throughout the affected environmental media (soil and groundwater) at the Site. PCP is a primary indicator hazardous substance based on historical facility operations and processes associated with production of wood preservative. Therefore, TPH and PCP will be the focus of the discussion of contaminant fate and transport for the Site. The chemical-specific fate and transport of the primary COPCs at the Bulk Terminal Property are discussed below.

3.3.1 Total Petroleum Hydrocarbons and Volatile Petroleum Compounds

In general, petroleum hydrocarbons with lower carbon numbers (e.g., gasoline-range petroleum hydrocarbon [GRPH] and BTEX) are more soluble, and have lower log K_{ow} values and higher vapor pressures than petroleum hydrocarbons with higher carbon numbers (e.g., diesel-range petroleum hydrocarbon [DRPH] and oil-range petroleum hydrocarbon [ORPH]). Therefore, GRPH and BTEX are more mobile, have less affinity to sorb to soil organic matter, are more likely to exist in vapor form, and are more easily biodegraded than heavy fuel fraction. For example, benzene is moderately water soluble (1,770 milligrams per liter [mg/L]), tends to rapidly volatilize from water (H = 5.48 x 10^{-3}), is quite hydrophobic and will sorb to soil (log K_{ow} = 2.05). Dodecane (a 12 carbon compound in DRPH) is nearly insoluble in water (S= 0.008 mg/L), may volatilize from water (H=24.2), but not as free-phase (P_v=0.3 mm Hg), and will strongly sorb to soil (log K_{ow}=6.44).

Biodegradation of TPH in groundwater is dependent on the oxidation-reduction conditions of the groundwater, which is a function of the presence or absence of electron acceptors that support biologically mediated degradation. Biologically mediated oxidation of TPH occurs most effectively under aerobic conditions. Aerobic metabolism occurs when microorganisms transfer electrons from the electron donor (TPH) to an electron acceptor (O_2) in order to gain energy. O_2 is the most energetically favored electron acceptor followed by nitrate (NO_3^-), manganese or ferric oxides (MnO_2), sulfate (SO_4^{2-}) and carbon dioxide (CO_2, methanogenesis). Aerobic metabolism tends to be the quickest form of biodegradation of TPH. Biodegradation occurs when the contaminants are in the dissolved-phase in groundwater or in the capillary fringe. TPH biodegrades at faster rates under aerobic conditions, which are typically found at dissolved-phase plume boundaries. Aerobic biodegradation occurs first in the source area, depleting oxygen levels and creating a predominantly anaerobic environment.

The results from this RI indicate the presence of DRPH, ORPH, GRPH, and BTEX at concentrations that exceed the preliminary cleanup levels in soil beneath the Site (Figures 8 through 12). The RI conducted by SoundEarth and historical investigations conducted by others at the Site have demonstrated the following:

- The highest concentration of DRPH remaining in soil was detected at a concentration of 33,900 milligrams per kilogram (mg/kg) in 01SB08 approximately 12.5 feet bgs beneath the Former Overhead Fuel Loading Racks and near the Pipeline Utilidor (Figures 13A and 13B). Concentrations of DRPH in soil are present at approximately 0.5 to 25 feet bgs across the Site in the vicinity of source areas.
- The highest concentration of ORPH remaining in soil was detected at a concentration of 7,730 mg/kg in SB-31 approximately 2 feet bgs near the former barrel incline on the ASKO Hydraulic Property (Figures 13A and 13B). Concentrations of ORPH in soil are present at approximately 1 to 2 feet bgs across the Site in the vicinity of source areas.
- The highest concentration of GRPH remaining in soil was detected at a concentration of 755,000 mg/kg in 01SB09 approximately 12.5 feet bgs beneath the former pump island (Figures 14A and 14B). Concentrations of GRPH in soil are present at approximately 1 to 20 feet bgs across the Site in the vicinity of source areas. The GRPH concentration of 755,000 mg/kg indicates LNAPL was present in the soil sample.
- The highest concentration of benzene remaining in soil was detected at a concentration of 5,590 mg/kg in 01SB09 approximately 12.5 feet bgs beneath the former pump island (Figures 14A and 14B). Concentrations of benzene in soil are present at approximately 0.5 to 20 feet bgs across the Site in the vicinity of source areas.
- The lateral extent of TPH as LNAPL covers an area of approximately 21,500 square feet in the Bulk Terminal Property and associated West Commodore Way ROW

(Figure 15). The maximum thickness of LNAPL measured in a monitoring well was 5.27 feet in well 01MW10 during the Second Quarter 2011 monitoring event (Table 7 of the RI Report).

- The highest concentrations of TPH and/or BTEX in groundwater are present in the shallow water-bearing zone near the former underground distribution pipelines, former ASTs and USTs, former manifold pit, former loading racks, and former pipeline utilidor (Figure 16).

The principal fate and transport mechanisms for TPH and BTEX in affected environmental media are summarized below:

- The lateral distribution of concentrations of TPH and BTEX in soil is a result of transport via adsorption of the soil matrix and direct contact of LNAPL.
- Surface erosion may transport contaminated soil to surface water. The direct contact of contaminated soil with surface water and groundwater may result in soil to water partitioning via leaching.
- The lateral distribution of concentrations of TPH and BTEX in groundwater is a result of direct contact with historical releases of LNAPL and associated LNAPL to water partitioning, and leaching of adsorbed-phase petroleum-contaminated soil via soil-to-water partitioning, and the natural attenuation processes, such as advection/dispersion, diffusion, sorption, and biodegradation.
- Natural mechanisms, including temperature, groundwater, and barometric pressure fluctuations, may result in the volatilization of TPH and BTEX in soil and groundwater to soil vapor via soil and/or groundwater to air partitioning. Soil vapor with concentrations of TPH and BTEX may transport to the surface with barometric pressure fluctuations.

3.3.2 Pentachlorophenol

The environmental fate for PCP in groundwater is similar to that of TPH, but is limited by the low water solubility of PCP. PCP has a high log K_{ow} and tends to sorb to soil. Once sorbed, PCP is unavailable for biodegradation. The low water solubility (S=14 mg/L) and moderate vapor pressure (1.4×10^{-4} millimeters mercury @ 20 °C) yield a low Henry's Law constant of 3.4×10^{-6} which indicates that PCP volatilizes very slowly. A log K_{ow} of 4.41 suggests PCP by itself is relatively immobile in the subsurface environment.

Environmental pH is an important parameter affecting the adsorption and mobility of chlorinated phenols. PCP sorption to clay has been observed to decrease with increasing pH.

PCP is a highly oxidized compound that can be biodegraded aerobically and anaerobically through pathways that include methylation, acylation, dechlorination and hydroxylation. In addition, the PCP has been observed to degrade via a reductive dechlorination pathway under anaerobic conditions. During reductive dechlorination, bacteria gain energy by transferring electrons from an electron donor (H_2) to an electron acceptor (PCP). The chlorine atoms of PCP are sequentially replaced with hydrogen atoms.

The RI conducted by SoundEarth and historical investigations conducted by others at the Site have demonstrated the following:

- The interim actions performed at the Bulk Terminal Property have removed PCP contaminated soil at the Site (Figures 17A through 17C).
- The highest concentration of PCP remaining in shallow groundwater after the 2012 interim remedial action was detected at a concentration of 2.1 micrograms per liter in well M5IW01 in January 2013 (Figure 18). Additional detections of PCP in groundwater above the MTCA Method B cleanup level after October 2012 were observed in wells 01MW69, 01MW74, A6IW01, and LWIW01. Detections of PCP in groundwater remain largely downgradient of the PCP mixing area and/or near the associated interim remedial action excavation area described in Section 4.3.4 of the RI Report.

The principal fate and transport mechanisms for PCP in affected environmental media are summarized below:

- The lateral distribution of concentrations of PCP in soil is a result of transport via adsorption of the soil matrix. No residual contamination (adsorbed-phase PCP contamination on soil particles) remains at the Site based on the results from the 2012 interim action.
- The low volatility of PCP precludes it from being present in the vapor phase (in soil vapor).
- The remaining transport mechanism is the aqueous phase (contaminants dissolved in groundwater). Subsurface contamination by PCP is controlled by the natural attenuation processes, such as advection/dispersion, diffusion, and biodegradation.

3.4 PRELIMINARY EXPOSURE ASSESSMENT

The preliminary exposure assessment identifies potential receptors for exposure pathways for environmental media of potential concern from contaminant fate and transport mechanisms. Potential receptors at risk from exposure associated with the presence of COPCs at the Site are human and ecological receptors. The two potential receptors were segregated into subcategories to better identify the potential receptors at risk of exposure from the presence of COPCs in environmental media of potential concern. The subcategories for human health include workers, recreational use, drinking water consumption, and fish and shellfish consumption; the subcategories for ecological include terrestrial and aquatic biota.

The objective of the preliminary exposure assessment is to assess the completeness of exposure pathways from environmental media of potential concern and associated contaminant fate and transport mechanisms for the potential receptors for the Site. The results from the preliminary exposure assessment will assist with the evaluation of potential feasible cleanup alternatives that are protective of the potential receptors identified as complete. The preliminary exposure assessment for the Site is illustrated in a flow diagram (Figure 7). The preliminary exposure assessment for each exposure pathway and associated environmental media of potential concern is summarized below by affected environmental media.

3.4.1 Soil

Soil with concentrations of COPCs above the preliminary cleanup levels may present a potential exposure pathway to human and/or ecological receptors. The principal contaminant fate and transport mechanisms for soil at the Site include sorption, volatilization, erosion, leaching, partitioning, advection, dispersion, and diffusion, biodegradation (Figure 7). Leaching of TPH and BTEX from soil by dissolution and desorption to groundwater is discussed below. The exposure pathway for soil at the Site includes direct contact with soil, volatilization to soil vapor/outdoor air, soil erosion and soil leaching to surface water, soil leaching to groundwater, and LNAPL associated with soil partitioning to groundwater. The human consumption of drinking water is not an applicable potential receptor for the exposure pathway for soil at the Site. The potential exposure pathways for soil are discussed in the sections below.

3.4.1.1 Direct Contact (Dermal Contact and Ingestion) with Subsurface Adsorbed-Phase Contaminated Soil

This exposure pathway is complete for subsurface soil via dermal contact or ingestion for COPCs at the Site. The standard point of compliance for the direct contact exposure pathway for soil is 15 feet bgs for human health and 6 feet bgs for terrestrial receptors. A depth of 15 feet bgs is a reasonable depth that could be excavated during normal redevelopment activities and distributed at the ground surface (WAC 173-340-[6][d] and WAC 173-340-7490[4][b]). COPCs above the preliminary cleanup levels are present in shallow subsurface soil within 6 feet bgs at the Site in areas that are unpaved. Although the unpaved areas are surrounded by a permanent fence and covered with 6 inches of quarry spall, which has minimized the exposure risk for workers, additional controls to mitigate the potential exposure pathway will be required. Most terrestrial receptors are not at risk for direct contact of surface soil due to quarry spall ground cover; however, the direct contact pathway for subsurface soil is complete for terrestrial receptors such as burrowing mammals.

3.4.1.2 Inhalation of Soil Vapor/Outdoor Air

This exposure pathway is considered complete for worker and terrestrial receptors by potential inhalation of volatile COPCs originating in the vadose zone and ambient air. The air-filled pore space between soil grains in the unsaturated zone, or partially saturated zone, is referred to as soil gas or soil vapor. Low molecular weight aromatic and aliphatic TPH fractions are highly volatile due to their relative low vapor pressures. The volatilization of TPH fractions from LNAPL, and adsorbed-phase contaminated soil can accumulate the concentrations of TPH in soil vapor and migrate to the surface to locally impact outdoor air quality near the unpaved surfaces. Once in the atmosphere, the vapors are unlikely to result in an exposure pathway to the general public due to the vapors being dispersed and/or degraded.

3.4.1.3 Direct Contact with Surface Water

Surface water (stormwater) that comes in contact with TPH in near-surface soil located below the quarry spall cover in unpaved areas at the Site are potentially susceptible to leaching/partitioning via dissolution and desorption. The exposure pathway could be complete for workers and terrestrial receptors for TPH in surface water runoff. The interim remedial actions completed in 2011 and 2012 to remediate sources of PCP resulted in removing near-surface soil with concentrations of PCP from the Site and the potential exposure pathway of soil leaching to surface water. Therefore, this exposure pathway is incomplete for PCP.

3.4.2 Groundwater

Groundwater has been affected by historical releases of COPCs to the surface and subsurface and the leaching of LNAPL directly into the shallow water-bearing zone and the leaching of TPH and PCP into infiltrating surface water that passes through unsaturated adsorbed-phase soil and migrates to groundwater. Groundwater with concentrations of TPH and PCP above the preliminary cleanup levels may present a potential risk to human and/or ecological receptors. The primary contaminant fate and transport mechanism for groundwater at the Site include leaching via dissolution and desorption, advection/dispersion, diffusion, and volatilization (Figure 7). Other contaminant fate and transport processes, such as biodegradation and oxidation or reduction, are expected to have minor to no influences in reducing potential exposures of COPCs to receptors without active source treatment. The biodegradation and oxidation or reduction processes appear to be occurring at a naturally slow rate to significantly contribute to the fate and transport processes of COPCs for the Site. The potential exposure pathways for groundwater are discussed below.

3.4.2.1 Direct Contact with Dissolved-Phase Contaminated Surface Water

This exposure pathway is considered incomplete for human and ecological receptors. The discharge of dissolved-phase TPH and PCP from groundwater hydraulically connected to Salmon Bay is unlikely based on empirical evidence from performance groundwater sampling that show concentrations of COPCs are below the preliminary cleanup levels at monitoring wells located on the northern side of the West Commodore Way ROW.

3.4.2.2 Direct Contact with Dissolved-Phase Contaminated Shallow Water-Bearing Zone

This exposure pathway is considered complete for workers and could be complete for drinking water for TPH and PCP based on results from performance groundwater sampling that indicate detectable concentrations of TPH and PCP exceeding the preliminary cleanup levels are present in the shallow water-bearing zone. Workers may come into direct contact with the shallow groundwater at the Site during environmental or development work. It is unlikely that water beneath the Site would be used for drinking water because of the availability of municipal water supplies and land use of the Site; however, there is potential that future land use could allow for use of groundwater beneath the Site for drinking water. The exposure pathway is incomplete for human recreational users, fish and shellfish consumption, terrestrial organisms, and aquatic biota because these receptors do not have contact with groundwater.

3.4.2.3 Direct Contact with Dissolved-Phase Contaminated Intermediate Water-Bearing Zone

This exposure pathway could be complete for workers and drinking water for COPCs; however, these potential receptors are unlikely. The COPCs released to the subsurface typically adsorbed to unsaturated soil with high total organic carbon content located within the vadose zone and/or migrate laterally when dissolved in groundwater. The vertical migration of COPCs from the shallow water-bearing zone through the semiconfining to confining silt and clay layer that separates the shallow and intermediate water-bearing zones is unlikely based on the chemical properties of the COPCs, such as specific gravity. Workers could come into direct contact with the intermediate water-bearing zone during environmental or development work. It is unlikely that water beneath the Site would be used for drinking water because of the availability of municipal water supplies and land use of the Site; however, there is potential that future land use could allow for use of groundwater beneath the Site for drinking water. The exposure pathway is incomplete for human recreational users, fish and shellfish consumption, terrestrial organisms, and aquatic biota because these receptors do not have contact with groundwater.

3.4.2.4 Inhalation of Vapors from the Dissolved-Phase Contamination in the Shallow Water-Bearing Zone

This exposure pathway is considered complete for workers and could be complete for drinking water consumption because light-range TPH fractions are readily volatile. PCP has low volatility, so this exposure pathway is incomplete for PCP. It is unlikely that water beneath the Site would be used for drinking water because of the availability of municipal water supplies and land use of the Site; however, there is potential that future land use could allow for use of groundwater beneath the Site for drinking water. The exposure pathway is incomplete for recreational users, fish and shellfish consumption, terrestrial organisms, and aquatic biota because these receptors do not have contact with groundwater.

3.4.2.5 Inhalation of Vapors from the Dissolved-Phase Contamination in the Intermediate Water-Bearing Zone

This exposure pathway could be complete for workers and drinking water, but the potential receptor is unlikely. It is unlikely that water beneath the Site would be used for drinking water because of the availability of municipal water supplies and land use of the Site; however, there is potential that future land use could allow for use of groundwater beneath the Site for drinking water. The exposure pathway is incomplete for recreational users, fish and shellfish consumption, terrestrial organisms, and aquatic biota because these receptors do not have contact with groundwater.

3.4.2.6 Inhalation of Soil Vapor/Outdoor Air

The fate and transport mechanism for this exposure pathway is volatilization of COPCs in groundwater to the vadose zone and outdoor air with subsequent inhalation by potential receptors. This exposure pathway is considered complete for workers and terrestrial receptors. The exposure pathway is incomplete for recreational use because the unpaved portions of the Site cannot be accessed by the general public. The exposure pathway is considered incomplete for fish and shellfish and drinking water consumption and for aquatic biota.

4.0 FIELD PILOT TESTS AND TREATABILITY STUDIES

This section summarizes field pilot tests and treatability studies performed to evaluate the effectiveness of potential remedial components presented in Table 2 and to obtain preliminary design information to develop and evaluate cleanup action alternatives for the Site. The tests and studies were performed at Bulk Terminal Property or the west-adjacent ASKO Hydraulic Property, where the test and study results are relevant to the evaluation and design of candidate remedial components for the Bulk Terminal Property. The tests and studies performed included the following:

- Aquifer testing to obtain subsurface soil physical and hydraulic properties. The soil properties were used to support the contaminant fate and transport analysis and the development of the CSM discussed above, and to evaluate the feasibility of in situ remedial components for perched water and shallow water-bearing zone.

- Soil vapor extraction (SVE) pilot test at the ASKO Hydraulic Property to assess the potential effectiveness of SVE technology to remediate unsaturated soil with concentrations of volatile COPCs.

The following sections summarize the field pilot tests and treatability studies including a description of the testing procedures and methods and a summary of results.

4.1 AQUIFER TESTING

Aquifer testing was conducted at the Seattle Terminal Properties including the Bulk Terminal Property between 2009 and 2011 to estimate the hydraulic characteristics of shallow water-bearing zone and the underlying semiconfining to confining layer comprised of silt and clay. The aquifer testing at the Seattle Terminal Properties included slug and pump testing, and laboratory analysis for soil physical properties and organic carbon data. The hydraulic parameters obtained from these tests were used for contaminant fate and transport analysis and development of the CSM. Summary tables and charts of data collected and analyzed and figures from the aquifer testing are provided in Appendix A.

4.1.1 Slug Tests

In March 2009, SoundEarth conducted slug tests in monitoring wells 01MW03, 01MW21, 01MW38, 01MW40, and 01MW59 to estimate the hydraulic conductivity of the shallow water-bearing zone encountered beneath the Bulk Terminal Property. Slug tests were also conducted on an additional five monitoring wells installed at the ASKO Hydraulic Property or the East Waterfront property.

The slug used for testing was constructed from a piece of PVC pipe filled with clean sand to displace a known volume within the water column. Water levels were monitored during the slug tests using AquiStar PT2X vented pressure transducers that incorporate automatic logging of water level data using AquiStar Aqua4Plus software. The pressure transducer was programmed to record readings at intervals ranging from 1 second to 1 minute during the slug tests. An electronic water level indicator was also used to obtain periodic manual water level measurements during the slug tests.

The test wells were opened and allowed to equilibrate with the atmosphere for at least 30 minutes prior to conducting each test. The pressure transducer was placed at a depth of at least 2 feet below the targeted submergence depth of the slug. Water levels were monitored after placing the pressure transducer in the monitoring well to confirm that the water level had stabilized before inserting the slug. To start the slug test, the slug was lowered into the well until it was fully submerged. Following the introduction of the slug, water levels were allowed to equilibrate. After equilibration was reached, the slug was quickly removed from the monitoring well to test the rising head, and water levels were allowed to re-equilibrate.

Following field testing, the water level data were downloaded from the pressure transducers, compiled, and processed for analysis. Data processing included selecting the time interval of interest, reducing the measurement frequency where appropriate, and converting the water levels to displacements (change versus the initial water level). Time series files of the recorded displacements for each test were then exported to AquiferWin32 (Environmental Solutions, Inc.) for analysis.

The data were analyzed by the Bouwer and Rice (1976) method, using the procedures described by Bouwer (1989), which pertain to wells screened across the water table. Assumptions of the Bouwer and Rice method include the following (Todd and Mays 2005, Bouwer 1989):

- The aquifer is unconfined and has an apparently infinite areal extent.
- The aquifer is homogeneous, isotropic, and of uniform thickness over the area influenced by the slug test.
- Prior to the test, the water table is (nearly) horizontal over the area that will be influence by the test.
- The head in the well is lowered instantaneously at time zero, the drawdown in the water table around the well is negligible, there is no flow above the water table.
- The inertia of the water column in the well and the linear and non-linear well losses are negligible.
- The well either partially or fully penetrates the saturated thickness of the aquifer.
- The flow to the well is in steady state.
- Because the water table in the aquifer is kept constant and is taken as a plane source of water, the Bouwer and Rice method can also be used for a leaky aquifer, provided that its lower boundary is an aquiclude and its upper boundary an aquitard.

The results from the slug tests indicated the following:

- The estimated hydraulic conductivity of the shallow water-bearing zone ranged from a low of 0.085 feet per day (ft/day) in monitoring well 01MW21 to a high of 5.1 ft/day in monitoring well 01MW38.
- The arithmetic mean hydraulic conductivity from the slug tests was 1.5 ft/day.

4.1.2 <u>Pump Tests</u>

Two pump tests were conducted by SoundEarth on August 16 and September 1, 2011, to estimate the hydraulic conductivity in the shallow water-bearing zone near the top of the water table beneath the Bulk Terminal Property. The pump tests were designed as low-flow pumping tests for the purpose of minimizing water level drawdowns and vertical migration of the LNAPL present on the water table. Existing injection, recovery, and monitoring wells completed in the shallow water-bearing zone were used as pumping and observation wells for the tests.

A pneumatic pump (positive air displacement pumps) was used to extract water from the pump wells during the tests. The pneumatic pumps were operated using 35-second cycles (5 seconds of compressed air, followed by 30 seconds of re-filling) during the low-flow pumping tests. This timing was sufficient to maintain the water level at the level of the pump intake, which was set at approximately 1.5 feet below the initial static water level.

Pressure transducers were used to measure water levels in the pumping and observation wells. Depths to water and, if present, LNAPL were also measured manually using oil/water interface probes. The August 16, 2011, pumping test utilized remediation well N7IW01 as the pumping well. Monitoring well 01MW21 and remediation wells IW03, IW05, and IW07 were used as observations wells during the pumping test. These observation wells are located at distances ranging from about 2 to 6 feet from pumping well N7IW01, as shown in Appendix A. The pumping test continued for a period of about 6 hours, with an average pumping rate of 0.20 gallons per minute (gpm).

Remediation well P8IW01 was utilized as the pumping well for the September 1, 2011, pumping test, and remediation wells O8IW011, P7IW01, P9IW01 and Q8IW01 were used as observation wells. The four observation wells are located at distances ranging from about 8 to 11 feet from pumping well P8IW01. Pumping continued at well P8IW01 for more than 24 hours, although continued operation of the pump affected the longer-term water level data as discussed below. Groundwater was extracted from well P8IW01 at an average rate of 0.41 gpm during the early portion of the pumping test.

Pressure transducer measurements were corrected for barometric effects. No corrections were required for LNAPL effects, since no changes in the LNAPL thicknesses (if present) in the monitoring wells were observed during the pumping tests.

A data summary table for each of the pump tests and each of the wells that were used in the analysis is included in Appendix A. The transmissivity and hydraulic conductivity values calculated for tests as well as graphical results with Neuman type curves and matches output from the AquiferWin32 program for each of the observation wells are included in Appendix A.

The resulting data were analyzed using the Neuman (Neuman 1972) method for unconfined aquifers. Pumping responses in unconfined aquifers are more complex than confined aquifers because the mechanisms releasing water from aquifer storage change over time. The delayed drainage of residual water above the water table provides an additional source of flow towards the pumping well. The Neuman method accounts for the delayed drainage in a water table aquifer. Assumptions of the Neuman method include the following (Neuman 1972):

- A confined aquifer is not dewatered during pumping and remains fully saturated.
- The water produced by a well in a confined aquifer comes from the expansion of the water in the aquifer due to a reduction of the water pressure, and from the compaction of the aquifer due to increased effective stresses.
- The flow towards the well in a confined aquifer is and remains horizontal and there are no vertical flow components in the aquifer.
- The aquifer is isotropic or anisotropic.
- The flow to the well is in an unsteady state.
- The influence of the unsaturated zone upon the drawdown in the aquifer is negligible.
- The volume of water released from storage per unit surface area per unit decline of the water table divided by the volume of water instantaneously released from storage per unit surface area per unit decline in head is greater than 10.
- An observation well screened over its entire length penetrates the full thickness of the aquifer.
- The diameters of the pumped and observation wells are small, i.e., storage in them can be neglected.

The results from the pump tests indicated the following:

- The estimated hydraulic conductivity from the pump test performed on August 16, 2011, ranged from approximately 0.12 to 0.75 ft/day. The arithmetic mean was 0.42 ft/day.
- The estimated hydraulic conductivity from the pump test conducted on December 16, 2011, ranged from approximately 2.5 to 4.2 ft/day. The arithmetic mean was 3.3 ft/day.

4.1.3 Laboratory Analysis of Soil Physical Properties and Organic Carbon Data

Soil samples were collected from the shallow water-bearing zone and underlying confining layer in boring B199 for laboratory analysis of soil physical properties. The samples were collected during drilling activities for the RI using Dames and Moore samplers lined with 2-inch-long brass rings. The containers were placed in an iced cooler and transported for laboratory analysis to PTS Laboratories, Inc. of Santa Fe Springs, California, under standard chain-of-custody protocols. The samples were submitted for laboratory analysis of the following:

- Moisture content by American Petroleum Institute (API) Recommended Practice (RP) 40 and American Society for Testing and Materials International (ASTM) D2216.
- Bulk and grain density, total and air filled porosity, and total pore fluid saturation by API RP 40.
- Effective permeability to water and hydraulic conductivity by API RP 40 and U.S. Environmental Protection Agency (EPA) Method 9100.
- Total and effective porosity by Modified ASTM D425.
- Fraction organic carbon and total organic carbon by Walkley-Black.
- Particle size analysis by ASTM D422 and ASTM 4464.

Analytical results for the samples analyzed for soil physical properties indicated the following:

- Moisture content was measured at 21.0 percent by weight in the shallow water-bearing zone at 9.25 feet below ground surface and 22.1 percent by weight in the confining layer at 19.6 feet below ground surface.
- Dry bulk grain density and grain density were measured at 1.52 and 2.70 grams per cubic centimeter (g/cm^3) in the shallow water-bearing zone. Dry bulk grain density and grain density were measured at 1.44 and 2.68 g/cm^3 in the confining layer at the Bulk Terminal Property.
- The total porosity and air-filled porosity in B199 were measured at 43.5 and 11.5 percent bulk volume, respectively, in the shallow water-bearing zone at 9.25 feet below ground surface. The total porosity and air-filled porosity in B199 were measured at 46.3 and 14.6 percent bulk volume, respectively, in the confining layer at 19.6 feet bgs at the Bulk Terminal Property.
- Total pore fluid saturation was measured at 73.6 percent pore volume in the shallow water-bearing zone and 68.6 percent pore volume in the confining layer at the Bulk Terminal Property.

- Effective permeability to water was measured in the confining layer at 1.33 millidarcys.
- Effective porosity was measured at 24.3 by percent bulk volume for the soil samples collected from the shallow water-bearing zone.
- Hydraulic conductivity was measured at 1.87 x 10^{-4} centimeters per second (cm/sec) for sample B199-9-9.5 collected from the shallow water-bearing zone, which is consistent with values obtained from slug tests. Hydraulic conductivity was measured at 1.31 x 10^{-6} cm/sec for sample B199-19.5-20 collected from the confining layer below the shallow water-bearing zone.
- Total organic carbon in the shallow water-bearing zone at the Bulk Terminal Property was 920 mg/kg in B199.
- Fraction organic carbon was measured at 0,00092 grams per gram in the shallow water-bearing zone in B199.
- The particle size distributions are consistent with the visual estimates recorded in the boring logs (Appendix H of the RI report), which indicate fine to medium sand with total silt and clay contents ranging from approximately 15 to 55 percent in the shallow water-bearing zone and total silt and clay contents ranging from approximately 31 to 100 percent in the confining layer below the shallow water-bearing zone.
- The values for the soil physical properties correspond to the range of typical values for soils with similar particle size distributions and densities (Freeze and Cherry 1979).

4.1.4 Aquifer Testing Analysis

SoundEarth conducted aquifer testing in the shallow water-bearing zone to analyze contaminant fate and transport. Aquifer properties of water storage include porosity, specific yield, and storativity. Aquifer properties of water transmission include hydraulic conductivity, transmissivity, hydraulic gradient, and seepage velocity.

The effective porosity was measured at 24.3 by percent bulk volume for the soil sample B199-9-9.5 collected from the shallow water-bearing zone. The soil observed at this boring is representative from the shallow water-bearing zone. Specific yield was not calculated based on limitations associated with the testing methods. The storage coefficient geometric mean calculated from the pumping test ranged from 1.2 x 10^{-2} to 3.4 x 10^{-3}.

Hydraulic conductivity is the capacity to transmit water. The shallow aquifer hydraulic conductivity values calculated from the slug test, pump test, and laboratory testing for most of the locations are relatively consistent. Based on the studies, the hydraulic conductivity in the Bulk Terminal Property ranges from about 0.085 to 5.1 ft/day. The lower hydraulic conductivity values calculated from the slug test and aquifer pumping test correspond to the finer-grained soil characteristics observed in explorations completed in the vicinity of monitoring well 01MW21.

The hydraulic conductivity values analyzed by laboratory samples collected from the shallow water-bearing zone compare favorably to those obtained from the slug tests and the pumping tests. This range of hydraulic conductivity values correspond to the range of published values for similar silty sand materials (Coduto 1999). This supports a conceptualization of the aquifer as mostly homogenous at scales ranging from inches to feet. The values for the soil physical properties correspond to the range of typical values for soils with similar particle size distributions and densities (Freeze and Cherry 1979).

Transmissivity is a measure of the hydraulic conductivity through the saturated thickness of an aquifer. Based on the studies, the transmissivity in the Bulk Terminal Property ranges from about 8.7×10^{-5} to 2.6×10^{-4} square feet per second. These numbers were generated based on measured saturated thickness in wells N7IW01 and P8IW01 during pump testing which ranged from 9 to 13 feet thick. The calculated transmissivity was used to evaluate the estimated horizontal hydraulic conductivity which ranged from 0.12 to 4.3 feet per day. Given that transmissivity is a product of hydraulic conductivity and the range of hydraulic conductivity values correspond to the range of published values for similar silty sand materials, these numbers support soil types observed at the Bulk Terminal Property.

The average hydraulic gradient of the shallow water-bearing zone at the Seattle Terminal Properties is 0.07 feet per foot as presented in RI Report. Seepage velocity is calculated by multiplying hydraulic conductivity by the hydraulic gradient and dividing by the porosity. Based on the results of this aquifer testing analyses, estimated range of groundwater seepage velocity for the shallow water-bearing zone is 0.024 to 1.47 ft/day.

4.2 SVE PILOT TEST

SoundEarth conducted an SVE pilot test at the ASKO Hydraulic Property on February 23 and 24, 2010, to evaluate the potential effectiveness of SVE technology to remediate soil with concentrations of trichloroethylene (TCE) and volatile TPH, if present. The pilot test was performed on three test wells: 01SVE01, 01MW44, and 01MW63, using a skid-mounted SVE blower, knock-out tank, and control panel. The locations of the test wells and observation wells are shown in Appendix B. The SVE blower was utilized to apply vacuum to the test wells through a piping assembly equipped with an instrument train and a bleed-air assembly. The instrument train and bleed-air assemblies were equipped to measure vacuum, temperature, and flow rates. Observation wells, 01MW54, 01MW65, 01MW55, and 01MW15, were utilized during each test to measure vacuum at varying distances from the test wells.

Pilot test activities commenced on February 23, 2010, by collecting depth to groundwater measurements prior to applying vacuum to the test wells and to establish the baseline airflow for the blower. Tests were performed by incrementally increasing the vacuum applied to one test well at a time by closing the manual air dilution valve on the instrument train. Flow and vacuum could also be controlled at the discretion of the test operator by varying the speed of the blower motor using a variable frequency drive. The test commenced with the manual air dilution valve fully open resulting in the minimum vacuum applied to the test well. Subsequent vacuum step tests involved closing the air dilution valve incrementally and allowing the flow to stabilize prior to collecting test well and observation well measurements. Samples of recovered soil vapor were collected at the initiation and the end of the test from each of the three test wells and submitted for laboratory analysis for chlorinated volatile organic compounds by EPA Method 8260. Vapor samples were also analyzed on a real-time basis for BTEX using a field gas chromatograph and for TCE, vinyl chloride, and benzene with colorimetric detector tubes. Vapor samples were also measured at various time intervals during each test for explosive vapor concentrations (expressed as a per cent of the lower explosive limit [LEL]), oxygen, and carbon dioxide concentrations.

Summary figures and tables as well as raw test data and laboratory analytical reports for the SVE pilot tests are provided in Appendix B. The analysis of the SVE pilot test provided below describes air flow as a function of applied vacuum and includes an assessment of the zone of vacuum influence (ZOI) and critical radius. An estimated contaminant mass removal rate in the vapor phase from the Site 1 was determined from analytical results and flow rates collected during the pilot test.

4.2.1 Flow versus Vacuum

Results of the SVE pilot test indicate that the subsurface exhibits a wide range in air flow permeability among the test wells, which is illustrated in the plots of flow versus vacuum for each test well in Appendix B. The slopes for the flow versus vacuum plots in Appendix B illustrate the relationship between applied vacuum and air flow. The greater the slope of the linear regression lines for each data set, the greater the air flow permeability for the test well. The tests wells exhibiting the highest to lowest unit air yields; respectively, were Wells 01SVE01, 01MW63; and 01MW44. The unit air yields for these wells respectively were approximately 0.89, 0.45, and 0.087 standard cubic feet per minute per inch of water (scfm/iow) vacuum applied.

The flow data obtained by the flow-averaging pitot tube connected to each test well is questionable because the velocities measured were below the manufacturer's recommended minimum levels. An alternative flow estimate for each well involves subtracting the bleed air flow rates (which were within the manufacturer's recommended range) from the total air flow rates. The total air flow rates were determined as a function of blower speed prior to commencing the tests by producing a blower calibration curve.

4.2.2 Zone of Vacuum Influence

The vacuum responses measured in observation wells during the SVE pilot test are tabulated in Appendix B. Included with the vacuum data are the blower speeds at the time of the vacuum measurements, and the approximate horizontal distance of each observation well from the test well. Data did not follow the expected pattern. Typically, when measuring vacuum in an observation well a certain distance from a pumping well, a fairly uniform vacuum gradient is observed radially decreasing with distance from the pumping well. In these tests, there was no consistent decreasing vacuum gradient with distance and in several wells a positive pressure was measured at the observation well while the test well was subjected to vacuum. Observing positive pressure in an observation well during an SVE test is not uncommon. This phenomenon, known as barometric pumping, may produce a positive pressure in an observation well caused by natural diurnal changes in barometric pressure. In addition, in the case where an observation well and a test well are screened over different depth intervals, there may not be a discernible vacuum in the observation well even though the two wells are in close proximity due to a flow boundary between the two wells.

One should not conclude from these observations that the unsaturated zone exhibits low relative air flow permeability, or that SVE is not an appropriate technology for remediating the unsaturated zone. It would be appropriate to conclude that there are subsurface heterogeneities within the test area that produce non-uniform pressure distributions and therefore non-uniform air flow when vacuum is applied to the subsurface.

These findings also illustrate a common problem of overestimating the ZOI of an extraction well using pressure gradients as the basis for establishing the ZOI for SVE design. Using pressure gradients as a basis for design often results in large areas with very low pore velocities and, therefore, long cleanup times. As a result, a design approach based on critical pore gas velocity (CPGV) has increased in popularity and acceptance (EPA 2001, USACE 2002). The CPGV is used to incorporate the effects of mass transfer limitations into SVE design based on the distinction between "mobile" and "immobile" zones. As described in USACE (2002), soils are often divided into two categories for remediation: low permeability and high permeability, relative to each other. Early models of pump-and-treat referred to the relatively low permeability soil as "immobile" since the water in the soil was practically stagnant. The higher permeability soil is named "mobile" since the majority of flow occurs in these soils. In the vadose zone, the mobile soils are the most permeable and appreciable air flow through these soils is induced when a pressure gradient is applied (e.g., extraction in a well). Immobile soils have relatively low permeability, and air flow through these soils during the application of a pressure gradient is considered negligible. Contaminant transport in immobile soils is dominated by diffusion in the vapor phase or liquid advection and diffusion if moisture contents are high.

USACE (2002) recommends a minimum CPGV between 0.01 and 0.001 centimeters per second (which is equivalent to 0.02 to 0.002 feet per minute [ft/min]) to address mass transfer limitations between immobile and mobile zones in the soil matrix. A CPGV of 0.02 ft/min is recommended because it optimizes the recovery of contaminants in the mobile vapor phase and prevents over-designing the SVE mechanical systems to attempt venting unproductive immobile zones.

An approximate value of the CPGV can be calculated if vapor flow is assumed to be uniformly radial around the extraction well. The velocity is then calculated from the vadose zone thickness, the fraction of soil characterized as mobile (USACE 2002), the porosity, the fraction water saturation, and the extraction rate in accordance with the following equation:

$$CPGV = \frac{Q}{2\pi \times b \times mf \times n \times (1 - Sm) \times r}$$

Where:

CPGV is in units of ft/min

Q = flow rate (ft^3/min)

B = thickness of vadose zone (feet)

m_f = mobile fraction (unitless)

n = porosity (unitless)

S_m = decimal equivalent of water saturation in vadose zone (unitless)

r = critical radius (feet)

Conditions of the SVE pilot test are estimated to be:

Q_{avg} = 29 ft^3/min (90% of 32 ft^3/min average flow rate)

b = 22 feet (average thickness of unsaturated zone)

m_f = 0.38 (estimated)

n = 0.4 (from soil properties testing Table 6 of Appendix B)

S_m = 0.68 (from soil properties testing Table 6 of Appendix B)

$$r = \frac{29}{2\pi \times 22 \times (0.38) \times 0.4 \times (1 - 0.68) \times 0.02}$$

The solution to the above equation for the critical radius (r) for a single extraction well pumping at 29 scfm at the minimum CPGV of 0.02 feet per minute yields a maximum radius of 216 feet. To account for the non-radial flow and unsaturated zone heterogeneities, a more conservative CPGV of 0.2 ft/min results in a radius of 22 feet. As such, 20 feet is selected as a reasonably conservative design critical radius for vertical SVE well spacing.

4.2.3 Vapor Phase Analytical Results

The laboratory analytical results of the air samples collected during the SVE pilot test indicate that a substantial volatile organic compound (VOC) mass could be removed from the subsurface via SVE. The laboratory results indicate a substantial concentration of TCE in the soil vapor recovered from each of the three wells. Other byproducts of reductive dechlorination of TCE, such as cis- and trans-1,2-dichloroethene, 1,1-dichloroethene, and vinyl chloride, were also detected in the samples. The highest concentrations of TCE and reductive dechlorination byproducts were found in well 01MW44. BTEX compounds were generally not detected in the soil vapor except at the end of the test conducted for well 01MW44.

Real time measurements of VOCs, oxygen, LEL, and carbon dioxide concentrations confirmed the presence of VOCs in soil vapor (VOCs and LEL) as well as the fact that hydrocarbons are undergoing aerobic bioremediation as evidenced by the deficit in oxygen and enrichment in carbon dioxide concentrations relative to atmospheric levels for these gases.

5.0 REMEDIAL ALTERNATIVES ASSESSMENT

The purpose of this FS is to develop and evaluate cleanup action alternatives to facilitate selection of a final cleanup action at the Site in accordance with WAC 173-340-350(8). An FS includes the development, screening, and evaluation process for numerous remedial alternatives.

The FS is used to screen cleanup action alternatives to eliminate alternatives that are not technically possible, or the costs are disproportionate under WAC 173-340-360(3)(e), or alternatives that will substantially affect the future planned business operations at the site. Based on the screening, the FS presented below evaluates the most advantageous remedial components to recommend a final cleanup action for the Site in conformance with WAC 173-340-360 through WAC 173-340-390.

5.1 CLEANUP STANDARDS

The selected cleanup action alternative must comply with MTCA cleanup regulations specified in WAC 173-340 and with applicable federal and state laws. The preliminary cleanup levels and remedial action objectives for the Site are discussed in this section.

5.1.1 Applicable or Relevant and Appropriate Requirements

Under WAC 173-340-350 and 173-340-710, applicable requirements include regulatory cleanup standards, standards of control, and other environmental requirements, criteria, or limitations established under state or federal law that specifically address a contaminant, remedial action, location, or other circumstances at a site.

MTCA defines relevant and appropriate requirements as follows:

> …those cleanup action standards, standards of control, and other human health and environmental requirements, criteria, or limitations established under state and federal law that, while not legally applicable to the hazardous substance, cleanup action, location, or other circumstances at a site, the department determines address problems or situations sufficiently similar to those encountered at the site that their use is well suited to the particular site. The criteria specified in WAC 173-340-710(3) shall be used to determine if a requirement is relevant and appropriate.

The criteria used to make this determination are presented in WAC 173-340-710(4)(a)-(i). Remedial actions conducted under MTCA must comply with the substantive requirements of the ARARs but are exempt from their procedural requirements (WAC 173-340-710[9]). Specifically, this exemption applies to state and local permitting requirements under the Washington State Water Pollution Control Act, Solid Waste Management Act, Hazardous Waste Management Act, Clean Air Act, State Fisheries Code, and Shoreline Management Act.

5.1.1.1 Screening of ARARs

ARARs were screened to assess their applicability to the Site. Only those that were deemed appropriate and applicable were retained. The following table identifies the preliminary ARARs that may be applicable to the Site.

Preliminary ARARs for the Site

Preliminary ARAR	Citation or Source
MTCA	Chapter 70.105 of the Revised Code of Washington (RCW)
MTCA Cleanup Regulation	WAC 173-340
Ecology, Toxics Cleanup Program – Guidance To Be Considered	*Guidance for Evaluating Soil Vapor Intrusion in Washington State: Investigation and Remedial Action*, Review DRAFT, October 2009, Publication No. 09-09-047
State Environmental Policy Act	RCW 43.21C
Washington State Shoreline Management Act	RCW 90.58; WAC 173-18, 173-22, and 173-27
The Clean Water Act	33 United States Code [USC] 1251 et seq.
Comprehensive Environmental Response, Compensation, and Liability Act of 1980	42 USC 9601 et seq. and Part 300 of Title 40 of the Code of Federal Regulations [40 CFR 300]
The Fish and Wildlife Coordination Act	16 USC 661-667e; the Act of March 10, 1934; Ch. 55; 48 Stat. 401

Preliminary ARAR	Citation or Source
Endangered Species Act	16 USC 1531 et seq.; 50 CFR 17, 225, and 402
Native American Graves Protection and Repatriation Act	25 USC 3001 through 3013; 43 CFR 10 and Washington's Indian Graves and Records Law (RCW 27.44)
Archaeological Resources Protection Act	16 USC 470aa et seq.; 43 CFR 7
Washington Dangerous Waste Regulations	WAC 173-303
Resource Conservation and Recovery Act (RCRA)	40 CFR Parts 260-280 and 148
Solid Waste Management Act	RCW 70.95; WAC 173-304 and 173-351
Occupational Safety and Health Administration Regulations	29 CFR 1910, 1926
Washington Department of Labor and Industries Regulations	WAC 296
Water Quality Standards for Surface Waters of the State of Washington	RCW 90.48 and 90.54; WAC 173-201A
Water Quality Standards for Ground Water	WAC 173-200
Department of Transportation Hazardous Materials Regulations	40 CFR 100 through 185
Washington State Water Well Construction Act	RCW 18.104; WAC 173-160
King County regulations, codes, and standards	King County Code 28.81, 28.82, 28.83; King County Public Rules PUT 8-12 through PUT 8-16
City of Seattle Pipeline System Ordinance	Ordinance No. 11537 issued by the City of Seattle
City of Seattle regulations, codes, and standards	All applicable or relevant and appropriate regulations, codes, and standards

5.1.2 Development of Cleanup Standards

The selected cleanup alternative must comply with the MTCA cleanup regulations specified in WAC 173-340 and with applicable state and federal laws. The preliminary cleanup levels selected for those portions of the Site located within the Property boundary and for the greater Site are consistent with the RAOs, which state that the RAO is to reduce concentrations of COPCs in soil and/or groundwater beneath the Site to below their preliminary cleanup levels or remediation levels, if applicable, at defined points of compliance. In addition to mitigating risks to human health and the environment, achieving the RAOs will allow Ecology to issue Property- and/or Site-specific determinations of No Further Action (NFA). The preliminary cleanup levels for the media and COPCs are presented in Table 1.

5.2 REMEDIAL ACTION OBJECTIVES

RAOs are administrative goals for a cleanup action that address the overall MTCA cleanup process. The purpose of establishing RAOs for a site is to provide remedial alternatives that protect human health and the environment (WAC 173-340-350). In addition, RAOs are designated to:

- Implement administrative principles for cleanup (WAC 173-340-130).
- Meet the requirements, procedures, and expectations for conducting an FS and developing cleanup action alternatives as discussed in WAC 173-340-350 through 173-340-370.
- Develop cleanup standards (WAC 173-340-700 through 173-340-760) and remedial alternatives that are protective of human health and the environment.

RAOs must include the following threshold requirements from Chapter 173-340 WAC:

- Protect human health and the environment.
- Comply with applicable state and federal laws.
- Comply with cleanup standards.
- Provide for compliance monitoring.

The RAOs for the Site are to mitigate potential exposure pathways for human and terrestrial receptors, to comply with specific hazardous waste ARARs, to remove the RCRA waste designation associated with chlorinated phenols in affected environmental media, to comply with and terminate the pipeline system ordinance with the City of Seattle, and to comply with ARARs and Site-specific cleanup standards to demonstrate compliance and obtain an NFA determination from Ecology. The implementation of the selected cleanup action alternative will address the potential exposure pathways to protect the human health and the environment. The full treatment and/or disposal of affected environmental media (soil and groundwater) with chlorinated phenols (PCP and associated byproduct compounds) will assist with a petition to remove the RCRA waste designation of F027. The removal of the pipeline system along with compliance soil samples collected from the pipeline system trench will demonstrate compliance with the pipeline system ordinance to terminate the ordinance with the City of Seattle. Compliance monitoring will demonstrate the cleanup standards have been met at the established points of compliance defined in the cleanup action plan. A request for an NFA determination from Ecology will be made upon completion of the compliance monitoring plan.

5.3 IDENTIFICATION AND EVALUATION OF REMEDIAL COMPONENTS

SoundEarth evaluated remedial components for the Site with respect to the cleanup requirements set forth in MTCA. According to MTCA, a cleanup action alternative must satisfy the minimum threshold requirements for RAOs, as outlined in Section 5.2 above. WAC 173-340-360 (2)(b) also requires that the cleanup action alternative meet the following requirements:

- Use permanent solutions to the maximum extent practicable.
- Provide for a reasonable restoration time frame.
- Consider public concerns.

A comprehensive list of remedial components and the rationale for inclusion or exclusion of specific components options with respect to the MTCA evaluation criteria are summarized in Table 2. The remedial components are separated into nine distinct component groups, including passive remediation, in situ physical treatment, in situ thermal, source removal, ex situ source treatment, in situ chemical oxidation, containment/immobilization, phytoremediation, and in situ bioremediation. The nine component groups are further subdivided into component options that are possible controls and technologies to achieve the RAOs. One or a combination of these component options may apply to remediate COPCs for the Site.

The remedial components retained after the screening evaluation include the following:

- Monitored natural attenuation (MNA)
- SVE
- Air Sparging
- Dual-phase extraction or Multiphase extraction (MPE)
- Excavation without and with shoring (Soldier Pile Wall – Non-Impervious)
- Land Disposal
- Aerobic bioremediation

A comprehensive list of remedial technologies is presented in Table 2. The remedial alternatives were evaluated using the above criteria. The screening matrix of each cleanup action alternatives is discussed in further detail below.

5.3.1 Monitored Natural Attenuation

MNA is a passive process that depends on intrinsic environmental factors to reduce contaminant concentrations over time in the absence of human effort through natural processes, such as biodegradation, adsorption, dissolution, diffusion, and advection and dispersion.

MNA includes the active process of monitoring and documenting the effectiveness of an otherwise passive technology. It is often used as a polishing technology after an active technology has reduced contaminant concentrations but is unable to achieve cleanup levels. Monitoring is needed to evaluate the effectiveness of natural attenuation and to document the achievement of cleanup levels.

5.3.2 Soil Vapor Extraction

SVE is proven technology for recovering volatile petroleum hydrocarbons from unsaturated soil. This technology is implemented by installing vertical and/or horizontal wells within the zone of contamination. Vacuum is applied to recover contaminants in the vapor phase for subsequent treatment and disposal, if necessary. This technology is not suitable for the treatment or recovery of contaminated groundwater and is not suitable for the remediation of middle- to heavy-range petroleum hydrocarbons. The initial treatment of recovered soil vapor would likely be required prior to release to the atmosphere.

5.3.3 Air Sparging

Air sparging is a proven technology for the remediation of VOCs, including volatile TPH, in saturated soil and groundwater. This technology is implemented by installing vertical or horizontal wells within the saturated zone and below the treatment zone. Compressed ambient air is injected into the air sparge wells to air strip volatile VOCs located in the saturated zone. Air sparging is combined with SVE to recover contaminants in the vapor phase. Air sparging is also referred to as biosparging when treating source areas with semivolatile TPH compounds, such as diesel and oil. Biosparging is an air or oxygen delivery system that uses lower air flow rates than an air sparging system. The goal of biosparging is to increase dissolved oxygen in the subsurface and stimulate biodegradation. The volatile compounds are degraded as dissolved-phase and vapor-phase contaminants slowly move through the biologically active soil.

5.3.4 Multiphase Extraction

MPE is proven technology for the remediation of LNAPL and VOCs in soil and groundwater. An MPE remediation system typically consists of a submersible pump to recover LNAPL and groundwater, simultaneous application of vacuum to the exposed soil column to recover VOCs from the soil in the vapor phase. The recovery of LNAPL and groundwater reduces the source of contamination and reduces the mobility of the dissolved-phase contaminant plume through hydraulic containment. Groundwater extraction can be effective for low- to high- permeability soils (EPA 1999). The vapor extraction component removes mass from the semi-saturated and unsaturated soil zones by volatilizing the contaminant and capturing the mass in the vapor phase for ex situ treatment or discharge.

5.3.5 Excavation without and with Shoring (Soldier Pile Wall – Non-Impervious) and Land Disposal

Excavation without and with shoring (soldier pile wall) and land disposal are remedial components for the excavation of source material. Excavation of source material is a proven technology for the removal of contaminants from the subsurface. Soldier pile wall shoring would be installed as the excavation advances with depth to protect existing structures and/or property boundaries.

Soil and groundwater excavated from the source area for petroleum-contaminated soil would be directly land disposal at a permitted facility. It is assumed that the generated waste stream will be designated as non-hazardous waste and Ecology will accept a petition to remove the RCRA waste designation of F027. Chlorinated phenol-contaminated soils might require pretreatment prior to land disposal if concentrations of regulated substances exceed levels permissible for land disposal; otherwise, excavated source material would be land disposed directly without pretreatment in accordance with federal, state, and local regulations.

5.3.6 Aerobic Bioremediation

Bioremediation of COPCs in soil and groundwater is most efficient and sustainable under aerobic conditions (i.e., in the presence of oxygen). Increasing the availability and concentration of oxygen in the subsurface by an engineered method enhances the rate at which the COPCs are degraded aerobically. Proven methods to increase oxygen concentrations in the saturated zone include injecting chemical reactants that produce elemental oxygen (e.g., sodium percarbonate or peroxide salts) and sparging compressed air or oxygen gas directly into the water-bearing zone. The increased oxygen concentration resulting from these enhancements produces an increased and sustained rate of biodegradation of COPCs.

5.4 CLEANUP ACTION ALTERNATIVES SELECTED FOR FURTHER EVALUATION

Further evaluation of the selected cleanup action alternatives for the Site was separated by the affected properties. The affected properties include the Bulk Terminal Property and the West Commodore Way ROW (Figure 3). The cleanup action alternatives for the Bulk Terminal Property and the West Commodore Way ROW were assembled from the remedial components retained from screening.

5.4.1 Bulk Terminal Property

A total of four cleanup action alternatives were selected for further evaluation for the Bulk Terminal Property. The alternatives are listed below:

- **Bulk Terminal Property, Cleanup Action Alternative 1**—Unsaturated Zone Excavation with Off-Site Land Disposal; MPE for LNAPL; Biosparge and Air Sparge/SVE for TPH in Groundwater
- **Bulk Terminal Property, Cleanup Action Alternative 2**—Unsaturated Zone Excavation with Off-Site Land Disposal; MPE for LNAPL and TPH in Groundwater
- **Bulk Terminal Property, Cleanup Action Alternative 3**—Unsaturated Zone and LNAPL Excavation with Off-Site Land Disposal; MNA for TPH in Groundwater
- **Bulk Terminal Property, Cleanup Action Alternative 4**—MPE for the Unsaturated Zone, LNAPL, and TPH in Groundwater

5.4.2 West Commodore Way ROW

Two cleanup action alternatives were selected for further evaluation for the West Commodore Way ROW. The alternatives are listed below:

- **West Commodore Way ROW, Cleanup Action Alternative 1**—MPE for LNAPL and the TPH in Groundwater
- **West Commodore Way ROW, Cleanup Action Alternative 2**—LNAPL Excavation for Off-Site Land Disposal; MPE for Residual LNAPL; and MNA for TPH in Groundwater

Remedial components that are common to all alternatives include MNA and aerobic bioremediation. The focused evaluation of these alternatives is presented in Section 5.6.

5.5 ALTERNATIVE EVALUATION CRITERIA

This section presents the criteria used to evaluate the potentially feasible cleanup alternatives with respect to the RAOs established for the Site. Remedial components were identified in accordance with the requirements set forth in MTCA under WAC 173-340-350(8)(b) and the focused screening of potential remedial components using the requirements and procedures for selecting cleanup actions as set forth in MTCA under WAC 173-340-360(2)(a)(b). The criteria used to evaluate and compare applicable cleanup action alternatives were derived from WAC 173-340-360(3)(f) and include the following:

- **Protectiveness.** The overall protectiveness of human health and the environment, including the degree to which existing risks are reduced, the time required to reduce risk at the facility and attain cleanup standards, the risks resulting from implementing the alternative, and improvement of overall environmental quality of the Site.

- **Permanence.** The degree to which the alternative permanently reduces the toxicity, mobility, or volume of hazardous substances, including the adequacy of the alternative in destroying the hazardous substances, the reduction or elimination of hazardous substance releases and sources of releases, the degree of irreversibility of waste treatment process, and the characteristics and quantity of treatment residuals generated during the treatment process.
- **Effectiveness over the Long Term.** The degree of certainty that the alternative will be successful, the reliability of the alternative during the period of time over which hazardous substances are expected to remain on the Site, and the magnitude of residual risk associated with the contaminated soil and/or groundwater components. The following types of cleanup action components, presented in descending order of preference under MTCA, may be used as a guide when assessing the relative degree of long-term effectiveness of the chosen alternative:
    - Reuse or recycling
    - Destruction or detoxification
    - Immobilization or solidification
    - On-property or off-property disposal in an engineered, lined, and monitored facility
    - On-property isolation or containment with attendant engineering controls
    - Institutional controls and monitoring
- **Management of Short-Term Risks.** The risk to human health and the environment associated with the alternative during its construction and implementation, and the effectiveness of measures that will be taken to manage such risks.
- **Technical and Administrative Implementability.** The ability to implement the alternative; includes consideration of the technical feasibility of the alternative, administrative and regulatory requirements, permitting, scheduling, size, complexity, monitoring requirements, access for construction operations and maintenance, and integration with the future development plans for the Site.
- **Consideration of Public Concerns.** Consideration of public concerns is mandated under the MTCA cleanup regulation for an Ecology-led or potentially liable person-led cleanup action under an Agreed Order or Consent Decree. This is typically implemented by Ecology through a mandatory public review and comment period on a proposed cleanup action plan. Because this public review and comment process is not implemented by the private party responsible for the cleanup under the Voluntary Cleanup Program (VCP) and because this FS Report was prepared within the purview of the VCP, public concerns regarding cleanup actions for the Sites were not evaluated in this document.
- **Cost.** The cost to implement the alternative, including the cost of construction, the net present value of long-term costs, and Ecology oversight costs. Long-term costs that were considered include those associated with operation and maintenance (O&M), monitoring, equipment

replacement, reporting, and maintaining institutional controls. Many of these costs are evaluated as part of the disproportionate cost analysis section presented below.

5.6 FOCUSED EVALUATION OF CLEANUP ACTION ALTERNATIVES

The focused evaluation of cleanup action alternatives considers the practicable remedial components confirmed to be effective at treating COPCs in the affected environmental media. The evaluation also considers whether Site-specific constraints would preclude the application of a remedial component due to the creation of a greater risk to human health and/or the environment, if such constraints could result in the component being technically or administratively infeasible to implement, or if the component was disproportionately costly relative to the benefits realized. A detailed description of the four cleanup action alternatives for the Bulk Terminal Property and the two cleanup action alternatives for the West Commodore Way ROW that were retained for a focused evaluation is provided below.

5.6.1 Bulk Terminal Property, Cleanup Action Alternative 1—Unsaturated Zone Excavation with Off-Site Land Disposal; MPE for LNAPL; Biosparge and Air Sparge/SVE for TPH in Groundwater

Cleanup Action Alternative 1 would be implemented in two phases. Figures 19A and 19B provide conceptual illustrations of how Phase 1 and Phase 2 of this alternative would be implemented, respectively. Phase I would involve excavating soils that exhibit COPCs in concentrations exceeding preliminary cleanup levels followed by backfilling and compacting the excavated areas to the starting grade with clean structural fill. Shoring would be installed, as shown on Figure 19A, to protect the structural integrity of the TOC Headquarters Office Building, and would consist of soldier piles and wood lagging. The excavation would be sloped to the east at maximum of H3:V1 (Horizontal to Vertical). This would require an excavation of approximately 3,300 bank cubic yards (bcy) of clean overburden, which would remain on site to backfill the excavated areas.

Excavated soil containing COPC concentrations above preliminary cleanup levels would be transported off site for land disposal at a permitted facility. A portion of the former tank yard unsaturated zone soils were excavated in 2012. An estimate of the remaining soil to be excavated under this alternative is approximately 14,100 bcy of which 3,300 bcy is clean overburden to achieve a safe slope to access the excavated area. Bank cubic yards is a measure of in-place volume. Transporters and disposal vendors often charge their fees based on weight rather than volume. The conversion factor used in this document to estimate the soil weight (mass) from volume is a bulk density of 1.5 tons per bcy. Soil that is excavated from its bank condition will usually expand between 15 to 30 percent in volume (the swell factor), depending on the soil type and moisture content. An excavated soil volume is termed “loose.” An estimate of the volume and mass of soil excavated for land disposal under this alternative would be approximately 10,830 bcy, and 16,250 tons, respectively, assuming a bulk density of 1.5 tons per bcy.

A temporary dewatering system would be installed to reduce the moisture content of the excavated soils. Recovered water would be pretreated and discharged to the King County sanitary sewer system under an industrial waste pretreatment permit. The wood lagging installed during Phase 1 would be pulled when backfilling the excavated area with clean fill to bring the Property back to pre-excavation grades before beginning Phase 2.

Phase 2 would involve installing MPE wells, air/biosparging wells, and associated pumps, pipes, and trenches for the purpose of remediating LNAPL, dissolved petroleum hydrocarbon plumes and soil vapor. MPE wells would recover three phases of contaminated media simultaneously for treatment: LNAPL, groundwater, and soil vapor. This would be accomplished by installing a pneumatically-powered total fluids pump in each well at a designed depth to remove both LNAPL and groundwater for treatment in an aboveground treatment facility. Soil vapor would also be recovered at the same time by applying vacuum to the well casing and conveying the recovered vapor to the remediation compound for treatment.

Air sparging and biosparging wells are identical in their materials of construction and installation; however, the difference between the two is the amount of air flow applied to the well and the target contaminants being treated. The primary mechanism for the treatment effectiveness of an air sparging well stems from its ability to physically transfer (or air strip) volatile COPCs dissolved in groundwater to the vapor phase (phase transfer) where they are more efficiently recovered. Secondary treatment effectiveness from air sparging is realized from the introduction of additional oxygen to the groundwater to sustain aerobic biodegradation of the COPCs in the groundwater. Because air sparging involves both the physical (phase transfer) and biological treatment (aerobic biodegradation) mechanisms, the air flow for an air sparging well is generally higher than that of a biosparging well. Biosparging is effective only by way of the biological mechanism to sustain aerobic biodegradation of nonvolatile hydrocarbons like those in DRPH. The properties of the DRPH constituents are such that they not able to be treated by the mechanism of air stripping.

The extents of the LNAPL and TPH plumes are illustrated in Figure 19B. MPE wells would be installed within the boundary of the LNAPL at a spacing of 20 feet. An estimated 45 wells would be installed for MPE. Each MPE well would be completed with a 20-foot length of slotted screen to a total depth of approximately 25 and 30 feet below existing grade so as to provide a sufficient depth to enable the dewatering of several feet of the semi-saturated zone and to recover vapor from both the unsaturated and semi-saturated zone. Each MPE wellhead would be completed within a below-grade flush-mounted vault with a steel-hinged lid to protect the wellhead and to allow future access for monitoring and maintenance.

Air/biosparging wells would be installed within the boundary of the GRPH and DRPH dissolved-phase plumes, spaced 20 feet apart along transects oriented perpendicular to the groundwater flow direction, and spaced 40 feet apart parallel to the groundwater flow direction, as shown on Figure 19B. This equates to approximately 30 air/biosparging wells. Each air/biosparge well would consist of 1-inch-diameter Schedule 40 galvanized steel blank riser pipe with a 1-foot length of slotted pipe at the bottom of the well for distributing the compressed air into the saturated zone. Experience and good design practice for air/biosparging wells requires that the bottom of each air/biosparging be set at 15 feet below the depth of the water table elevation. To recover potential vapors created during air sparging, an additional 20 SVE wells would be installed in transects between the air/biosparge wells. Each SVE well would consist of 2-inch-diameter, schedule 40 PVC slotted well casing screened from approximately 3 feet below grade to 10 feet below grade. A pre-engineered steel building would be installed on a new slab-on-grade for a remedial compound to house the control, treatment, mechanical, and electrical equipment associated with the remedial systems.

LNAPL and water recovered from the MPE system would be subjected to phase separation using an oil/water separator located within the remedial compound. Separated LNAPL would be containerized and shipped off site for recycling. Water from the oil/water separator would be pretreated using liquid-phase granular-activated carbon (LPGAC) and discharged to the King County sanitary sewer system under an industrial waste pretreatment permit. Vapor recovered from the SVE pipe trenches would be treated before discharging to the atmosphere under an air discharge permit with the Puget Sound Clean Air Agency (PSCAA).

Additional assumptions for this cleanup action alternative include the following:

- All soil and LNAPL are nonhazardous.
- Ecology will accept a petition to remove the RCRA waste designation of F027 based on the results of the interim actions and associated compliance groundwater monitoring completed to address the former PCP plume treatment area.
- Excavated soil would be transported by truck to a permitted land disposal facility.
- A total of 12 new monitoring wells would be installed to evaluate groundwater quality following the excavation.
- For the purpose of estimating the present worth cost of annual O&M, it is assumed O&M would be performed monthly for 10 years. It is assumed that compliance groundwater monitoring would be monitored quarterly in 20 wells for 10 years for COPCs and natural attenuation parameters. Analyses would indicate that concentrations of COPCs are below the preliminary cleanup levels for groundwater.
- The life cycle for this alternative is estimated to be 10 years for the purpose of estimating the present worth cost. This duration should not be construed as a guaranteed remediation time frame.
- Future annual costs only include groundwater monitoring and system O&M. Associated project management, regulatory reporting and interaction, additional investigations, or any other services are not included in future direct costs.

The present worth cost estimate to implement Bulk Terminal Property Cleanup Action Alternative 1, assuming a real discount rate of 0.1 percent and a life cycle of 10 years, is approximately $6,029,000 (Table 3). This feasibility level cost should not be considered a design cost estimate or guaranteed cost.

5.6.2 Bulk Terminal Property, Cleanup Action Alternative 2—Unsaturated Zone Excavation with Off-Site Land Disposal; MPE for LNAPL and TPH in Groundwater

Cleanup Action Alternative 2 would be implemented in two phases with Phase I being implemented in the same manner as Cleanup Action Alternative 1. Figure 20A illustrates the conceptual site layout for Phase 1 of Cleanup Action Alternative 2.

Phase 2 of Cleanup Action Alternative 2 would involve the drilling and installation of MPE wells to address the remediation of LNAPL and the dissolved-phase GRPH and DRPH plumes in groundwater. Figure 20B illustrates the conceptual layout for Phase 2 of this alternative. MPE wells within the LNAPL boundary would be installed at an approximate spacing of 20 feet; MPE wells located outside of the LNAPL boundary, but within the GRPH and DRPH plume areas, would be spaced at 40 feet. An estimated 76 wells would be installed for MPE. Each well would be completed with a 20-foot length of slotted screen to a total of depth of between 25 and 30 feet below existing grade to provide a sufficient depth to enable the dewatering of several feet of the saturated zone and to recover vapor from both the unsaturated and the dewatered saturated zone. Each MPE well would be equipped with a pneumatically-operated total fluids pump to dewater the well. Total fluids pumps are distinguished from “product only” pumps in that the former pumps all fluids including groundwater and LNAPL whereas the latter pumps only LNAPL. Trenches would be installed to house the buried air supply tubing to the pneumatic pumps, electrical lines, the water return pipes, and the SVE pipes to and from the remediation compound.

A concrete slab would be installed to support a pre-engineered steel building for the remediation compound similar to that conceptualized for Cleanup Action Alternative 1.

LNAPL and water recovered from the MPE system would be subjected to phase separation using an oil/water separator located within the remedial compound. Separated LNAPL would be containerized and shipped off site for land disposal. Water from the oil/water separator would be pretreated using LPGAC and discharged to the King County sanitary sewer system under an industrial waste pretreatment permit. Vapor recovered from the SVE pipe trenches would be treated prior to discharging to the atmosphere under an air discharge permit with the PSCAA.

Additional assumptions for this cleanup action alternative include the following:

- All soil and LNAPL are nonhazardous.
- Ecology will accept a petition to remove the RCRA waste designation of F027 based on the results of the interim actions and associated compliance groundwater monitoring completed to address the former PCP plume treatment area.
- Excavated soil would be transported by truck to a permitted disposal facility.
- A total of 12 new monitoring wells would be installed to evaluate groundwater quality following the excavation.
- For the purpose of estimating the present worth cost of annual O&M, it is assumed O&M would be performed monthly for 10 years, and compliance groundwater would be monitored quarterly in 20 wells for 10 years for COPCs and natural attenuation parameters. Analyses would indicate that concentrations of COPCs are below the preliminary cleanup levels for groundwater.
- The life cycle for this alternative is estimated to be 10 years for the purpose of estimating the present worth cost. This duration should not be construed as a guaranteed remediation time frame.
- Future annual costs only include groundwater monitoring and system O&M. Associated project management, regulatory reporting and interaction, additional investigations, or any other services are not included in future direct costs.

The present worth cost estimate to implement Bulk Terminal Property Cleanup Action Alternative 2, assuming a real discount rate of 0.1 percent and a life cycle of 10 years, is approximately $5,796,000 (Table 4). This feasibility level cost should not be considered a design cost estimate or guaranteed cost.

5.6.3 Bulk Terminal Property, Cleanup Action Alternative 3—Unsaturated Zone and LNAPL Excavation with Off-Site Land Disposal; MNA for TPH in Groundwater

Cleanup Action Alternative 3 would involve excavating not only the unsaturated zone as delineated in Cleanup Action Alternatives 1 and 2, but also an additional 7-foot thickness of the saturated zone where LNAPL may be present. Excavated areas would be backfilled with clean structural fill to the starting grade. Because the source of the dissolved-phase plumes (the LNAPL) would be removed, the dissolved-phase plumes of GRPH and DRPH would be remediated by MNA under this alternative. Figure 21 illustrates how this alternative would be implemented. Similar to Cleanup Action Alternatives 1 and 2, shoring would be required to protect the TOC Headquarters Office Building. However, because the excavation would be approximately 7 feet deeper, the shoring would also be deeper to accommodate the full excavation depth of approximately 15 feet bgs. It is assumed, for purposes of estimating the cost of this alternative, that shoring would consist of soldier piles and wood lagging installed as shown in Figure 21.

An estimate of the soil to be excavated under this alternative includes approximately 19,467 bcy including the LNAPL. This would require an excavation of approximately 4,554 bank cubic yards of clean overburden, which would remain on site to backfill the excavated areas. An estimate of the remaining soil to be excavated under this alternative for land disposal is approximately 14,915 bcy. This equates to a mass of approximately 22,370 tons, assuming a bulk density of 1.5 tons per bcy. All soil containing COPC concentrations above preliminary cleanup levels would be transported off site for land disposal at a permitted facility.

A temporary dewatering system would be installed to reduce the moisture content of the excavated soils. Recovered water would be pretreated and discharged to the King County sanitary sewer system under an industrial waste pretreatment permit. The wood lagging installed during Phase 1 would be pulled when backfilling the excavated area with clean fill to bring the property back to pre-excavation grades before beginning Phase 2.

Phase 2 would involve installing 12 new groundwater monitoring wells within the Bulk Terminal Property to monitor the progress of natural attenuation of the dissolved-phase GRPH and DRPH plumes remaining after the removal of the source area.

Under MTCA, MNA can be considered an active remedial measure if site conditions conform to the expectations listed in WAC 173-340-370(7), as follows:

- Source control (including removal and/or treatment of hazardous substances) has been conducted to the maximum extent practicable.
- Leaving contaminants in place during the restoration time frame does not pose an unacceptable threat to human health or the environment.
- There is evidence that natural biodegradation or chemical degradation is occurring and will continue to occur at a reasonable rate at the Site.
- Appropriate monitoring requirements are conducted to ensure that the natural attenuation process is taking place and that human health and the environment are protected.

In accordance with the above-listed expectations, ongoing groundwater monitoring would be performed using 12 newly installed groundwater monitoring wells to demonstrate that natural biodegradation is occurring at a reasonable rate. In addition to monitoring changes in concentrations of COPCs beneath the property, critical parameters to be measured include the following:

- pH
- Dissolved oxygen
- Oxidation-reduction potential
- Metals scan (total iron, ferrous iron, calcium, magnesium, dissolved manganese)
- Anion scan (chloride, sulfate, nitrate included)
- Methane
- Total organic carbon

Key assumptions for this cleanup action alternative include the following:

- All soil and LNAPL are nonhazardous.
- Ecology will accept a petition to remove the RCRA waste designation of F027 based on the results of the interim actions and associated compliance groundwater monitoring completed to address the former PCP plume treatment area.
- Excavated soil would be transported by truck to a permitted disposal facility.
- A total of 12 new monitoring wells would be installed to evaluate groundwater quality following the excavation.
- For the purpose of estimating the present worth cost of annual O&M, it is assumed O&M would be performed monthly for 20 years. It is assumed that compliance groundwater monitoring would be monitored quarterly in 20 wells for 20 years for COPCs and natural attenuation parameters. Analyses would indicate that concentrations of COPCs are below the preliminary cleanup levels for groundwater.
- The life cycle for this alternative is estimated to be 20 years for the purpose of estimating the present worth cost. This duration should not be construed as a guaranteed remediation time frame.
- Future annual costs only include groundwater monitoring and system O&M. Associated project management, regulatory reporting and interaction, additional investigations, or any other services are not included in future direct costs.

The present worth cost estimate to implement Bulk Terminal Property Cleanup Action Alternative 3, assuming a real discount rate of 0.8 percent and a life cycle of 20 years, is approximately $4,841,000 (Table 5). This feasibility level cost should not be considered a design cost estimate or guaranteed cost.

5.6.4 Bulk Terminal Property, Cleanup Action Alternative 4—MPE for the Unsaturated Zone, LNAPL, and TPH in Groundwater

Cleanup Action Alternative 4 involves in situ remediation of contaminated soil, LNAPL, and groundwater using MPE. Because the layout of MPE wells for this alternative would be the same as Cleanup Action Alternative 2. Figure 22 illustrates the conceptual site layout for Cleanup Action Alternative 4.

MPE wells within the LNAPL boundary would be installed at an approximate spacing of 20 feet; MPE wells located outside of the LNAPL boundary, but within the GRPH and DRPH plume areas, would be spaced at 40 feet. An estimated 76 wells would be installed for MPE. Each well would be completed with a 20-foot length of slotted screen to a total of depth of between 25 and 30 feet below existing grade to provide a sufficient depth to enable the dewatering of several feet of the saturated zone and to recover vapor from both the unsaturated and the dewatered saturated zone. Each MPE well would be equipped with a pneumatically-operated total fluids pump to dewater the well. Trenches would be installed to house the buried air supply tubing to the pneumatic pumps, electrical lines, the water return pipes, and the SVE pipes to and from the remediation compound.

A concrete slab would be installed to support a pre-engineered steel building for the remediation compound similar to that conceptualized for Cleanup Action Alternatives 1 and 2.

LNAPL and water recovered from the MPE system would be subjected to phase separation using an oil/water separator located within the remedial compound. Separated LNAPL would be containerized for disposal. Water from the oil/water separator would be pretreated using LPGAC and discharged to the King County sanitary sewer system under an industrial waste pretreatment permit. Vapor recovered from the SVE pipe trenches would be treated before discharging to the atmosphere under an air discharge permit with the PSCAA.

Because this alternative relies on in situ treatment to remediate all of the unsaturated and saturated zone contamination, the life cycle for this alternative is estimated to be 15 years for the purpose of estimating the present worth cost. This duration should not be construed as a guaranteed remediation time frame.

Key assumptions for this cleanup action alternative include the following:

- All soil and LNAPL are nonhazardous.
- Ecology will accept a petition to remove the RCRA waste designation of F027 based on the results of the interim actions and associated compliance groundwater monitoring completed to address the former PCP plume treatment area.
- For the purpose of estimating the present worth cost of annual O&M, it is assumed O&M would be performed monthly for 15 years. It is assumed that compliance groundwater monitoring would be monitored quarterly in 20 wells for 15 years for COPCs and natural attenuation parameters. Analyses would indicate that concentrations of COPCs are below the preliminary cleanup levels for groundwater.
- The life cycle for this alternative is estimated to be 15 years for the purpose of estimating the present worth cost. This duration should not be construed as a guaranteed remediation time frame.
- Future annual costs only include groundwater monitoring and system O&M. Associated project management, regulatory reporting and interaction, additional investigations, or any other services are not included in future direct costs.

The present worth cost estimate to implement Bulk Terminal Property Cleanup Action Alternative 4, assuming a real discount rate of 0.5 percent and a life cycle of 15 years, is approximately $3,980,000 (Table 6). This feasibility level cost should not be considered a design cost estimate or guaranteed cost.

5.6.5 West Commodore Way ROW, Cleanup Action Alternative 1—MPE for LNAPL and the TPH in Groundwater

The West Commodore Way ROW Cleanup Action Alternative 1 involves the installation of an MPE system to remediate two areas of residual LNAPL and dissolved-phase TPH plumes that are located within the ROW. Figure 23 illustrates the conceptual implementation of this cleanup action alternative. It is assumed that existing monitoring wells 01MW09, 01MW03, 01MW02, 01MW86, 01MW16, 01MW10, 01MW33, and 01MW11 would be suitable for use as MPE remediation wells so that only three new wells would be installed under this alternative.

New wells would be installed as 4-inch-diameter wells constructed of Schedule 40 PVC with 20 to 25 feet of slotted screen to a total depth of approximately 30 feet bgs to provide a sufficient depth to enable the dewatering of several feet of the saturated zone and to recover vapor from both the unsaturated and the dewatered saturated zone. Each MPE well would be equipped with a pneumatically-operated total fluids pump to dewater the well. Trenches would be installed to house the buried air supply tubing to the pneumatic pumps, electrical lines, the water return pipes, and the SVE pipes to and from a remediation compound. If a remediation compound is constructed for the Bulk Terminal Property cleanup action, it would also be used for the treatment of recovered LNAPL, groundwater, and soil vapor from the West Commodore Way ROW. If not, a remediation compound would be constructed on the Bulk Terminal Property for the treatment of the media recovered from the West Commodore Way ROW under this alternative. The estimated costs for this alternative assume that a new remediation compound would be constructed to treat the contaminated media recovered by the MPE system on the West Commodore Way ROW.

LNAPL and water recovered from the MPE system would be subjected to phase separation using an oil/water separator located within the remedial compound. Separated LNAPL would be containerized for disposal. Water from the oil/water separator would be pretreated using LPGAC and discharged to the King County sanitary sewer system under an industrial waste pretreatment permit. Vapor recovered from the SVE pipe trenches would be treated before discharging to the atmosphere under an air discharge permit with the PSCAA.

Key assumptions for this cleanup action alternative include the following:

- All soil and LNAPL are nonhazardous.
- Ecology will accept a petition to remove the RCRA waste designation of F027 based on the results of the interim actions and associated compliance groundwater monitoring completed to address the former PCP plume treatment area.
- A well spacing of 20 feet and a well depth of 30 feet bgs would effectively remediate the treatment zone.
- A new and separate remediation compound would be constructed to treat media recovered by the MPE system.

- For the purpose of estimating the present worth cost of annual O&M, it is assumed O&M would be performed monthly for 15 years. It is assumed that compliance groundwater monitoring would be monitored quarterly in 20 wells for 15 years for COPCs and natural attenuation parameters. Analyses would indicate that concentrations of COPCs are below the preliminary cleanup levels for groundwater.
- The life cycle for this alternative is estimated to be 15 years for the purpose of estimating the present worth cost. This duration should not be construed as a guaranteed remediation time frame.
- Future annual costs only include groundwater monitoring and system O&M. Associated project management; regulatory reporting and interaction; additional investigations or any other services are not included in future direct costs.

The present worth cost estimate to implement West Commodore Way ROW Cleanup Action Alternative 1, assuming a real discount rate of 0.5 percent and a life cycle of 15 years, is approximately $2,986,000 (Table 7). This feasibility level cost should not be considered a design cost estimate or guaranteed cost.

5.6.6 West Commodore Way ROW, Cleanup Action Alternative 2—LNAPL Excavation for Off-Site Land Disposal; MPE for Residual LNAPL; MNA for TPH in Groundwater

The West Commodore Way ROW Cleanup Action Alternative 2 involves excavating one main area of LNAPL, retrofitting four existing monitoring wells as MPE remediation wells, installing a new MPE well and treatment system, and using MNA to remediate any residual dissolved TPH plumes following excavation of the main source of LNAPL. Figure 24 illustrates the conceptual implementation of this cleanup action alternative.

It is assumed that the area of excavation would not be shored but benched and sloped to reach the estimated depth of 18 feet bgs and that the City of Seattle DPD will allow the street to be temporarily closed during the excavation phase of work.

An estimated 1,808 bcy (2,710 tons) of soil would be excavated to remove the LNAPL zone shown on Figure 24. The majority (approximately 1,046 bcy) of the total excavated soil would be stockpiled on the Bulk Terminal Property to be reused as clean structural backfill for the excavation. The remaining 760 bcy (1,140 tons) would be transported off site and disposed of as non-hazardous TPH waste at a permitted disposal facility. Temporary dewatering and treatment of the recovered water would be necessary to minimize the moisture content of the excavated waste soil. Clean structural fill would be imported, backfilled, and compacted to bring the excavated areas back to starting grade. Well drilling and pipe trench installation would commence for the MPE wells following the excavation, backfilling, and compaction of the excavation.

LNAPL and water recovered from the MPE system would be subjected to phase separation using an oil/water separator located within the remedial compound. Separated LNAPL would be containerized for disposal. Water from the oil/water separator would be pretreated using LPGAC and discharged to the King County sanitary sewer system under an industrial waste pretreatment permit. Vapor recovered from the SVE pipe trenches would be treated before discharging to the atmosphere under an air discharge permit with the PSCAA.

Key assumptions for this cleanup action alternative include the following:

- All soil and LNAPL are nonhazardous.
- Ecology will accept a petition to remove the RCRA waste designation of F027 based on the results of the interim actions and associated compliance groundwater monitoring completed to address the former PCP plume treatment area.
- The City of Seattle DPD will allow the street to be temporarily closed during the excavation phase of work.
- A well spacing of 20 feet and a well depth of 30 feet bgs would effectively remediate the treatment zone.
- A new and separate remediation compound would be constructed to treat media recovered by the MPE system.
- For the purpose of estimating the present worth cost of annual O&M, it is assumed O&M would be performed monthly for 10 years. It is assumed that compliance groundwater monitoring would be monitored quarterly in 20 for 10 years for COPCs and natural attenuation parameters. Analyses would indicate that concentrations of COPCs are below the preliminary cleanup levels for groundwater.
- The life cycle for this alternative is estimated to be 10 years for the purpose of estimating the present worth cost. This duration should not be construed as a guaranteed remediation time frame.
- Future annual costs only include groundwater monitoring and system O&M. Associated project management; regulatory reporting and interaction; additional investigations or any other services are not included in future direct costs.

The present worth cost estimate to implement West Commodore Way ROW Cleanup Action Alternative 2, assuming a real discount rate of 0.1 percent and a life cycle of 10 years, is approximately $2,455,000 (Table 8). This feasibility level cost should not be considered a design cost estimate or guaranteed cost.

5.7 COMPARISON OF ALTERNATIVES

A summary of the comparative evaluation of the cleanup action alternatives using the MTCA evaluation criteria (WAC 173-340-360[3][f]) is presented in Table 9 for the four Bulk Terminal Property cleanup action alternatives and the two West Commodore Way ROW cleanup action alternatives and discussed in the following subsections, respectively.

5.7.1 Bulk Terminal Property, Cleanup Action Alternatives

This section provides a comparative analysis of the four Bulk Terminal Property cleanup action alternatives.

- **Protectiveness.** Cleanup Action Alternative 3 scores the highest compared to the other alternatives for this criterion because it involves LNAPL source removal by excavation. Cleanup Action Alternative 4 scores lower than the other three alternatives for this criterion because contaminated unsaturated zone soils are not excavated and there is uncertainty as to whether these soils would be treated sufficiently or in a reasonable time frame by in situ methods alone. Depending on compliance monitoring of soil conditions over time, engineering or institutional controls may be warranted for Cleanup Action Alternative 4.

- **Permanence.** All cleanup action alternatives provide a permanent solution to the reduction of toxicity, mobility, and volume of COPCs through either biological, chemical, or physical means. Cleanup Action Alternative 3 would achieve the cleanup levels in soil more quickly than Cleanup Action Alternatives 1, 2, and 4. Cleanup Action Alternatives 1, 2, and 4 have lower scores than Cleanup Action Alternative 3 because the former rely on in situ processes to mitigate risks whereas the latter provide for the permanent removal and treatment and disposal of the COPCs.
- **Effectiveness over the Long Term.** The long-term effectiveness of Cleanup Action Alternative 3 are greater than that of Cleanup Action Alternatives 1, 2, and 4 due to the higher degree of permanence achieved by the Cleanup Action Alternative 3. Cleanup Action Alternative 3 is the most effective of the alternatives over the long term because it includes the physical removal of more contaminated source material.
- **Management of Short-Term Risks.** The short-term risks are substantial for all cleanup action alternatives and the scores are low to reflect these risks. Significant risks are posed to workers for all of the cleanup action alternatives from hazards posed by drilling equipment, shoring, heavy equipment use, and transportation-related accidents. These risks improve slightly for Cleanup Action Alternatives 3 and 4. Cleanup Action Alternative 4 presents the least amount of short-term risks and therefore scores the highest.
- **Technical and Administrative Implementability.** Cleanup Action Alternative 4 scores much higher than Cleanup Action Alternatives 1 through 3 because Cleanup Action Alternative 4 is more readily implementable. There are significant technical and administrative obstacles to implementation of the Cleanup Action Alternatives 1 through 3. Shoring the TOC Headquarter Building presents extraordinary technical challenges requiring structural and geotechnical engineering expertise during the design process. The permitting process with the City of Seattle DPD to approve the shoring plan is time consuming and presents unique administrative obstacles common to Cleanup Alternatives 1, 2, and 3. Cleanup Alternative 4, however, scores much higher because it does not involve excavation. Cleanup Action Alternative 3 scores higher than Cleanup Action Alternatives 1 and 2 because it avoids the O&M of a remedial treatment system which simplifies the implementation of this remedy over the long term after the Phase I excavation is completed.

Results of the comparative evaluation indicate Cleanup Action Alternative 3 ranks the highest with a total ranking score of 35 (Table 9). Cleanup Action Alternative 4 ranks second with a total ranking score of 33. Cleanup Action Alternatives 1 and 2 has total ranking scores of 28 and 29, respectively.

5.7.2 West Commodore Way ROW, Cleanup Action Alternatives

This section provides a comparative analysis of the two West Commodore Way ROW cleanup action alternatives.

- **Protectiveness.** Cleanup Action Alternative 2 ranks higher than Cleanup Action Alternative 1 because it involves source removal by excavation and MPE for residual LNAPL and dissolved-phase TPH plume remediation.
- **Permanence.** Both cleanup action alternatives provide a permanent solution to the reduction of toxicity, mobility, and volume of COPCs through physical and biological mechanisms. Cleanup Action Alternative 2 scores higher for this criterion because it removes the majority of the source LNAPL for permanent destruction through treatment. Cleanup Action Alternative 1 also provides permanent reduction in toxicity, mobility, and volume of the COPCs through treatment, but uses in situ treatment technologies to achieve these reductions. In situ treatment is regarded as less permanent than source removal because of uncertainty relating to the permanent treatment effectiveness of in situ technologies.
- **Effectiveness over the Long Term.** For the same reasons listed for the "protectiveness" and "permanence" criteria, Cleanup Action Alternative 2 is judged to exhibit a higher degree of long-term effectiveness than Cleanup Action Alternative 1. Cleanup Action Alternative 2 is more effective over the long term because it includes the physical removal of more contaminated source material.
- **Management of Short-Term Risks.** The short-term risks are greater for Cleanup Action Alternative 2 when compared to Cleanup Action Alternative 1 because the former poses extra risks from excavation and hauling that are not associated with the latter alternative.
- **Technical and Administrative Implementability.** There are significant technical and administrative obstacles for implementing both of the cleanup action alternatives. Drilling and excavating within the ROW presents extraordinary technical challenges requiring structural and geotechnical engineering expertise during the design process. The permitting process with the City of Seattle DPD to approve the work within the ROW is time consuming and poses significant administrative obstacles common to both cleanup action alternatives. In comparison, Cleanup Action Alternative 1 scores much higher than Cleanup Action Alternative 2 because the former alternative does not involve excavating within the ROW.

Results of the comparative evaluation indicate Cleanup Action Alternative 2 ranks the higher than Cleanup Action Alternative 1 (Table 9). Cleanup Action Alternatives 1 and 2 have total ranking scores of 33 and 35, respectively.

5.8 DISPROPORTIONATE COST ANALYSIS

The disproportionate cost analysis involves comparing the costs and benefits of cleanup action alternatives and selecting the alternative whose incremental costs are not disproportionate to the incremental benefits. Costs are considered disproportionate to benefits if the incremental costs of one alternative versus a less expensive alternative exceed the incremental degree of benefit achieved by the more expensive alternative. The following is a description of the factors that were used to estimate the cost of the alternatives discussed above.

- **Capital Costs.** Direct capital costs include expenditures for equipment, labor, and material necessary to implement a remedial action. Indirect capital costs are those costs incurred for engineering, project management, financial, or other services not directly involved with implementation of remedial alternatives but necessary for completion of this activity.

- **Operation and Maintenance Costs.** These costs are post-construction costs necessary to provide effective implementation of the alternative. Such costs may include, but are not limited to the following: operating labor; maintenance materials and labor; disposal of residues; and administrative, insurance, and licensing costs.
- **Monitoring Costs.** These costs are incurred from monitoring activities associated with remedial activities. Cost items may include sampling labor, laboratory, analyses, and report preparation.
- **Other Direct Costs.** These costs are future post-remediation costs necessary to complete the alternative. The costs are typically incurred for one-time events and may include labor, equipment, and material for environmental engineering, compliance monitoring, or other indirect services.
- **Present Worth Analysis.** Present worth analysis provides a method of evaluating and comparing costs that occur over different time periods by discounting all future expenditures to the present year. The present worth cost or value represents the amount of money which, if invested in year 0 and disbursed as needed, would be sufficient to cover all costs associated with a remedial alternative. The assumptions necessary to derive a present worth cost are inflation rate, discount rate, and period of performance. A discount rate, which is similar to an interest rate, is used to account for the time value of money. EPA policy on the use of discount rates for RI/FS cost analyses is stated in the preamble to the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) published at the Federal Register (55 FR 8722) and in Office of Solid Waste and Emergency Response Directive 9355.3-20 titled Revisions to the Executive Office of the President, Office of Management and Budget (OMB) Circular A-94 on Guidelines and Discount Rates for Benefit-Cost Analysis (OMB 1993). Based on the NCP and this directive, a discount rate of 7 percent is recommended when developing present value cost estimates for remedial action alternatives during the feasibility study. This specified rate of 7 percent represents a "real" discount rate in that it approximates the marginal pretax rate of return on an historical average investment in the private sector adjusted to eliminate the effect of expected inflation. For this FS Report, a more conservative real discount rate of 0.9 percent is used based on the December 2013 revisions to Appendix C of the OMB Circular A-94. The real discount rates used to estimate the present worth of annual operating costs are based on the estimated restoration time frame (life cycle) for each alternative and are extrapolated from the referenced circular, which is published annually by the OMB in December.

  It is assumed that all capital and other direct costs are incurred in year 0. The present worth analysis is performed only on annual O&M and groundwater monitoring costs. The total present worth for a given alternative is equal to the sum of the capital and other direct costs and the present worth of annual O&M and monitoring costs over the anticipated life cycle of the alternative.

Using these criteria, and relying on the assumptions outlined in Section 5.6, the estimated present worth costs for the four cleanup action alternatives for the Bulk Terminal Property and the two cleanup action alternatives for the West Commodore Way ROW are as follows:

Bulk Terminal Property

- Bulk Terminal Property, Cleanup Action Alternative 1, $6,029,000 (Table 3)
- Bulk Terminal Property, Cleanup Action Alternative 2, $5,796,000 (Table 4)
- Bulk Terminal Property, Cleanup Action Alternative 3, $4,841,000 (Table 5)
- Bulk Terminal Property, Cleanup Action Alternative 4, $3,980,000 (Table 6)

Although Bulk Terminal Property Cleanup Action Alternative 3 ranks slightly higher than Cleanup Action Alternative 4 in the comparison evaluation presented in Section 5.7, the cost of Cleanup Action Alternative 4 is less than Cleanup Action Alternative 3. In addition, the cost of Cleanup Action Alternative 4 is significantly less than Cleanup Action Alternatives 1 and 2. Chart 1 plots the relative cost and ranking scores, and Chart 2 plots the cost–to-benefit ratios for the four alternatives for the Bulk Terminal Property to illustrate the relative cost and benefits afforded by each alternative. The charts indicate that Bulk Terminal Property Cleanup Action Alternative 4 exhibits the lowest cost-to-benefit ratio.

West Commodore Way ROW

- West Commodore Way ROW, Cleanup Action Alternative 1, $2,986,000 (Table 7)
- West Commodore Way ROW, Cleanup Action Alternative 2, $2,455,000 (Table 8)

The West Commodore Way ROW Cleanup Action Alternative 2 ranks higher than Cleanup Action Alternative 1 in the comparison evaluation presented in Section 5.7. The cost of Cleanup Action Alternative 2 is also less than Cleanup Action Alternative 1. Chart 3 plots the relative cost and ranking scores, and Chart 4 plots the cost–to-benefit ratios for the two alternatives for the West Commodore Way ROW to illustrate the relative cost and benefits afforded by each alternative. The charts indicate that West Commodore Way ROW Cleanup Action Alternative 2 exhibits the lowest cost-to-benefit ratio.

5.9 RECOMMENDED CLEANUP ACTION ALTERNATIVES

The following subsections described the recommended cleanup action alternatives for the Bulk Terminal Property and West Commodore Way ROW.

5.9.1 Bulk Terminal Property

After performing the comparative analysis and ranking of alternatives in accordance with the MTCA evaluation criteria, Cleanup Action Alternative 4 is the recommended alternative for the Bulk Terminal Property. MPE and MNA are proven technologies for the remediation of the contaminants and affected environmental media identified in the RI. Cleanup Action Alternative 4 meets the threshold requirements for cleanup actions set forth in WAC 173-340-360(3) and WAC 173-340-370. Cleanup Action Alternative 4 is protective of human health and the environment, is more easily implemented than competing alternatives, and provides a permanent solution for reducing concentrations of COPCs at the Site. The cost to implement Cleanup Action Alternative 4 is the lowest and exhibits the lowest cost-to-benefit ratio when compared to competing alternatives.

5.9.2 West Commodore Way ROW

Cleanup Action Alternative 2 is the recommended alternative for the West Commodore Way ROW based on the results of the comparative analysis and ranking of alternatives performed in accordance with the MTCA evaluation criteria. Excavation of source material combined with MPE and MNA are proven technologies for the remediation of the contaminants and media of concern identified in the RI. Cleanup Action Alternative 2 meets the threshold requirements for cleanup actions set forth in WAC 173-340-360(3) and WAC 173-340-370. Cleanup Action Alternative 2 is protective of human health and the environment, is more easily implemented than the competing alternative, and provides a permanent solution for reducing concentrations of COPCs at the Site. The cost to implement Cleanup Action Alternative 2 is lower and this alternative exhibits a lower cost-to-benefit ratio when compared to the competing alternative.

Details of the implementation of the recommended cleanup action alternatives for the Bulk Terminal Property and the West Commodore Way ROW and the decision process used to evaluate whether modifications to the selected approach are warranted will be provided in a draft Cleanup Action Plan.

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7.0 LIMITATIONS

The services described in this report were performed consistent with generally accepted professional consulting principles and practices. No other warranty, expressed or implied, is made. These services were performed consistent with our agreement with our client. This report is solely for the use and information of our client unless otherwise noted. Any reliance on this report by a third party is at such party’s sole risk.

Opinions and recommendations contained in this report apply to conditions existing when services were performed and are intended only for the client, purposes, locations, time frames, and project parameters indicated. We are not responsible for the impacts of any changes in environmental standards, practices, or regulations subsequent to performance of services. We do not warrant the accuracy of information supplied by others, or the use of segregated portions of this report.

FIGURES

P:\0440 TOC HOLDINGS CO\01-600 SEATTLE TERMINAL\TECHNICAL\CAD\FIGURE 1\01-600_FIG1_VICINITY_BULK.DWG

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DATE:	06/16/11
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CAD FILE:	0600_FIG1_VICINITY_BULK

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

FIGURE 1
PROPERTY LOCATION MAP

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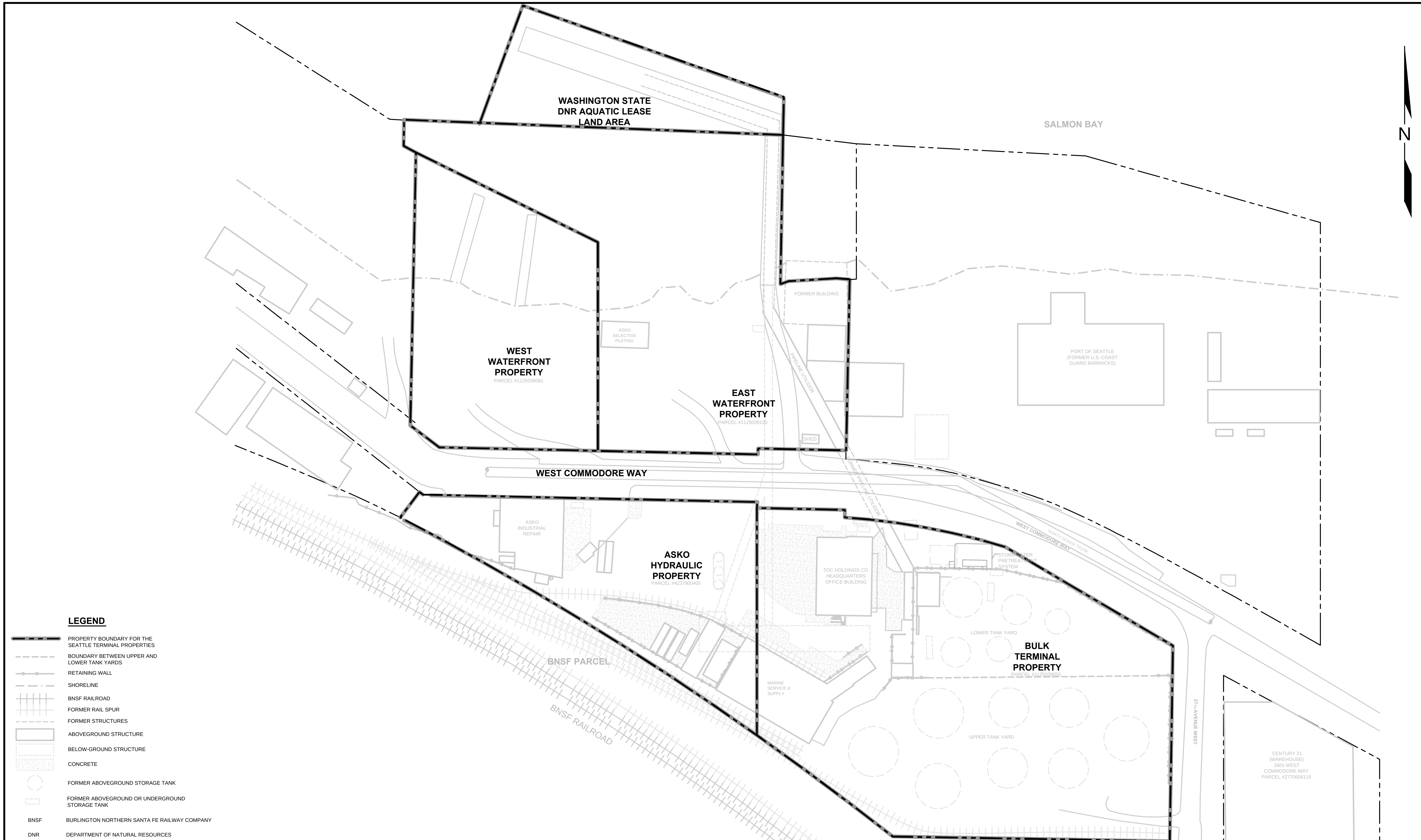

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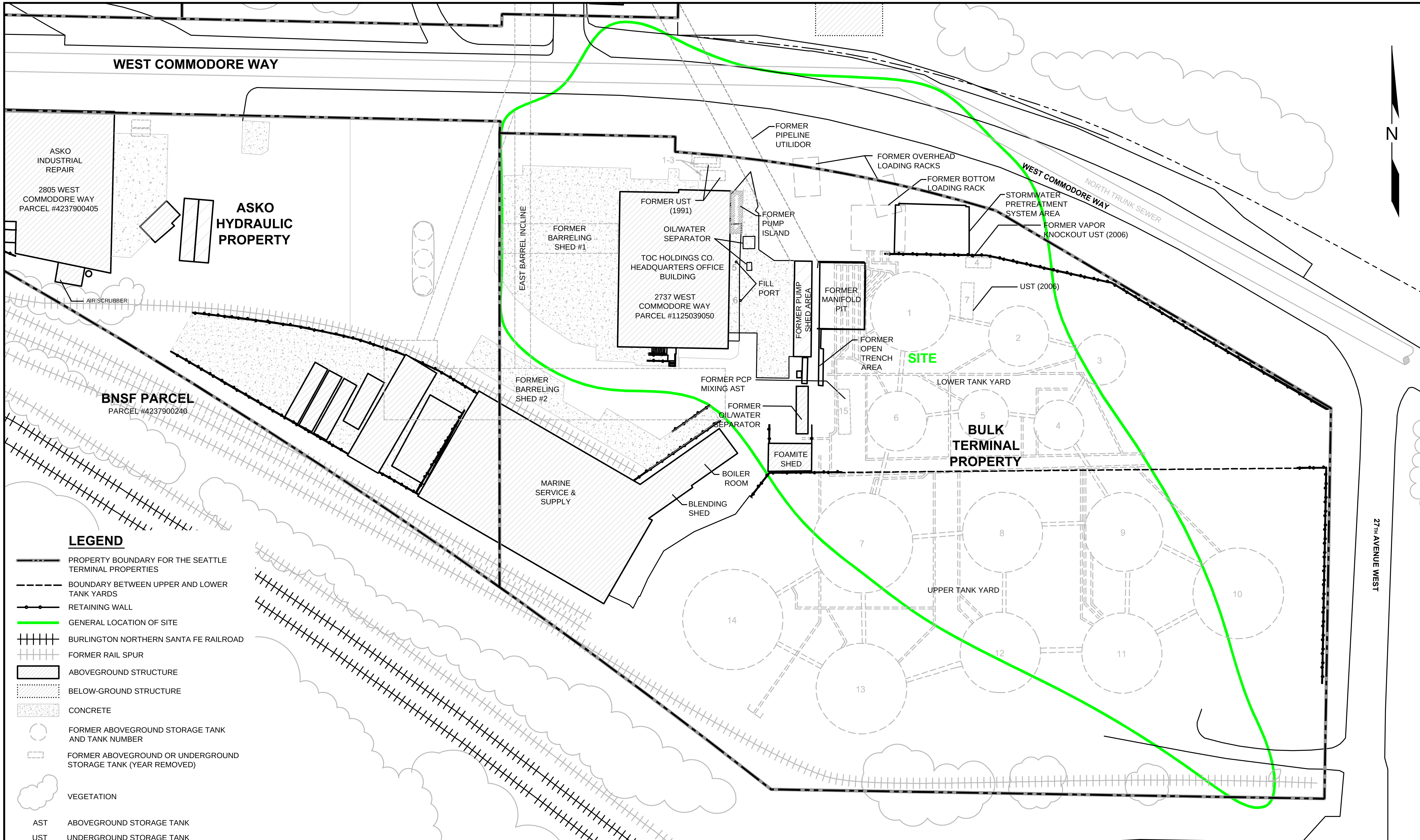
PROJECT NAME: TOC HOLDINGS CO. SEATTLE TERMINAL PROPERTIES
PROJECT NUMBER: 0440-004
STREET ADDRESS: 2737, 2750, 2800, AND 2805 WEST COMMODORE WAY
CITY, STATE: SEATTLE, WASHINGTON

REGION:

0 30 60 120 240
APPROXIMATE SCALE IN FEET

FIGURE 2
SEATTLE TERMINAL PROPERTIES
PROPERTY PLAN

P:\0440 TOC HOLDINGS CO\01-600 SEATTLE TERMINAL\TECHNICAL\CAD\2014\BTP\FS\01-600_2014FS_PP_F.DWG
6/18/2014



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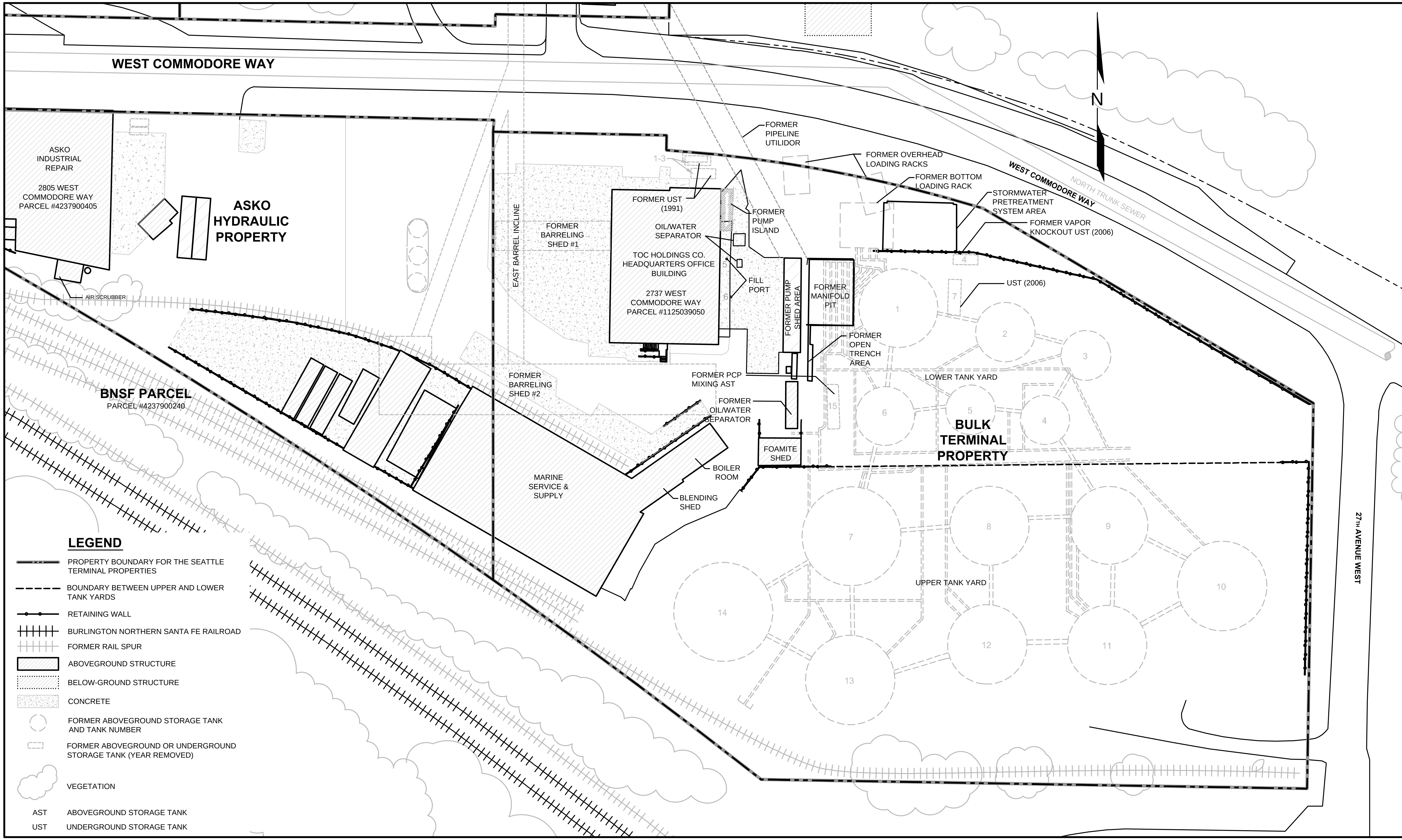
SES PROJECT NUMBER: 0440-004
STREET ADDRESS: 2737 WEST COMMODORE WAY
CITY, STATE: SEATTLE, WASHINGTON

REGION:

FIGURE 3
SITE BOUNDARY MAP

P:\0440 TOC HOLDINGS CO\01-600 SEATTLE TERMINAL\TECHNICAL\CAD\2014\BTP\FS\01-600_2014FS_SITES_F.DWG



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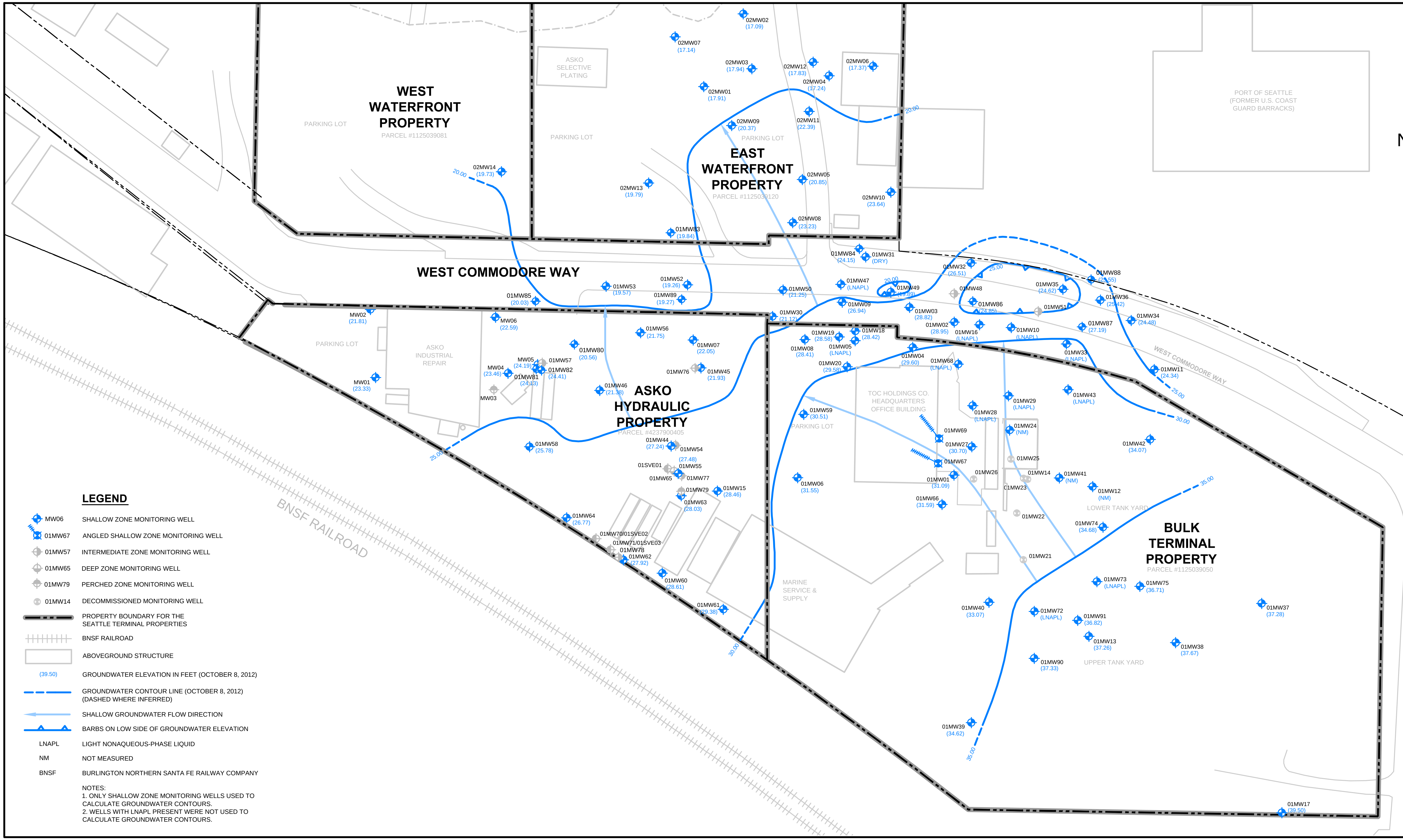
CITY, STATE: SEATTLE, WASHINGTON

REGION:

0 20 40 80
APPROXIMATE SCALE IN FEET

FIGURE 4
HISTORICAL FEATURES



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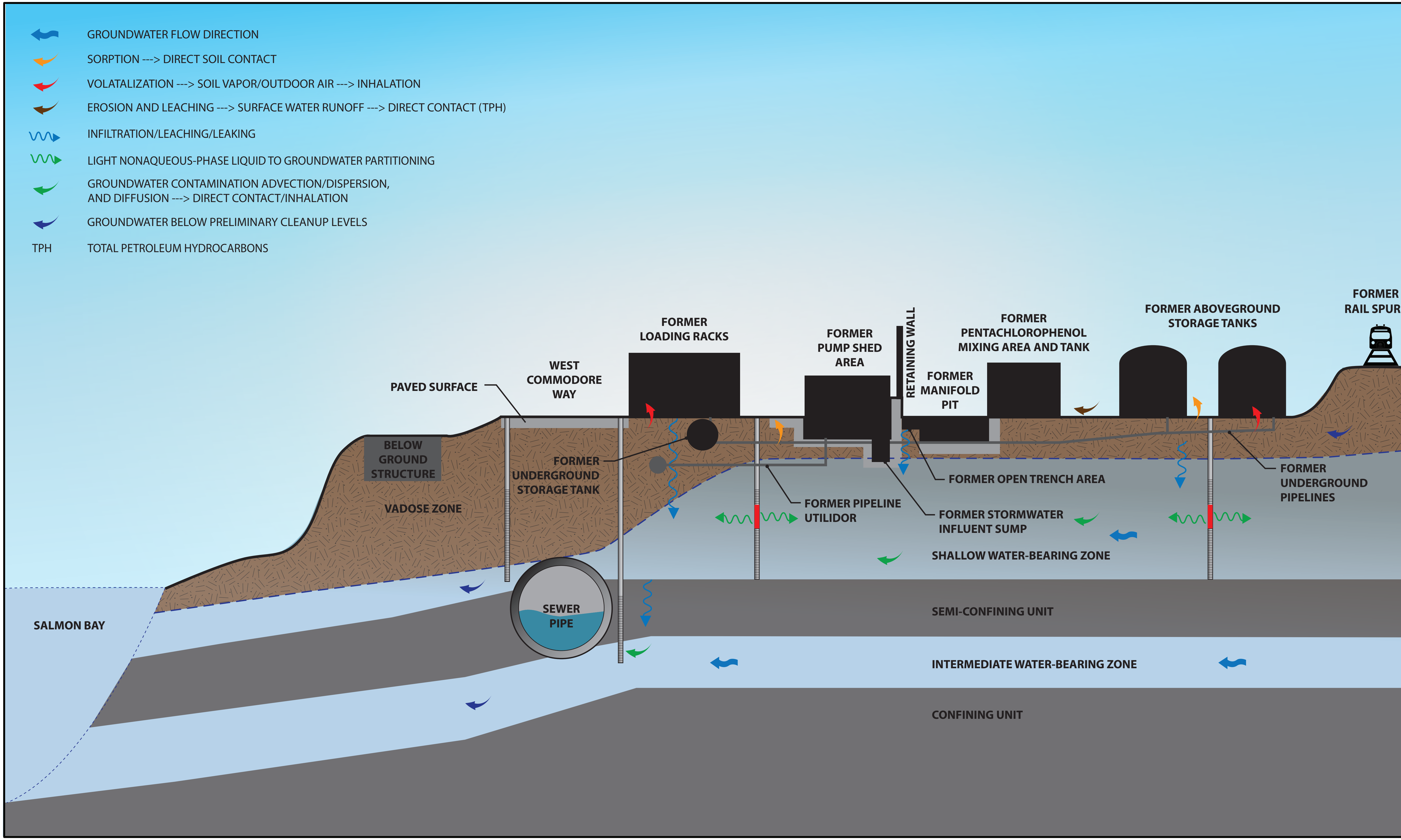
PROJECT NUMBER: 0440-004
STREET ADDRESS: 2737, 2750, 2800, AND 2805 WEST COMMODORE WAY
CITY, STATE: SEATTLE, WASHINGTON

REGION:

0 40 80 160
APPROXIMATE SCALE IN FEET

FIGURE 5
GROUNDWATER CONTOUR MAP
SHALLOW WATER-BEARING ZONE
(OCTOBER 8, 2012)



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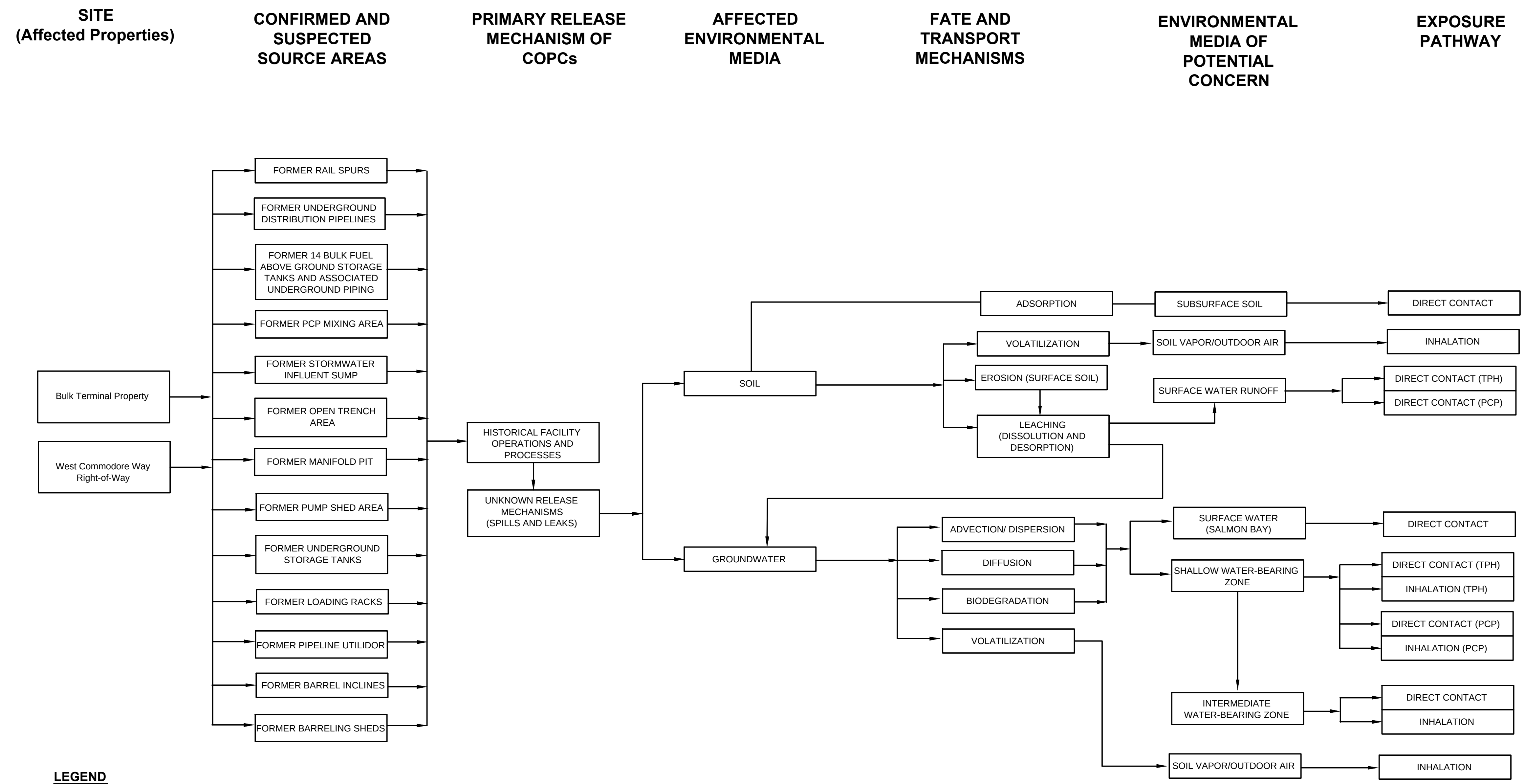
PROJECT NUMBER: 0440-004
STREET ADDRESS: 2737 WEST COMMODORE WAY
CITY, STATE: SEATTLE, WASHINGTON

REGION:

NO SCALE

FIGURE 6
CONCEPTUAL SITE MODEL



POTENTIAL RECEPTORS

Environmental Media	Exposure Pathway	HUMAN: Workers	HUMAN: Recreational	HUMAN: Drinking Water	HUMAN: Fish and Shellfish Consumption	ECOLOGICAL: Terrestrial	ECOLOGICAL: Aquatic Biota
Subsurface Soil	Direct Contact	●	X	NA	X	●	X
Soil Vapor/Outdoor Air	Inhalation	●	X	NA	X	●	X
Surface Water Runoff	Direct Contact (TPH)	●	X	NA	X	●	X
Surface Water Runoff	Direct Contact (PCP)	X	X	NA	X	X	X
Surface Water (Salmon Bay)	Direct Contact	X	X	X	X	X	X
Shallow Water-Bearing Zone	Direct Contact (TPH)	●	X		X	X	X
Shallow Water-Bearing Zone	Inhalation (TPH)	●	X		X	X	X
Shallow Water-Bearing Zone	Direct Contact (PCP)	●	X		X	X	X
Shallow Water-Bearing Zone	Inhalation (PCP)	X	X		X	X	X
Intermediate Water-Bearing Zone	Direct Contact		X		X	X	X
Intermediate Water-Bearing Zone	Inhalation		X		X	X	X
Soil Vapor/Outdoor Air	Inhalation	●	X	X	X	●	X

LEGEND

●	EXPOSURE PATHWAY COMPLETE FOR POTENTIAL RECEPTOR
(blank)	EXPOSURE PATHWAY COULD BE COMPLETE, BUT THE POTENTIAL RECEPTOR IS UNLIKELY
X	EXPOSURE PATHWAY INCOMPLETE
NA	NOT APPLICABLE
UST	UNDERGROUND STORAGE TANK
PCP	PENTACHLOROPHENOL
TPH	TOTAL PETROLEUM HYDROCARBONS
COPC	CHEMICAL OF POTENTIAL CONCERN

NOTE: DIRECT CONTACT INCLUDES DERMAL AND INGESTION

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SES PROJECT NUMBER: 0440-004
STREET ADDRESS: 2737 WEST COMMODORE WAY
CITY, STATE: SEATTLE, WASHINGTON

REGION:

NOT TO SCALE

FIGURE 7
PRELIMINARY EXPOSURE ASSESSMENT
CONCEPTUAL SITE MODEL
BULK TERMINAL PROPERTY

6/18/2014
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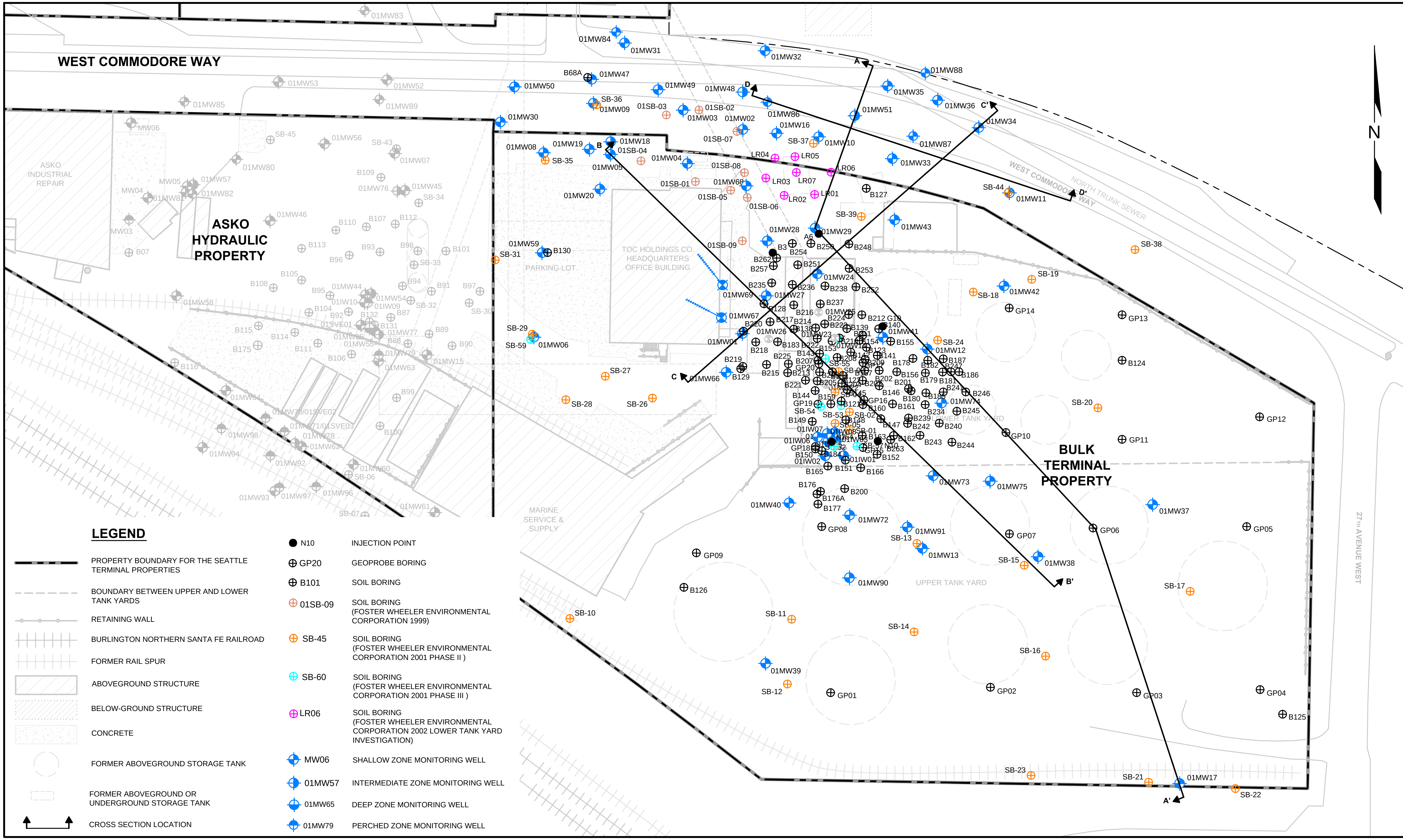

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STREET ADDRESS:	2737 WEST COMMODORE WAY
CITY, STATE:	SEATTLE, WASHINGTON

REGION:

0 30 60 120
APPROXIMATE SCALE IN FEET

FIGURE 8
CROSS SECTION LOCATION MAP

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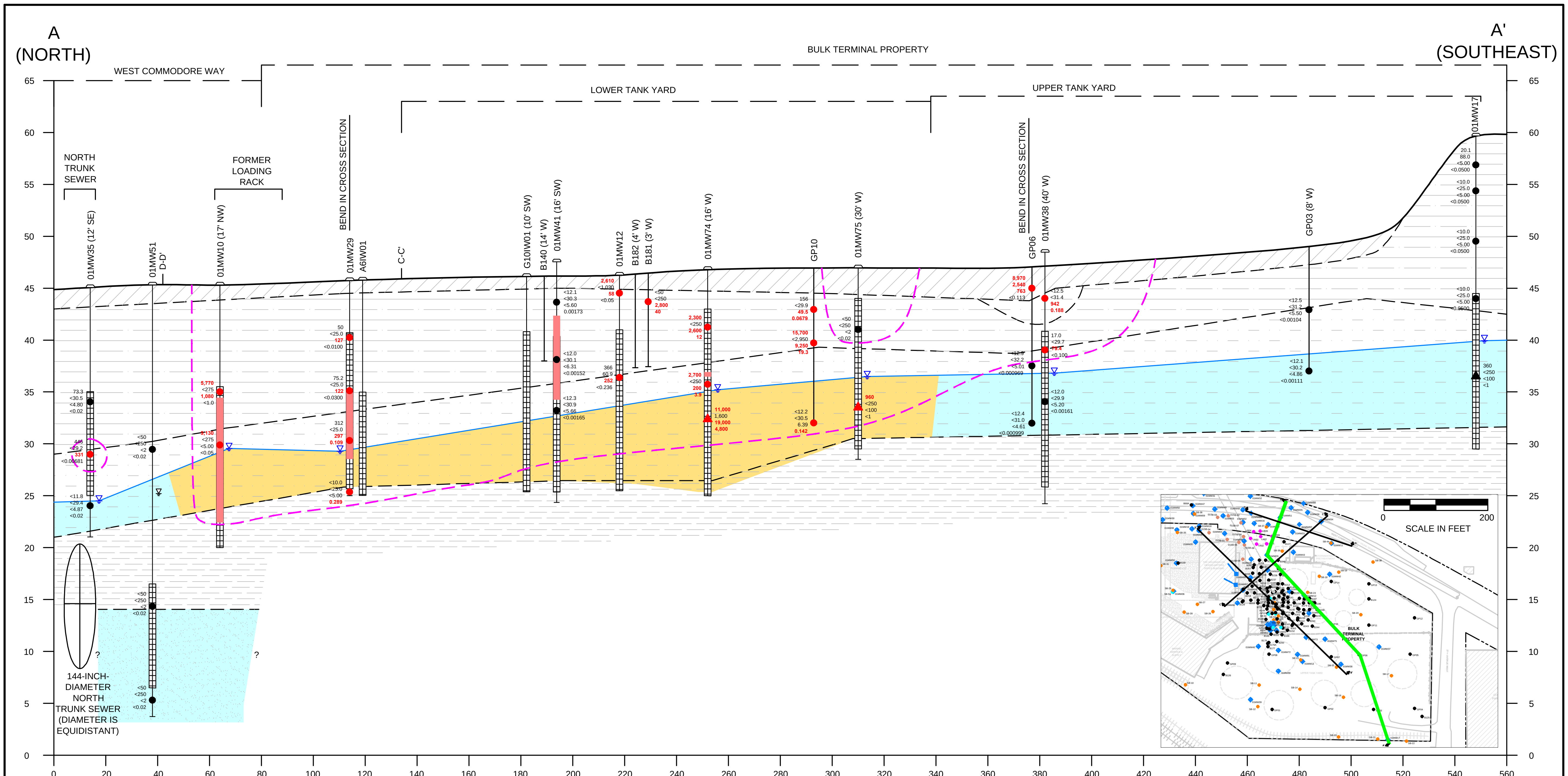
P:\0440 TOC HOLDINGS CO\01-600 SEATTLE TERMINAL\TECHNICAL\CAD\2014\BTP\FS\01-600_2014FS_XSLOC_F.DWG
6/18/2014



6/18/2014

LEGEND

(6' W)	OFFSET 6' WEST FROM SECTION LINE
	MONITORING WELL
	SCREEN INTERVAL
	INTERMEDIATE ZONE GROUNDWATER LEVEL (OCTOBER 2012)
	SHALLOW ZONE GROUNDWATER LEVEL (OCTOBER 2012)

HISTORICAL CONCENTRATIONS OF TPH IN SOIL (mg/kg):

- ● CONCENTRATION BELOW MTCA METHOD A CLEANUP LEVEL
- ● CONCENTRATION ABOVE MTCA METHOD A CLEANUP LEVEL

HISTORICAL CONCENTRATIONS OF TPH IN GROUNDWATER IN OCTOBER, 2012 (μg/L):

- ▲ CONCENTRATION BELOW MTCA METHOD A CLEANUP LEVEL
- ▲ CONCENTRATION ABOVE MTCA METHOD A CLEANUP LEVEL

- HISTORICAL LIGHT NONAQUEOUS-PHASE LIQUID
- TPH CONTAMINATION IN SOIL
- TPH CONTAMINATION IN GROUNDWATER
- GROUNDWATER

- SAND, SILTY SAND, AND GRAVEL (Hf)
- SAND AND SILTY SAND (Hdf)
- SAND, SILT AND CLAY (Hdf)
- SILT AND CLAY (Qpf)
- SAND AND SILTY SAND (Qpf)
- INFERRED CONTACT

AST	ABOVEGROUND STORAGE TANK
TPH	TOTAL PETROLEUM HYDROCARBONS
--	NOT ANALYZED
<	RESULT BELOW LABORATORY REPORTING LIMIT
mg/kg	MILLIGRAMS PER KILOGRAM
µg/L	MICROGRAMS PER LITER
MTCA	WASHINGTON STATE MODEL TOXICS CONTROL ACT

NOTE: ALL LOCATIONS ARE APPROXIMATE.

2,300	DIESEL-RANGE PETROLEUM HYDROCARBONS
<250	OIL-RANGE PETROLEUM HYDROCARBONS
2,600	GASOLINE-RANGE PETROLEUM HYDROCARBONS
12	BENZENE
MTCA	WASHINGTON STATE MODEL TOXICS CONTROL ACT
RED	DENOTES CONCENTRATION EXCEEDS MTCA METHOD A CLEANUP LEVEL
Hf	HOLOCENE FILL
Hdf	HOLOCENE DEPRESSION FILLINGS
Qpf	PRE-FRASER DEPOSITS

VERTICAL SCALE IN FEET: 0, 5, 10
HORIZONTAL SCALE IN FEET: 0, 20, 40

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

REGION:

SCALE DEPICTED ABOVE

FIGURE 9
CROSS SECTION A-A'

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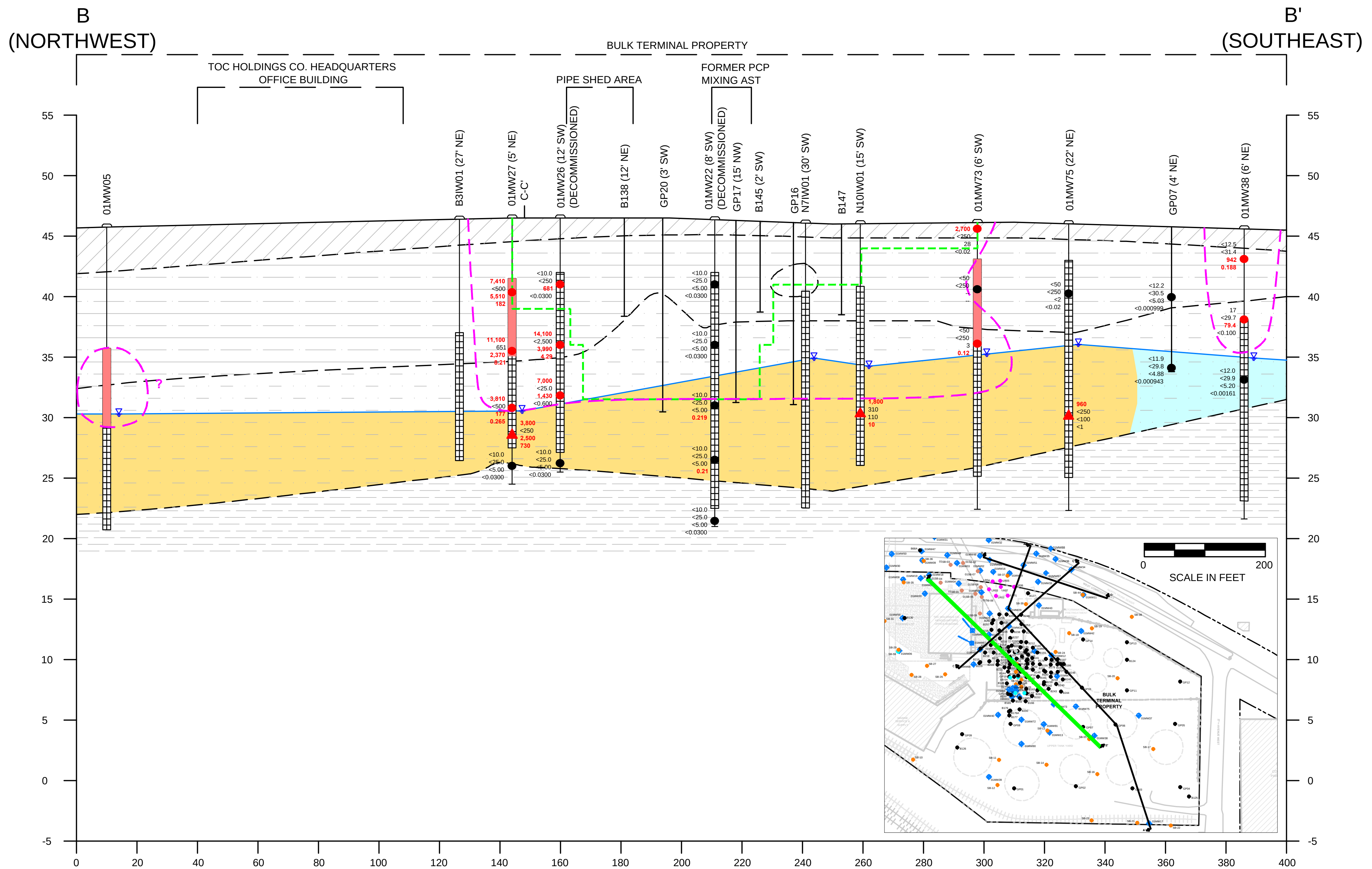

LEGEND

(6' W)	OFFSET 6' WEST FROM SECTION LINE
	MONITORING WELL
	SCREEN INTERVAL
	SHALLOW ZONE GROUNDWATER LEVEL (OCTOBER 2012)

HISTORICAL CONCENTRATIONS OF TPH IN SOIL (mg/kg):
- CONCENTRATION BELOW MTCA METHOD A CLEANUP LEVEL
- CONCENTRATION ABOVE MTCA METHOD A CLEANUP LEVEL

HISTORICAL CONCENTRATIONS OF TPH IN GROUNDWATER IN OCTOBER, 2012 (µg/L):
- CONCENTRATION BELOW MTCA METHOD A CLEANUP LEVEL
- CONCENTRATION ABOVE MTCA METHOD A CLEANUP LEVEL

- HISTORICAL LIGHT NONAQUEOUS-PHASE LIQUID
- TPH CONTAMINATION IN SOIL
- TPH CONTAMINATION IN GROUNDWATER
- GROUNDWATER
- APPROXIMATE 2012 EXCAVATION LIMITS
- SAND, SILTY SAND, AND GRAVEL (Hf)
- SAND AND SILTY SAND (Hdf)
- SAND, SILT AND CLAY (Hdf)
- SILT AND CLAY (Qpf)
- INFERRED CONTACT

AST	ABOVEGROUND STORAGE TANK
TPH	TOTAL PETROLEUM HYDROCARBONS
--	NOT ANALYZED
<	RESULT BELOW LABORATORY REPORTING LIMIT
mg/kg	MILLIGRAMS PER KILOGRAM
µg/L	MICROGRAMS PER LITER
MTCA	WASHINGTON STATE MODEL TOXICS CONTROL ACT

NOTE: ALL LOCATIONS ARE APPROXIMATE.

3,800	DIESEL-RANGE PETROLEUM HYDROCARBONS
<250	OIL-RANGE PETROLEUM HYDROCARBONS
2,500	GASOLINE-RANGE PETROLEUM HYDROCARBONS
730	BENZENE
MTCA	WASHINGTON STATE MODEL TOXICS CONTROL ACT
RED	DENOTES CONCENTRATION EXCEEDS MTCA METHOD A CLEANUP LEVEL
Hf	HOLOCENE FILL
Hdf	HOLOCENE DEPRESSION FILLINGS
Qpf	PRE-FRASER DEPOSITS

VERTICAL SCALE IN FEET: 0, 5, 10
HORIZONTAL SCALE IN FEET: 0, 20, 40

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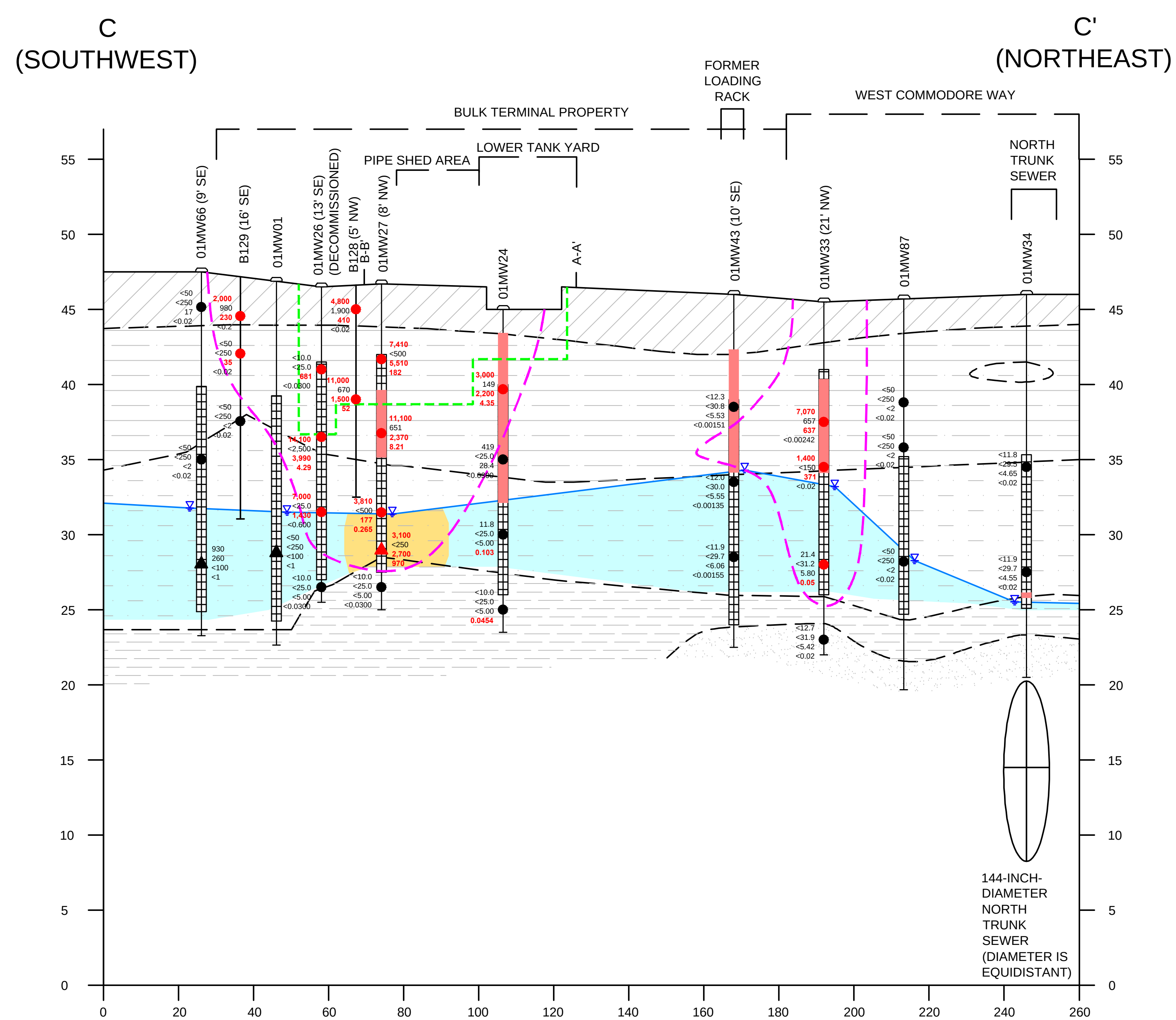
PROJECT NUMBER: 0440-004
STREET ADDRESS: 2737 WEST COMMODORE WAY
CITY, STATE: SEATTLE, WASHINGTON

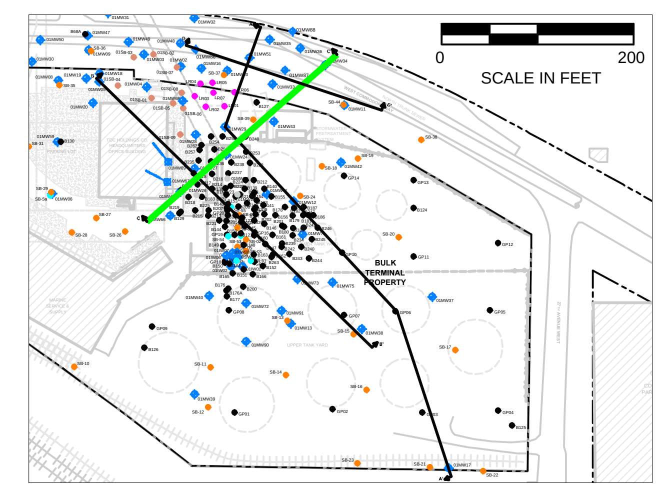
REGION:

SCALE DEPICTED ABOVE

FIGURE 10
CROSS SECTION B-B'

P:\0440 TOC HOLDINGS CO\01-600 SEATTLE TERMINAL\TECHNICAL\CAD\2014\BT\FS\01-600_2014FS_XBB_F.DWG





LEGEND

(6' W) OFFSET 6' WEST FROM SECTION LINE

MONITORING WELL

SCREEN INTERVAL

SHALLOW ZONE GROUNDWATER LEVEL (OCTOBER 2012)

HISTORICAL CONCENTRATIONS OF TPH IN SOIL (mg/kg):

- CONCENTRATION BELOW MTCA METHOD A CLEANUP LEVEL
- CONCENTRATION ABOVE MTCA METHOD A CLEANUP LEVEL

HISTORICAL CONCENTRATIONS OF TPH IN GROUNDWATER IN OCTOBER, 2012 (µg/L):

- CONCENTRATION BELOW MTCA METHOD A CLEANUP LEVEL
- CONCENTRATION ABOVE MTCA METHOD A CLEANUP LEVEL

HISTORICAL LIGHT NONAQUEOUS-PHASE LIQUID

TPH CONTAMINATION IN SOIL

TPH CONTAMINATION IN GROUNDWATER

GROUNDWATER

APPROXIMATE 2012 EXCAVATION LIMITS

SAND, SILTY SAND, AND GRAVEL (Hf)

SAND AND SILTY SAND (Hdf)

SAND, SILT AND CLAY (Hdf)

SILT AND CLAY (Qpf)

SAND AND SILTY SAND (Qpf)

INFERRED CONTACT

AST	ABOVEGROUND STORAGE TANK
TPH	TOTAL PETROLEUM HYDROCARBONS
--	NOT ANALYZED
<	RESULT BELOW LABORATORY REPORTING LIMIT
mg/kg	MILLIGRAMS PER KILOGRAM
µg/L	MICROGRAMS PER LITER
MTCA	WASHINGTON STATE MODEL TOXICS CONTROL ACT

NOTE: ALL LOCATIONS ARE APPROXIMATE.

3,100	DIESEL-RANGE PETROLEUM HYDROCARBONS
<250	OIL-RANGE PETROLEUM HYDROCARBONS
2,700	GASOLINE-RANGE PETROLEUM HYDROCARBONS
970	BENZENE
MTCA	WASHINGTON STATE MODEL TOXICS CONTROL ACT
RED	DENOTES CONCENTRATION EXCEEDS MTCA METHOD A CLEANUP LEVEL
Hf	HOLOCENE FILL
Hdf	HOLOCENE DEPRESSION FILLINGS
Qpf	PRE-FRASER DEPOSITS

VERTICAL SCALE IN FEET: 0 5 10

HORIZONTAL SCALE IN FEET: 0 20 40

SoundEarth Strategies
WWW.SOUNDEARTHINC.COM

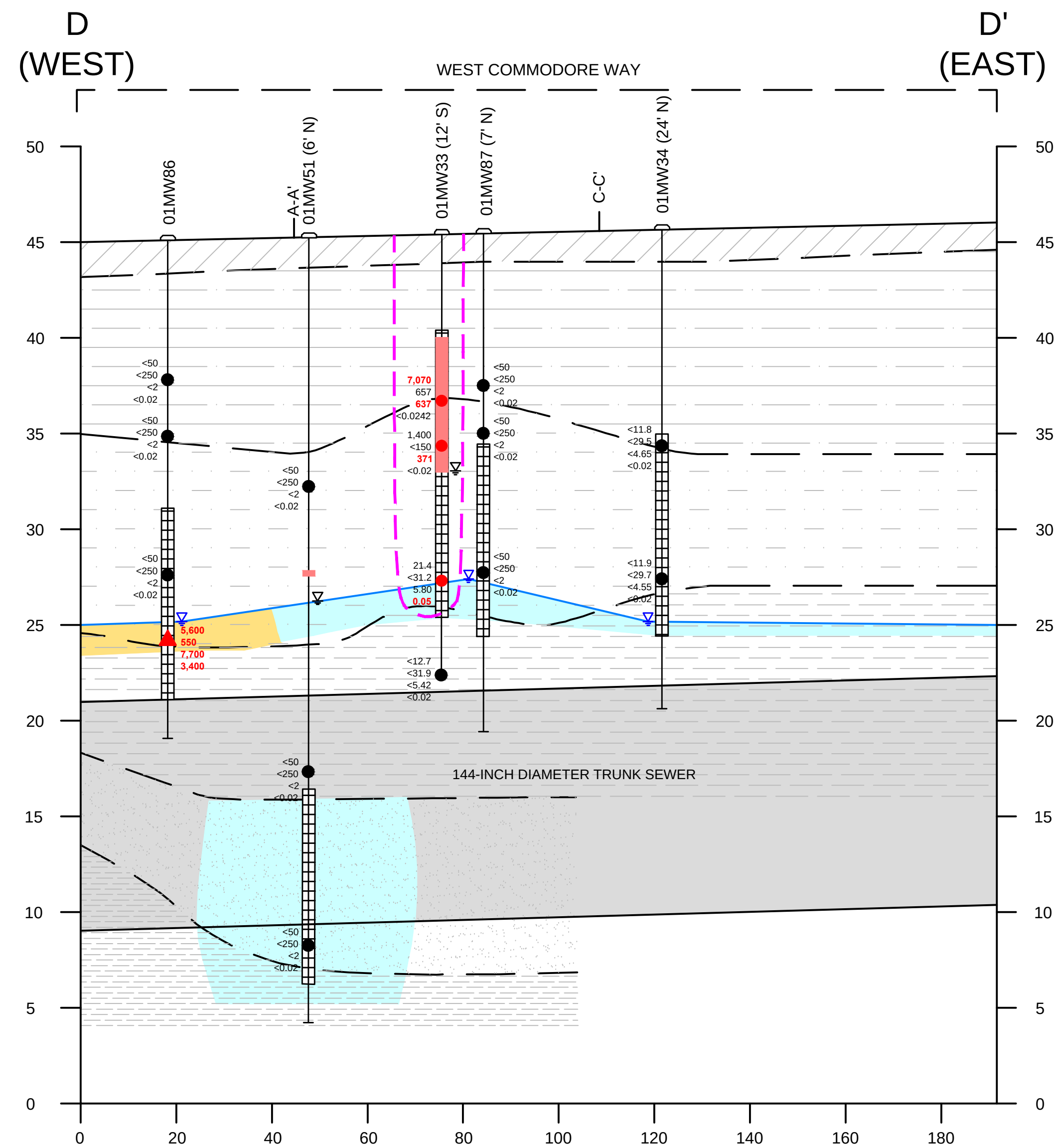
DATE: 07/12/13
DRAWN BY: NAC
CHECKED BY: JAB/TSB
CAD FILE: 01-600_2014FS_XCC

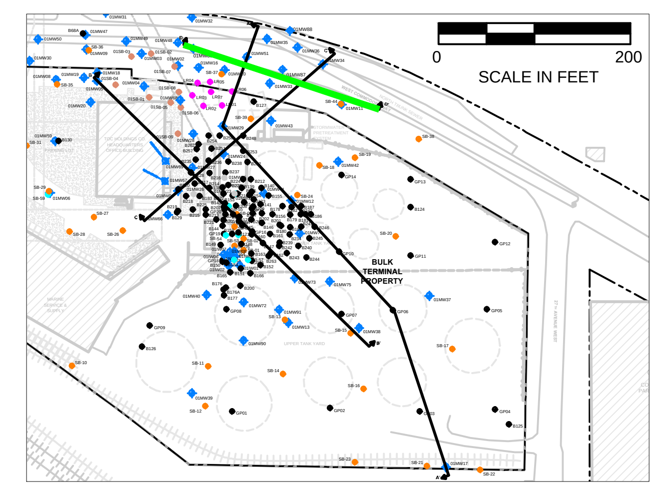
PROJECT NAME: TOC HOLDINGS CO. BULK TERMINAL PROPERTY
PROJECT NUMBER: 0440-004
STREET ADDRESS: 2737 WEST COMMODORE WAY
CITY, STATE: SEATTLE, WASHINGTON

REGION:

SCALE DEPICTED ABOVE

FIGURE 11
CROSS SECTION C-C'





LEGEND

(6' W) OFFSET 6' WEST FROM SECTION LINE

MONITORING WELL

SCREEN INTERVAL

INTERMEDIATE ZONE GROUNDWATER LEVEL (OCTOBER 2012)

SHALLOW ZONE GROUNDWATER LEVEL (OCTOBER 2012)

HISTORICAL CONCENTRATIONS OF TPH IN SOIL (mg/kg):

- CONCENTRATION BELOW MTCA METHOD A CLEANUP LEVEL
- CONCENTRATION ABOVE MTCA METHOD A CLEANUP LEVEL

HISTORICAL CONCENTRATIONS OF TPH IN GROUNDWATER IN OCTOBER, 2012 (µg/L):

- CONCENTRATION BELOW MTCA METHOD A CLEANUP LEVEL
- CONCENTRATION ABOVE MTCA METHOD A CLEANUP LEVEL

HISTORICAL LIGHT NONAQUEOUS-PHASE LIQUID

TPH CONTAMINATION IN SOIL

TPH CONTAMINATION IN GROUNDWATER

GROUNDWATER

SAND, SILTY SAND, AND GRAVEL (Hf)

SAND AND SILTY SAND (Hdf)

SAND, SILT AND CLAY (Hdf)

SILT AND CLAY (Qpf)

SAND AND SILTY SAND (Qpf)

INFERRED CONTACT

AST	ABOVEGROUND STORAGE TANK
TPH	TOTAL PETROLEUM HYDROCARBONS
--	NOT ANALYZED
<	RESULT BELOW LABORATORY REPORTING LIMIT
mg/kg	MILLIGRAMS PER KILOGRAM
µg/L	MICROGRAMS PER LITER
MTCA	WASHINGTON STATE MODEL TOXICS CONTROL ACT

NOTE: ALL LOCATIONS ARE APPROXIMATE.

7,070	DIESEL-RANGE PETROLEUM HYDROCARBONS
657	OIL-RANGE PETROLEUM HYDROCARBONS
637	GASOLINE-RANGE PETROLEUM HYDROCARBONS
<0.0242	BENZENE
MTCA	WASHINGTON STATE MODEL TOXICS CONTROL ACT
RED	DENOTES CONCENTRATION EXCEEDS MTCA METHOD A CLEANUP LEVEL
Hf	HOLOCENE FILL
Hdf	HOLOCENE DEPRESSION FILLINGS
Qpf	PRE-FRASER DEPOSITS

VERTICAL SCALE IN FEET 0 5 10

HORIZONTAL SCALE IN FEET 0 20 40

SoundEarth Strategies
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DATE: 07/12/13
DRAWN BY: NAC
CHECKED BY: JAB/TSB
CAD FILE: 01-600_2014FS_XDD

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

REGION:

SCALE DEPICTED ABOVE

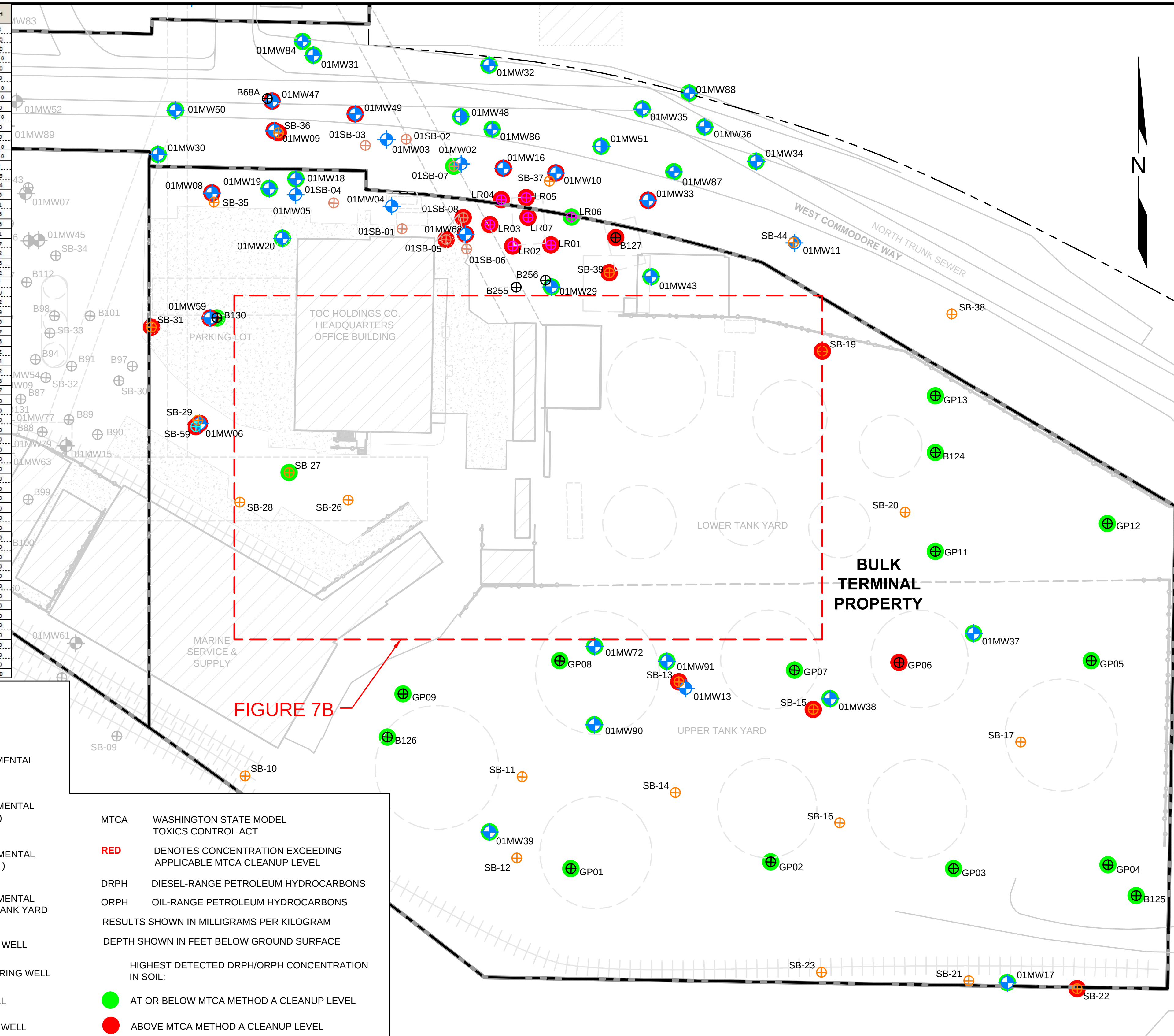
FIGURE 12
CROSS SECTION D-D'

6/18/2014

Sample Location	Date Sampled	Sample Depth	DRPH	ORPH
Bulk Terminal Property				
01SB05	06/06/99	10	2,450	<126
01SB08	06/06/99	12.5	33,900	<1,030
SB-27	11/00	5	1,190	<525
SB-13	2000	2	10,600	1,500
SB-15	2000	2	2,910	265
SB-19	2000	2	4,070	<275
		5	1,340	<75
SB-22	2000	5	19.4	<25.0
		10	6,490	<25.0
01MW06/SB-29	11/00	2	3,220	1,160
		5	1,930	488
SB-31	11/00	2	11,400	7,730
01MW08/SB-35	2000	5	1,190	631
		15	9,440	1,160
SB-39	2001	2	2,440	460
		5	1,300	157
SB-59	07/19/01	2	528	470
		5	4,950	1,170
		10	<10.0	<25.0
		15	<10.0	<25.0
		20	<10.0	<25.0
01MW17/SB-61	07/19/01	2	20.1	88.0
		5	<10.0	<25.0
		10	<10.0	<25.0
		15	<10.0	<25.0
01MW18/SB-65	03/11/02	5	<10.0	<25.0
		10	<10.0	<25.0
		15	676	<25.0
		20	<10.0	<25.0
		25	<10.0	<25.0
		30	<10.0	<25.0
01MW19/SB-66	03/11/02	5	42.9	70.1
		10	17.9	29.3
		15	<10.0	<25.0
		20	<10.0	<25.0
		25	<10.0	<25.0
01MW20/SB-67	03/11/02	5	112	75.2
		10	<10.0	<25.0
		15	<10.0	<25.0
		20	<10.0	<25.0
		25	<10.0	<25.0
01MW29	12/03/02	5	50	<25.0
		10	75.2	<25.0
		15	312	<25.0
		20	<10.0	<25.0
LR01	12/03/02	5	7,440	<1,000
		10	2,670	<250
		15	13,500	<2,500
		20	<10.0	<25.0
LR02	12/04/02	5	280	<25.0
		10	11,700	<2,500
		15	19,500	<2,500
		20	<10.0	<25.0
LR03	12/04/02	5	219	<25.0
		10	18,800	<2,500
		15	17,500	<25.0
LR07	12/02	5	4,230	<25.0
		10	5,840	<25.0
		15	11,400	<25.0
01MW37/SB-58	09/07/06	2.5	<12.7	<31.8
		7.5	<12.4	<31.0
		12.5	<12.5	<31.2
01MW38/SB-59	09/07/06	2.5	<12.5	<31.4
		7.5	17	<29.7
		12.5	<12.0	<29.9
MTCA Method A Cleanup Level			2,000	2,000

Sample Location	Date Sampled	Sample Depth	DRPH	ORPH
01MW39/SB-60	09/07/06	2.5	<12.3	<30.6
		7.5	<11.2	<28.0
		12.5	<13.0	<32.4
01MW43/SB-64	09/08/06	7.5	<12.3	<30.8
		12.5	<12.0	<30.0
		17.5	<11.9	<29.7
GP01	08/31/06	8	<12.6	<31.6
		11	<11.5	<28.6
		15	<12.1	<30.4
GP02	08/31/06	8	<12.4	<30.9
		11	<12.0	<30.0
		15	<12.4	<31.0
GP03	08/31/06	6	<12.5	<31.2
		12	<12.1	<30.2
GP04	08/31/06	8	<12.1	<30.2
		10	<12.7	<31.8
		15	<11.5	<28.7
GP05	08/31/06	8	<12.2	<30.6
		12	<12.2	<30.6
		15	<12.0	<29.9
GP06	08/31/06	2	8,970	2,540
		9.5	<12.9	<32.2
		15	<12.4	<31.0
GP07	08/31/06	5.5	<12.2	<30.5
		12	<11.9	<29.8
GP08	08/31/06	2.5	438	161
		6	<13.2	<32.9
		12	<12.3	<30.7
		15	<12.2	<30.4
GP09	09/01/06	8	<12.2	<30.6
		12	<11.8	<29.6
		15	<12.3	<30.6
GP11	09/01/06	8	<11.6	<29.1
		10	<12.1	<30.2
		15	<12.3	<30.8
GP12	09/01/06	12	<11.9	<29.6
		15	<11.7	<29.2
GP13	09/01/06	8	<11.1	<27.9
		12	<11.4	<28.5
		14	<11.9	<29.7
01MW59/B82	11/17/08	2.5	<50	<250
		5	7,100	1,400
		15	<50	<250
01MW68/B119	07/23/09	10.5	6,400	<250
		21	<50	<250
B124	12/28/09	2.5	<50	<250
		4.5	<50	<250
B125	12/28/09	4.5	<50	<250
B126	12/28/09	2.5	<50	<250
		4.5	<50	<250
B127	12/28/09	2.5	6,600	<250
		4.5	2,100	<250
		9.5	2,400	<250
B130	12/29/09	7.5	<50	<250
01MW72/B167	03/10/10	0.5	360	<250
01MW90/B198	12/29/11	2.5	<50	<250
		7.5	<50	<250
01MW91/B199	12/29/11	2.5	<50	<250
		5	<50	<250
		7.5	<50	<250
West Commodore Way				
01SB07	06/06/99	5	1,190	783
01MW09/SB-36	2000	15	11,300	<275
01MW10/SB-37	2000	10	5,770	<275
		15	9,130	<275
MTCA Method A Cleanup Level			2,000	2,000

Sample Location	Date Sampled	Sample Depth	DRPH	ORPH
01MW16/SB-60	07/19/01	2	58.7	79.8
		5	<10.0	<25.0
		10	<10.0	<25.0
		15	11,400	<2,520
		20	<10.0	<25.0
LR04	12/04/02	5	7,970	<500
		10	7,060	<1,000
		15	27,700	<5,000
LR05	12/04/02	5	2,990	<500
		10	14,600	<2,500
		15	5,780	<500
LR06	12/01/02	5	17.6	<500
		10	317	<1,000
		15	10.3	<1,000
01MW30/B01	04/21/06	2	293	428
		8	390	<61.5
		21	<11.4	<28.4
01MW31	07/06/06	10	<12.2	<30.5
		13	<11.7	<29.1
		20	<11.8	<29.5
		23	<11.8	<29.5
01MW32	07/06/06	10	<12.4	<31.1
		17.5	<11.5	<28.7
		20	<12.1	<30.2
		25	<12.3	<30.8
		27	<12.5	<31.2
01MW33	07/07/06	8.5	7,070	657
		11	1,400	<150
		18	21.4	<31.2
		23	<12.7	<31.9
01MW34	07/07/06	11	<11.8	<29.5
		18	<11.9	<29.7
01MW35	07/07/06	11	73.3	<30.5
		16	446	<29.2
		21	<11.8	<29.4
01MW36	07/07/06	11	<12.1	<30.2
		15	<11.1	<27.8
		21	<12.3	<30.7
01MW47/B68	11/29/06	10	<50	<250
		15	11,000	<250
		20	10,000	<250
		25	<50	<250
01MW48/B69	11/30/06	15	<50	<250
		23	<50	<250
		28	<50	<250
		35	<50	<250
01MW49/B70	12/21/06	10	<50	<250
		13	6,800	<250
		16	<50	<250
01MW50/B71	12/21/06	11	<50	<250
		18	<50	<250
		33	<50	<250
01MW51/B72	12/22/06	16	<50	<250
		31	<50	<250
		40	<50	<250
01MW84/B192	04/19/11	7.5	<50	<250
		15	<50	<250
01MW86/B194	04/20/11	7.5	<50	<250
		10	<50	<250
		17.5	<50	<250
01MW87/B195	04/20/11	7.5	<50	<250
		10	<50	<250
		17.5	<50	<250
01MW88/B196	04/21/11	7.5	<50	<250
		10	<50	<250
		17.5	<50	<250
MTCA Method A Cleanup Level			2,000	2,000



LEGEND

PROPERTY BOUNDARY FOR THE SEATTLE TERMINAL PROPERTIES

BOUNDARY BETWEEN UPPER AND LOWER TANK YARDS

RETAINING WALL

FORMER RAIL SPUR

ABOVEGROUND STRUCTURE

BELOW-GROUND STRUCTURE

CONCRETE

FORMER ABOVEGROUND STORAGE TANK

FORMER ABOVEGROUND OR UNDERGROUND STORAGE TANK

GP20 GEOPROBE BORING

B101 SOIL BORING

01SB-09 SOIL BORING (FOSTER WHEELER ENVIRONMENTAL CORPORATION 1999)

SB-45 SOIL BORING (FOSTER WHEELER ENVIRONMENTAL CORPORATION 2001 PHASE II)

SB-60 SOIL BORING (FOSTER WHEELER ENVIRONMENTAL CORPORATION 2001 PHASE III)

LR06 SOIL BORING (FOSTER WHEELER ENVIRONMENTAL CORPORATION 2002 LOWER TANK YARD INVESTIGATION)

MW06 SHALLOW ZONE MONITORING WELL

01MW57 INTERMEDIATE ZONE MONITORING WELL

01MW65 DEEP ZONE MONITORING WELL

01MW79 PERCHED ZONE MONITORING WELL

MTCA WASHINGTON STATE MODEL TOXICS CONTROL ACT

RED DENOTES CONCENTRATION EXCEEDING APPLICABLE MTCA CLEANUP LEVEL

DRPH DIESEL-RANGE PETROLEUM HYDROCARBONS

ORPH OIL-RANGE PETROLEUM HYDROCARBONS

RESULTS SHOWN IN MILLIGRAMS PER KILOGRAM

DEPTH SHOWN IN FEET BELOW GROUND SURFACE

HIGHEST DETECTED DRPH/ORPH CONCENTRATION IN SOIL:

AT OR BELOW MTCA METHOD A CLEANUP LEVEL

ABOVE MTCA METHOD A CLEANUP LEVEL

SoundEarth Strategies
WWW.SOUNDEARTHINC.COM

DATE: 06/28/13
DRAWN BY: NAC
CHECKED BY: JAB/TSB
CAD FILE: 01-600_2014FS_SD_DO

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

REGION:

0 30 60 120
APPROXIMATE SCALE IN FEET

FIGURE 13A

HISTORICAL SOIL ANALYTICAL RESULTS FOR DRPH AND ORPH

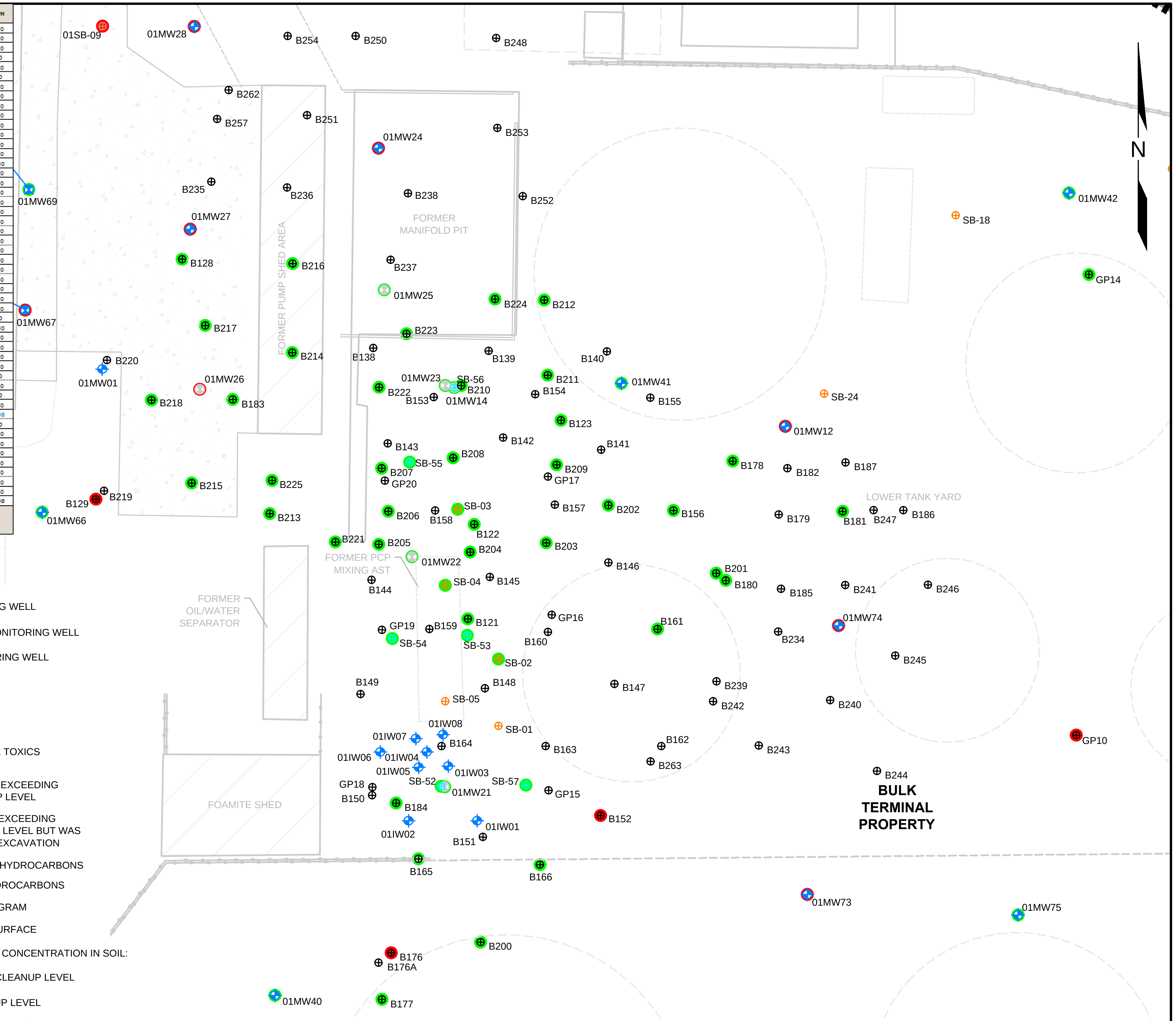
P:\0440 TOC HOLDINGS CO\01-600 SEATTLE TERMINAL\TECHNICAL\CAD\2014\BTP\FS\01-600_2014FS_SD_DO_F.DWG

6/18/2014

Sample Location	Date Sampled	Sample Depth	DRPH	ORPH
01SB09	06/06/99	2.5	1,780	514
		7	24,800	<525
		12.5	15,000	<525
		18	5,870	<525
SB-02	11/00	2	1,400	158
SB-03	11/00	0.5	2,010	4,780
		2	14,700	6,350
SB-04	11/00	2	5,670	2,320
		5	217	260
01MW12/SB-24	2000	2	2,610	<1,030
		10	366	60.9
SB-52	07/16/01	2.5	4,180	<1,020
		6	34.4	<25.0
		10	10.3	<25.0
SB-53	07/16/01	2	<10.0	<25.0
		5	<10.0	<25.0
		10	15.7	<25.0
SB-54	07/16/01	2	1,500	1,230
		5	<10.0	<25.0
		10	<10.0	<25.0
SB-55	07/16/01	2.5	<10.0	<25.0
		6	370	<75.0
		10	13.4	<25.0
01MW14/SB-56	07/17/01	2.5	28,300	<5,020
		5	2,040	<525
		10	<10.0	<25.0
SB-57	07/2001	1.5	3,970	881
01MW21	12/02/02	5	14	<25.0
		10	<10.0	<25.0
		15	<10.0	<25.0
		20	21.5	<25.0
		23	<10.0	<25.0
01MW22	12/02/02	5	<10.0	<25.0
		10	<10.0	<25.0
		15	<10.0	<25.0
		20	<10.0	<25.0
		25	<10.0	<25.0
01MW23	12/02/02	5	681	114
		10	32.5	<25.0
		15	<10.0	<25.0
		20	<10.0	<25.0
01MW24	12/03/02	5	3,000	149
		10	419	<25.0
		15	11.8	<25.0
		20	<10.0	<25.0
01MW25	12/03/02	5	<10.0	<25.0
		10	<10.0	<25.0
		15	<10.0	<25.0
		18	<10.0	<25.0
MTCA Method A Cleanup Level			2,000	2,000

Sample Location	Date Sampled	Sample Depth	DRPH	ORPH
01MW26	12/04/02	5	<10.0	<25.0
		10	14,100	<2,500
		15	7,000	<25.0
		20	<10.0	<25.0
01MW27	12/04/02	5	7,410	<500
		10	11,100	651
		15	3,810	<500
		20	<10.0	<25.0
01MW28	12/03/02	5	1,840	<250
		10	19,300	<2,500
		15	2,810	<500
		20	<10.0	<25.0
		25	<10.0	<25.0
01MW40/SB-61	09/07/06	2.5	<12.9	<32.3
		7.5	<11.3	<28.3
		12.5	<12.4	<31.0
01MW41/SB-62	09/08/06	2.5	<12.1	<30.3
		7.5	<12.0	<30.1
		12.5	<12.3	<30.9
01MW42/SB-63	09/08/06	2.5	<11.5	<28.7
		7.5	<11.9	<29.6
		12.5	<11.9	<29.8
GP10	09/01/06	4	156	<29.9
		7	15,700	<2,950
		15	<12.2	<30.5
GP14	09/01/06	7	1,390	<300
		10	<12.1	<30.3
		15	<11.7	<29.3
01MW66/B117	07/23/09	2.5	<50	<250
	08/03/09	12.5	<50	<250
01MW67/B118	07/23/09	1	8,700	3,100
		11	<50	<250
01MW69/B120	07/24/09	13	<50	<250
B121	12/28/09	2.5	<50	<250
		4.5	<50	<250
B122	12/28/09	0.5	1,300	2,200
		7.5	200	<250
B123	12/28/09	2.5	490	<250
		4.5	2,900	390
B128	12/29/09	1.5	4,800	1,900
		7.5	11,000	670
B129	12/29/09	2.5	2,000	980
		5	<50	<250
		9.5	<50	<250
B152	03/01/10	7	8,700	460
B156	03/02/10	2.5	13,000	990
B161	03/02/10	2.5	96	<250
B165	03/02/10	7	<50	<250
B166	03/02/10	2.5	2,400	<250
01MW73/B168	03/10/10	0.5	2,700	<250
		5.5	<50	<250
		10	<50	<250
MTCA Method A Cleanup Level			2,000	2,000

Sample Location	Date Sampled	Sample Depth	DRPH	ORPH
01MW74/B169	03/10/10	5.5	2,300	<250
		10.5	2,700	<250
01MW75/B170	03/10/10	5.5	<50	<250
B176	03/25/11	2.5	2,400	360
B177	03/25/11	2.5	610	<250
B178	03/25/11	0.5	640	890
B180	03/25/11	4.5	810	<250
B181	03/25/11	2.5	<50	<250
B183	04/14/11	0.5	62	<250
		2.5	420	<250
B184	04/14/11	2.5	2,300	<250
		6	<50	<250
B200	03/28/12	0.5	<50	<250
		2.5	<50	<250
B201	03/28/12	0.5	1,300	1,900
B202	04/05/12	12.5	<50	<250
B203	04/06/12	12.5	<50	<250
B204	04/06/12	10	<50	<250
		12.5	<50	<250
B205	04/05/12	12.5	<50	<250
B206	04/05/12	10	<50	<250
		12.5	<50	<250
B207	04/05/12	8	<50	<250
		12.5	1,600	<250
B208	04/05/12	12.5	<50	<250
B209	04/05/12	10	<50	<250
		12.5	<50	<250
B210	03/29/12	12.5	<50	<250
B211	03/29/12	12.5	<50	<250
B212	03/29/12	12.5	<50	<250
B213	03/29/12	0.5	160	330
B214	03/30/12	2.5	11,000	1,700
		4.5	3,900	<250
B215	03/30/12	2.5	<50	<250
		6.5	<50	<250
B216	03/30/12	0.5	6,900	<250
		2.5	13,000	430
		4.5	<50	<250
B217	03/30/12	6.5	6,300	360
B218	03/30/12	6.5	<50	<250
B221	04/06/12	8	20,000	2,400
		12.5	5,500	950
B222	04/06/12	12.5	<50	<250
B223	04/06/12	12.5	<50	<250
B224	04/06/12	12.5	440	<250
B225	04/11/12	2.5	<50	<250
		6.5	<50	<250
		8	<50	<250
		10	<50	<250
MTCA Method A Cleanup Level			2,000	2,000



LEGEND

BOUNDARY BETWEEN UPPER AND LOWER TANK YARDS

RETAINING WALL

ABOVEGROUND STRUCTURE

CONCRETE

FORMER ABOVEGROUND STORAGE TANK

FORMER ABOVEGROUND OR UNDERGROUND STORAGE TANK

PCP PENTACHLOROPHENOL

AST ABOVEGROUND STORAGE TANK

01SB-09 SOIL BORING (FOSTER WHEELER ENVIRONMENTAL CORPORATION 1999)

SB-03 SOIL BORING (FOSTER WHEELER ENVIRONMENTAL CORPORATION 2001 PHASE II)

SB-57 SOIL BORING (FOSTER WHEELER ENVIRONMENTAL CORPORATION 2001 PHASE III)

MW06 SHALLOW ZONE MONITORING WELL

01MW69 ANGLED SHALLOW ZONE MONITORING WELL

01MW14 DECOMMISSIONED MONITORING WELL

GP20 GEOPROBE BORING

B101 SOIL BORING

mg/kg MILLIGRAMS PER KILOGRAM

MTCA WASHINGTON STATE MODEL TOXICS CONTROL ACT

RED DENOTES CONCENTRATION EXCEEDING APPLICABLE MTCA CLEANUP LEVEL

BLUE DENOTES CONCENTRATION EXCEEDING APPLICABLE MTCA CLEANUP LEVEL BUT WAS REMOVED DURING A PRIOR EXCAVATION

DRPH DIESEL-RANGE PETROLEUM HYDROCARBONS

ORPH OIL-RANGE PETROLEUM HYDROCARBONS

RESULTS SHOWN IN MILLIGRAMS PER KILOGRAM

DEPTH SHOWN IN FEET BELOW GROUND SURFACE

HIGHEST DETECTED DRPH/ORPH CONCENTRATION IN SOIL:

AT OR BELOW MTCA METHOD A CLEANUP LEVEL

ABOVE MTCA METHOD A CLEANUP LEVEL

SoundEarth Strategies

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DATE: 06/28/13
DRAWN BY: NAC
CHECKED BY: JAB/TSB
CAD FILE: 01-600_2014FS_SD_DO_Z

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

REGION:

0 10 20 40
APPROXIMATE SCALE IN FEET

FIGURE 13B

HISTORICAL SOIL ANALYTICAL RESULTS FOR DRPH AND ORPH

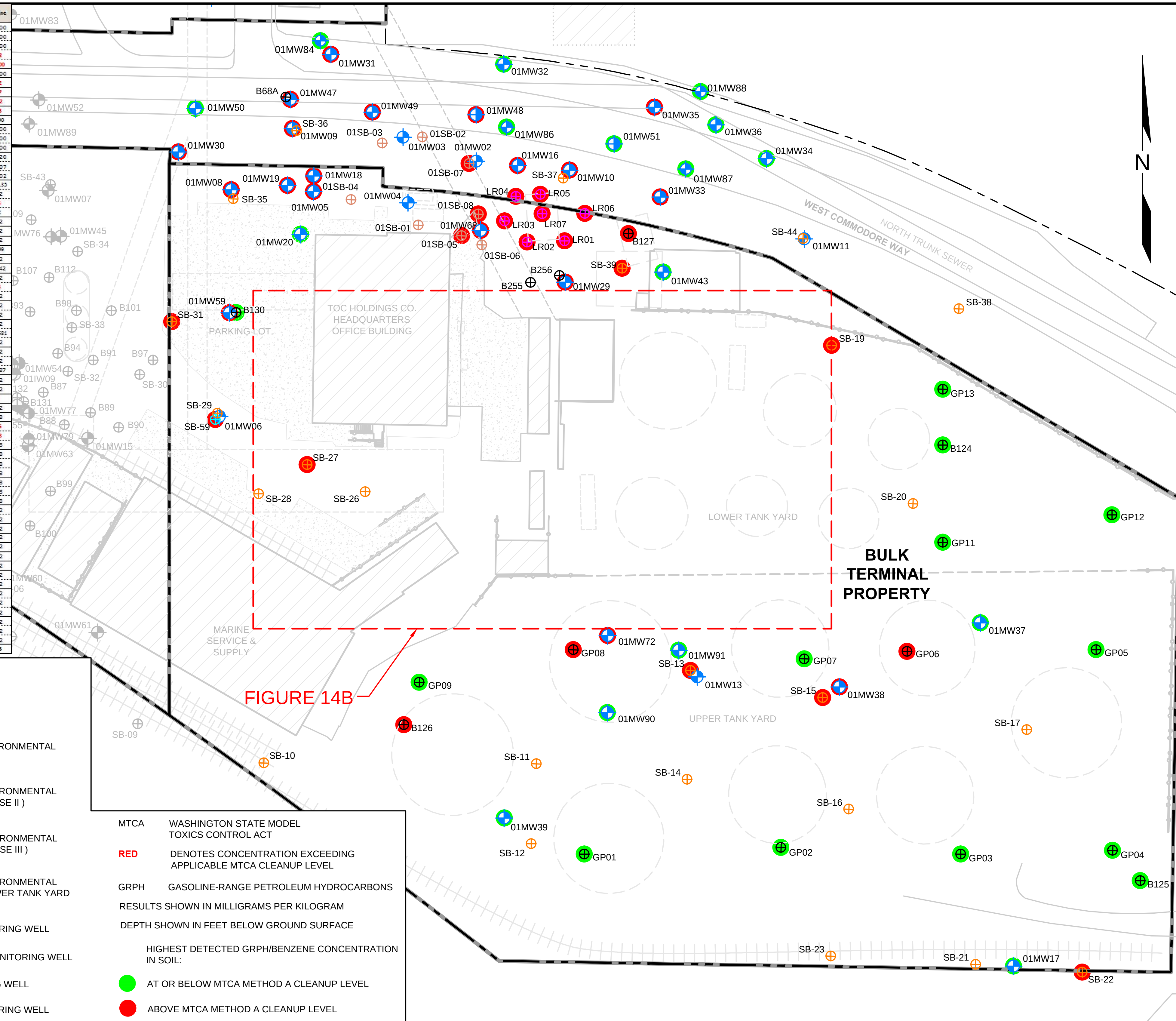
P:\0440 TOC HOLDINGS CO\01-600 SEATTLE TERMINAL\TECHNICAL\CAD\2014\BTP\FS\01-600_2014FS_SD_DO_Z.DWG

6/20/2014

Sample Location	Date Sampled	Sample Depth	GRPH	Benzene
Bulk Terminal Property				
01SB05	06/06/99	10	2,360	<2.5
01SB08	06/06/99	12.5	3,650	9.96
SB-27	11/00	5	121	<0.1
SB-13	2000	2	9,340	14.3
SB-15	2000	2	902	<0.5
SB-19	2000	2	1,500	<1
		5	960	<0.5
SB-22	2000	5	266	<0.25
		10	293	<0.25
01MW06/SB-29	11/00	2	536	<0.5
		5	393	<0.2
SB-31	11/00	2	577	<0.312
01MW08/SB-35	2000	5	192	<0.1
		15	1,640	<1.00
SB-39	2001	2	34.8	<0.05
		5	605	<0.280
SB-59	07/19/01	2	65.6	<0.0500
		5	799	<1.00
		10	<5.00	<0.0500
		15	<5.00	<0.0500
		20	<5.00	<0.0500
01MW17/SB-61	07/19/01	2	<5.00	<0.0500
		5	<5.00	<0.0500
		10	<5.00	<0.0500
		15	<5.00	<0.0500
01MW18/SB-65	03/11/02	5	<5.00	<0.030
		10	<5.00	<0.030
		15	278	<0.120
		20	220	0.317
		25	<5.00	<0.030
		30	<5.00	<0.030
01MW19/SB-66	03/11/02	5	<5.00	<0.030
		10	<5.00	<0.030
		15	11.2	0.292
		20	<5.00	<0.030
		25	<5.00	<0.030
01MW20/SB-67	03/11/02	5	<5.00	<0.030
		10	<5.00	<0.030
		15	7.23	<0.030
		20	<5.00	<0.030
		25	<5.00	<0.030
01MW29	12/03/02	5	127	<0.0100
		10	122	<0.0300
		15	297	0.109
		20	<5.00	0.289
LR01	12/03/02	5	251	0.39
		10	178	<0.0300
		15	1,420	0.885
		20	5.01	1.4
LR02	12/04/02	5	<5.00	<0.0300
		10	1,140	0.831
		15	1,320	1.1
		20	51.9	0.0871
LR03	12/04/02	5	59.7	<0.0600
		10	1,460	1.51
		15	1,860	6.70
LR07	12/02	5	1,490	1.13
		10	534	<0.300
		15	1,370	2.52
01MW37/SB-58	09/07/06	2.5	<6.02	<0.00189
		7.5	<6.78	<0.00162
		12.5	<5.87	<0.00159
01MW38/SB-59	09/07/06	2.5	942	0.188
		7.5	79.4	<0.100
		12.5	<5.20	<0.00161
MTCA Method A Cleanup Level			30	0.03

Sample Location	Date Sampled	Sample Depth	GRPH	Benzene
01MW39/SB-60	09/07/06	2.5	<5.35	<0.00182
		7.5	<5.18	<0.00159
		12.5	<5.26	<0.00158
01MW43/SB-64	09/08/06	7.5	<5.53	<0.00151
		12.5	<5.55	<0.00135
		17.5	<6.06	<0.00135
GP01	08/31/06	8	<6.02	0.00339
		11	<4.41	0.000802
		15	<4.69	<0.000914
GP02	08/31/06	8	<4.71	<0.000998
		11	<4.32	<0.000960
		15	<4.81	<0.00103
GP03	08/31/06	6	<5.50	<0.00104
		12	<4.86	<0.00111
GP04	08/31/06	8	<5.05	<0.000946
		10	<4.86	<0.00103
		15	<4.91	<0.00103
GP05	08/31/06	8	<4.45	<0.00102
		12	<4.71	<0.00111
		15	<4.35	<0.00105
GP06	08/31/06	2	763	<0.113
		9.5	<5.01	<0.000969
		15	<4.61	<0.000999
GP07	08/31/06	5.5	<5.03	<0.000999
		12	<4.88	<0.000943
GP08	08/31/06	2.5	759	0.495
		6	<4.79	<0.00105
		12	<4.62	<0.000976
		15	<4.77	<0.000887
GP09	09/01/06	8	<5.25	<0.00173
		12	<5.36	<0.00164
		15	<5.39	<0.00154
GP11	09/01/06	8	<4.96	<0.000969
		10	<4.91	<0.00101
		15	<4.44	<0.000915
GP12	09/01/06	12	<5.10	<0.00100
		15	<4.79	<0.000997
GP13	09/01/06	8	<5.06	<0.00113
		12	<4.63	0.00173
		14	<4.3	<0.000942
01MW59/B82	11/17/08	2.5	160	<0.03
		5	200	<0.03
		15	<2	<0.02
01MW68/B119	07/23/09	10.5	1,100	29
		21	<2	0.07
B124	12/28/09	2.5	<2	<0.02
		4.5	<2	<0.02
B125	12/28/09	4.5	<2	<0.02
B126	12/28/09	2.5	<2	0.1
		4.5	<2	<0.02
B127	12/28/09	2.5	47	<0.02
		4.5	780	<0.2
		9.5	17	<0.02
B130	12/29/09	7.5	<2	<0.02
01MW72/B167	03/10/10	0.5	8	0.05
01MW90/B198	12/29/11	2.5	<2	<0.02
		7.5	<2	<0.02
01MW91/B199	12/29/11	2.5	5.0	<0.02
		5	<2	<0.02
		7.5	<2	<0.02
West Commodore Way				
01SB07	06/06/99	5	1,240	2.17
01MW09/SB-36	2000	15	4,340	<7.70
01MW10/SB-37	2000	10	1,080	<1.0
		15	<5.00	<0.05
MTCA Method A Cleanup Level			30	0.03

Sample Location	Date Sampled	Sample Depth	GRPH	Benzene
01MW16/SB-60	07/19/01	2	22.8	<0.0500
		5	<5.00	<0.0500
		10	<5.00	<0.0500
		15	1,240	1.68
		20	<5.00	0.0500
LR04	12/04/02	5	<5.00	<0.0300
		10	827	0.32
		15	2,850	4.87
LR05	12/04/02	5	663	0.542
		10	1,320	2.23
		15	935	<0.600
LR06	12/01/02	5	38	<0.0300
		10	<5.00	<0.0300
		15	5.71	<0.0300
01MW30/B01	04/21/06	8	83.9	<0.0220
		15	<5.31	<0.0207
		21	<4.89	<0.0202
01MW31	07/06/06	10	7.01	<0.00135
		13	<4.74	<0.02
		20	4.90	0.05
		23	<4.71	0.02
01MW32	07/06/06	10	<4.35	<0.02
		17.5	<4.81	<0.02
		20	<4.92	<0.02
		25	<4.77	0.0109
		27	<4.67	<0.02
01MW33	07/07/06	8.5	637	<0.0242
		11	371	<0.02
		18	5.80	0.05
		23	<5.42	<0.02
01MW34	07/07/06	11	<4.65	<0.02
		18	<4.55	<0.02
01MW35	07/07/06	11	<4.80	<0.02
		16	331	<0.00681
		21	<4.87	<0.02
01MW36	07/07/06	11	<4.62	<0.02
		15	<4.96	<0.02
		21	<4.87	<0.0137
01MW47/B68	11/29/06	10	3	<0.02
		15	26	<0.02
		20	150	1.4
		25	10	<0.02
01MW48/B69	11/30/06	15	<2	<0.03
		23	3	0.55
		28	<2	0.28
		35	<2	<0.03
01MW49/B70	12/21/06	10	<2.5	<0.03
		13	280	<0.03
		16	<2.5	<0.03
01MW50/B71	12/21/06	11	5.0	<0.03
		18	3.5	<0.03
		33	<2.5	<0.03
01MW51/B72	12/22/06	16	<2	<0.02
		31	<2	<0.02
		40	<2	<0.02
01MW84/B192	04/19/11	7.5	<2	<0.02
		15	5.4	<0.02
		17.5	<2	<0.02
01MW86/B194	04/20/11	7.5	<2	<0.02
		10	<2	<0.02
		17.5	<2	<0.02
01MW87/B195	04/20/11	7.5	<2	<0.02
		10	<2	<0.02
		17.5	<2	<0.02
01MW88/B196	04/21/11	7.5	<2	<0.02
		10	<2	<0.02
		17.5	<2	<0.02
MTCA Method A Cleanup Level			30	0.03



LEGEND

	PROPERTY BOUNDARY FOR THE SEATTLE TERMINAL PROPERTIES
	BOUNDARY BETWEEN UPPER AND LOWER TANK YARDS
	RETAINING WALL
	BURLINGTON NORTHERN SANTA FE RAILROAD
	FORMER RAIL SPUR
	ABOVEGROUND STRUCTURE
	BELOW-GROUND STRUCTURE
	CONCRETE
	FORMER ABOVEGROUND STORAGE TANK
	FORMER ABOVEGROUND OR UNDERGROUND STORAGE TANK
GP20	GEOPROBE BORING
B101	SOIL BORING
01SB-09	SOIL BORING (FOSTER WHEELER ENVIRONMENTAL CORPORATION 1999)
SB-45	SOIL BORING (FOSTER WHEELER ENVIRONMENTAL CORPORATION 2001 PHASE II)
SB-60	SOIL BORING (FOSTER WHEELER ENVIRONMENTAL CORPORATION 2001 PHASE III)
LR06	SOIL BORING (FOSTER WHEELER ENVIRONMENTAL CORPORATION 2002 LOWER TANK YARD INVESTIGATION)
MW06	SHALLOW ZONE MONITORING WELL
01MW57	INTERMEDIATE ZONE MONITORING WELL
01MW65	DEEP ZONE MONITORING WELL
01MW79	PERCHED ZONE MONITORING WELL

MTCA	WASHINGTON STATE MODEL TOXICS CONTROL ACT
RED	DENOTES CONCENTRATION EXCEEDING APPLICABLE MTCA CLEANUP LEVEL
GRPH	GASOLINE-RANGE PETROLEUM HYDROCARBONS

RESULTS SHOWN IN MILLIGRAMS PER KILOGRAM

DEPTH SHOWN IN FEET BELOW GROUND SURFACE

HIGHEST DETECTED GRPH/BENZENE CONCENTRATION IN SOIL:

- AT OR BELOW MTCA METHOD A CLEANUP LEVEL
- ABOVE MTCA METHOD A CLEANUP LEVEL

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DATE: 06/28/13
DRAWN BY: NAC
CHECKED BY: JAB/TSB
CAD FILE: 01-600_2014FS_SD_GB

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

REGION:

0 30 60 120
APPROXIMATE SCALE IN FEET

FIGURE 14A
HISTORICAL SOIL ANALYTICAL RESULTS FOR GRPH AND BENZENE

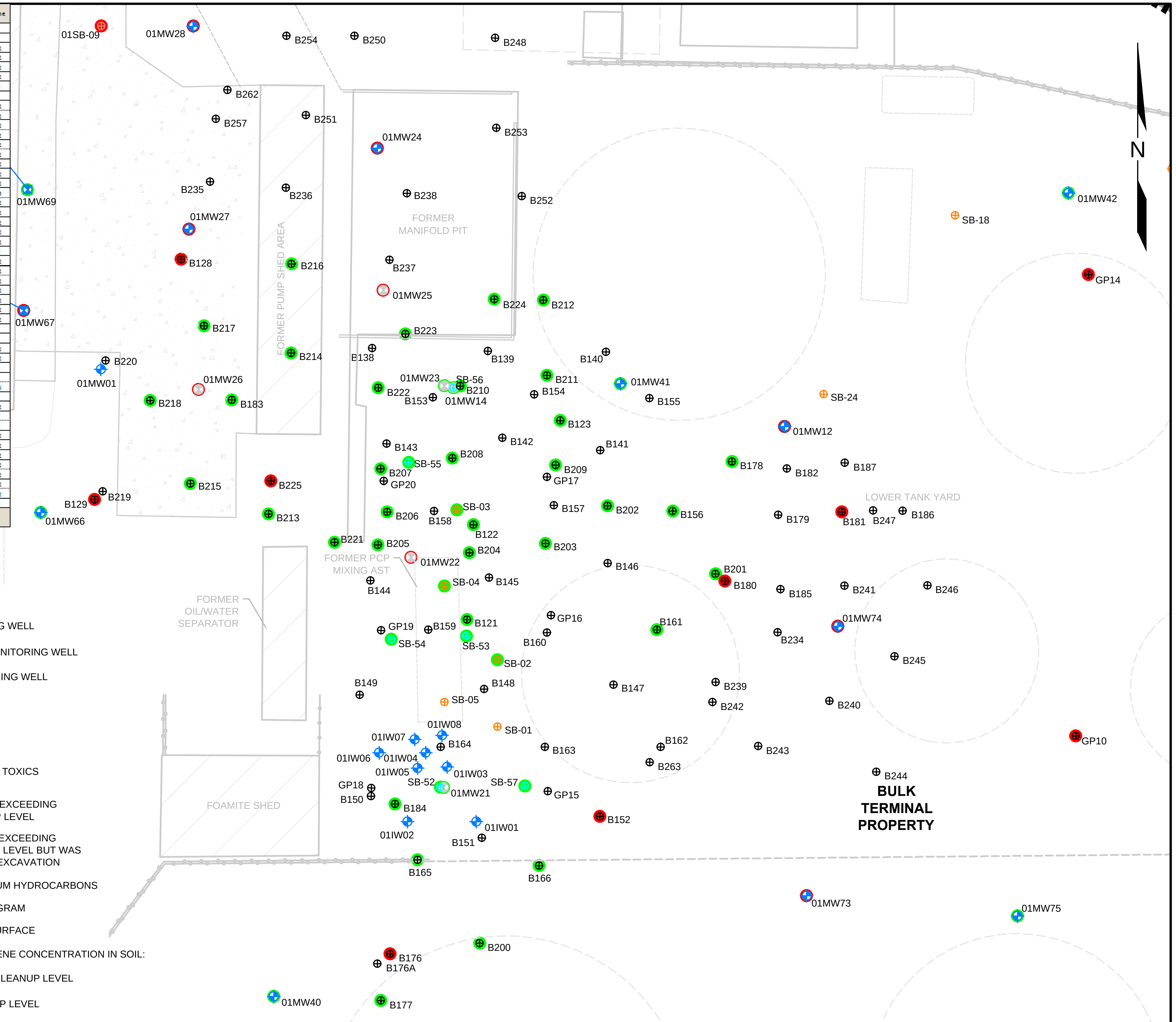
P:\0440 TOC HOLDINGS CO\01-600 SEATTLE TERMINAL\TECHNICAL\CAD\2014\BTP\FS\01-600_2014FS_SD_GB_F.DWG

6/18/2014

Sample Location	Date Sampled	Sample Depth	GRPH	Benzene
01SB09	06/06/99	2.5	381	2.12
		7	2,360	3.45
		12.5	755,000	5,590
		18	3,970	5.26
SB-02	11/00	2	217	<0.2
SB-03	11/00	0.5	<5.00	<0.05
		2	1,670	<1.0
SB-04	11/00	2	513	<0.25
		5	8.42	<0.05
01MW12/SB-24	2000	2	58	<0.05
		10	252	<0.236
SB-52	07/16/01	2.5	1,410	<1.00
		6	<5.00	<0.0500
		10	<5.00	<0.0500
SB-53	07/16/01	2	<5.00	<0.0500
		5	<5.00	<0.0500
		10	<5.00	<0.0500
SB-54	07/16/01	2	86.2	<0.100
		5	<5.00	<0.0500
		10	<5.00	<0.0500
SB-55	07/16/01	2.5	<5.00	<5.00
		6	185	<0.200
		10	<5.00	<5.00
01MW14/SB-56	07/17/01	2.5	5,100	10.2
		5	4,060	9.36
		10	<5.00	<0.0500
SB-57	07/2001	1.5	2,590	0.387
01MW21	12/02/02	5	<5.00	<0.0300
		10	<5.00	<0.0300
		15	<5.00	<0.0300
		20	<5.00	<0.0300
		23	<5.00	<0.0300
01MW22	12/02/02	5	<5.00	<0.0300
		10	<5.00	<0.0300
		15	<5.00	0.219
		20	<5.00	0.21
		25	<5.00	<0.0300
01MW23	12/02/02	5	73.2	0.317
		10	<5.00	<0.0300
		15	5.71	<0.0300
		20	<5.00	<0.0300
01MW24	12/03/02	5	2,200	4.35
		10	28.4	<0.0300
		15	<5.00	0.103
		20	<5.00	0.0454
01MW25	12/03/02	5	<5.00	0.0491
		10	176	0.0658
		15	<5.00	<0.0300
		18	<5.00	<0.0300
MTCA Method A Cleanup Level			30	0.03

Sample Location	Date Sampled	Sample Depth	GRPH	Benzene
01MW26	12/04/02	5	681	<0.0300
		10	3,990	4.29
		15	1,430	<0.600
		20	<5.00	<0.0300
01MW27	12/04/02	5	5,510	18.2
		10	2,370	8.21
		15	177	0.265
		20	<5.00	<0.0300
01MW28	12/05/02	5	46.5	<0.0300
		10	1,170	<0.0300
		15	2,870	9.82
		20	<0.00262	<0.0300
		25	<5.00	<0.0300
01MW40/SB-61	09/07/06	2.5	<5.53	<0.00165
		7.5	<5.02	<0.00143
		12.5	<5.22	<0.00129
01MW41/SB-62	09/08/06	2.5	<5.60	0.00173
		7.5	<6.31	<0.00152
		12.5	<5.66	<0.00165
01MW42/SB-63	09/08/06	2.5	<5.33	<0.00139
		7.5	<5.87	<0.00151
		12.5	<5.93	<0.00150
GP10	09/01/06	4	49.5	0.0679
		7	9,250	14.3
		15	6.39	0.142
GP14	09/01/06	7	11.5	0.012
		10	<5.17	0.0735
		15	<4.96	<0.000899
01MW66/B117	07/23/09	2.5	17	<0.02
	08/03/09	12.5	<2	<0.02
01MW67/B118	07/23/09	1	450	<0.2
		11	7	<0.02
01MW69/B120	07/24/09	13	<2	<0.02
B121	12/28/09	2.5	<2	<0.02
		4.5	<2	<0.02
B122	12/28/09	0.5	<2	<0.02
		4.5	79	<0.02
B123	12/28/09	2.5	10	<0.02
		4.5	640	21
B128	12/29/09	1.5	410	<0.02
		7.5	1,500	52
B129	12/29/09	2.5	230	<0.2
		5	35	<0.02
		9.5	<2	<0.02
B152	03/01/10	7	200	0.51
B156	03/02/10	2.5	560	<0.2
B161	03/02/10	2.5	17	0.16
B165	03/02/10	7	<2	<0.02
B166	03/02/10	2.5	<2	<0.02
01MW73/B168	03/10/10	0.5	28	<0.02
		10	3	0.12
MTCA Method A Cleanup Level			30	0.03

Sample Location	Date Sampled	Sample Depth	GRPH	Benzene
01MW74/B169	03/10/10	5.5	2,600	12
		10.5	200	3.9
01MW75/B170	03/10/10	5.5	<2	<0.02
B176	03/25/11	2.5	200	<0.02
B177	03/25/11	2.5	4.9	<0.02
B178	03/25/11	0.5	<2	<0.02
B180	03/25/11	4.5	1,300	0.50
B181	03/25/11	2.5	2,800	40
B183	04/14/11	0.5	6.8	<0.02
		2.5	230	<0.02
B184	04/14/11	2.5	39	<0.02
		6	<2	<0.02
B200	03/28/12	0.5	<2	<0.02
		2.5	<2	<0.02
B201	03/28/12	0.5	<2	<0.02
B202	04/05/12	12.5	<2	<0.02
B203	04/06/12	12.5	<2	<0.02
B204	04/06/12	10	33	0.025
		12.5	2.5	<0.02
B205	04/05/12	12.5	<2	<0.02
B206	04/05/12	10	<2	<0.02
		12.5	<2	<0.02
B207	04/05/12	8	5.1	<0.02
		12.5	190	0.26
B208	04/05/12	12.5	<2	<0.02
B209	04/05/12	10	30	<0.02
		12.5	<2	<0.02
B210	03/29/12	12.5	<2	<0.02
B211	03/29/12	12.5	<2	<0.02
B212	03/29/12	12.5	<2	<0.02
B213	03/29/12	0.5	<2	<0.02
B214	03/30/12	2.5	5,000	18
		4.5	3,700	20
B215	03/30/12	2.5	4.2	<0.02
		6.5	<2	<0.02
B216	03/30/12	0.5	680	0.95
		2.5	1,600	27
		4.5	9.1	0.035
B217	03/30/12	6.5	570	11
B218	03/30/12	6.5	<2	<0.02
B221	04/06/12	8	940	0.67
		12.5	490	0.16
B222	04/06/12	12.5	<2	<0.02
B223	04/06/12	12.5	<2	<0.02
B224	04/06/12	12.5	42	<0.02
B225	04/11/12	2.5	<2	<0.02
		6.5	<2	<0.02
		8	<2	<0.02
		10	13	0.062
MTCA Method A Cleanup Level			30	0.03



LEGEND

	BOUNDARY BETWEEN UPPER AND LOWER TANK YARDS	MW06	SHALLOW ZONE MONITORING WELL
	RETAINING WALL	01MW69	ANGLED SHALLOW ZONE MONITORING WELL
	ABOVEGROUND STRUCTURE	01MW14	DECOMMISSIONED MONITORING WELL
	CONCRETE	GP20	GEOPROBE BORING
	FORMER ABOVEGROUND STORAGE TANK	B101	SOIL BORING
	FORMER ABOVEGROUND OR UNDERGROUND STORAGE TANK	mg/kg	MILLIGRAMS PER KILOGRAM
PCP	PENTACHLOROPHENOL	MTCA	WASHINGTON STATE MODEL TOXICS CONTROL ACT
AST	ABOVEGROUND STORAGE TANK	RED	DENOTES CONCENTRATION EXCEEDING APPLICABLE MTCA CLEANUP LEVEL
01SB-09	SOIL BORING (FOSTER WHEELER ENVIRONMENTAL CORPORATION 1999)	BLUE	DENOTES CONCENTRATION EXCEEDING APPLICABLE MTCA CLEANUP LEVEL BUT WAS REMOVED DURING A PRIOR EXCAVATION
SB-03	SOIL BORING (FOSTER WHEELER ENVIRONMENTAL CORPORATION 2001 PHASE II)	GRPH	GASOLINE-RANGE PETROLEUM HYDROCARBONS
SB-57	SOIL BORING (FOSTER WHEELER ENVIRONMENTAL CORPORATION 2001 PHASE III)		

RESULTS SHOWN IN MILLIGRAMS PER KILOGRAM

DEPTH SHOWN IN FEET BELOW GROUND SURFACE

HIGHEST DETECTED GRPH/BENZENE CONCENTRATION IN SOIL:

- AT OR BELOW MTCA METHOD A CLEANUP LEVEL
- ABOVE MTCA METHOD A CLEANUP LEVEL

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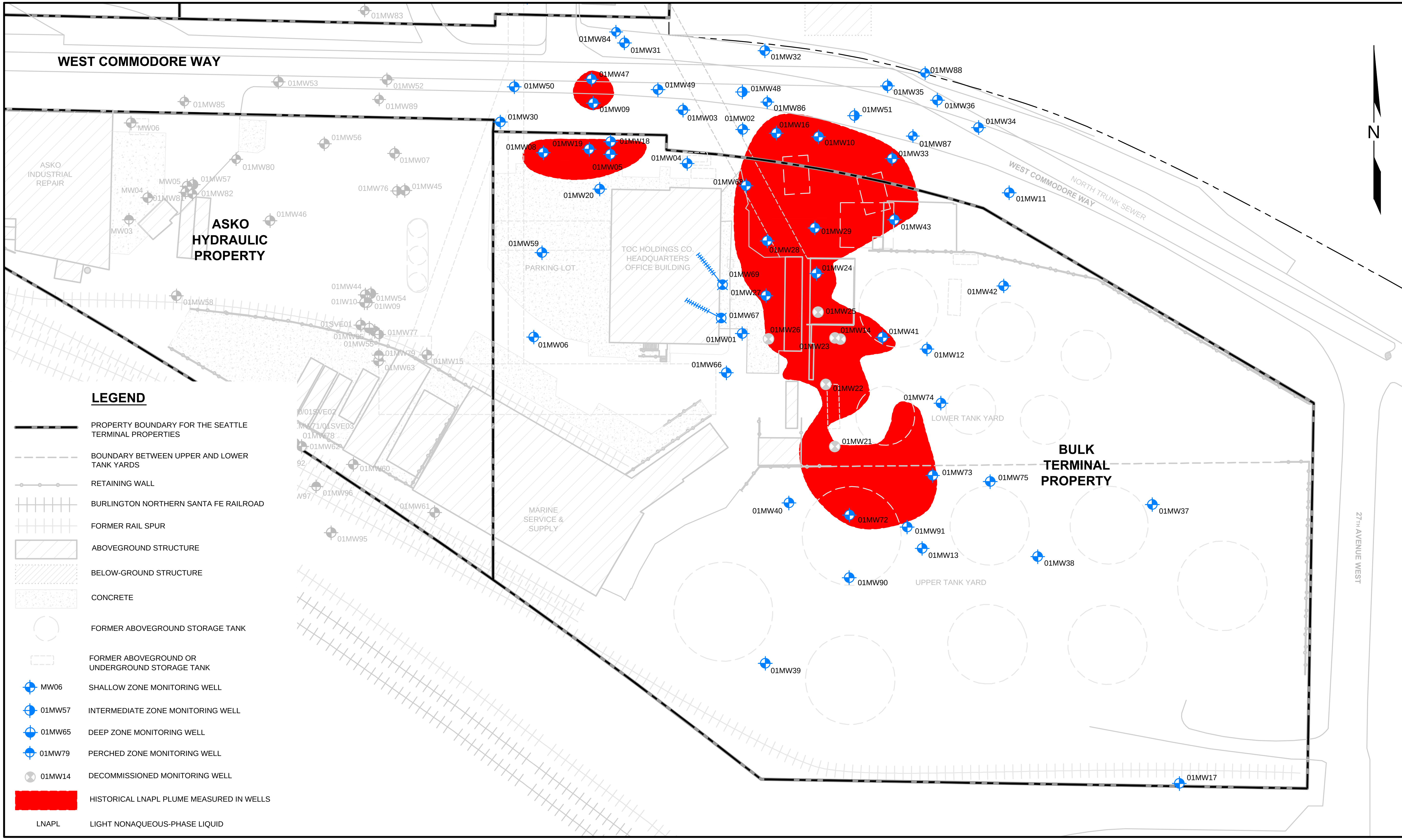
PROJECT NAME: TOC HOLDINGS CO. BULK TERMINAL PROPERTY
PROJECT NUMBER: 0440-004
STREET ADDRESS: 2737 WEST COMMODORE WAY
CITY, STATE: SEATTLE, WASHINGTON

REGION:

0 10 20 40
APPROXIMATE SCALE IN FEET

FIGURE 14B
HISTORICAL SOIL ANALYTICAL RESULTS FOR GRPH AND BENZENE

P:\0440 TOC HOLDINGS CO\01-600 SEATTLE TERMINAL\TECHNICAL\CAD\2014\BTP\FS\01-600_2014FS_SD_GB_Z_F.DWG



P:\0440 TOC HOLDINGS CO\01-600 SEATTLE TERMINAL\TECHNICAL\CAD\2014\BTP\FS\01-600_2014FS_LNAPL_F.DWG 6/18/2014

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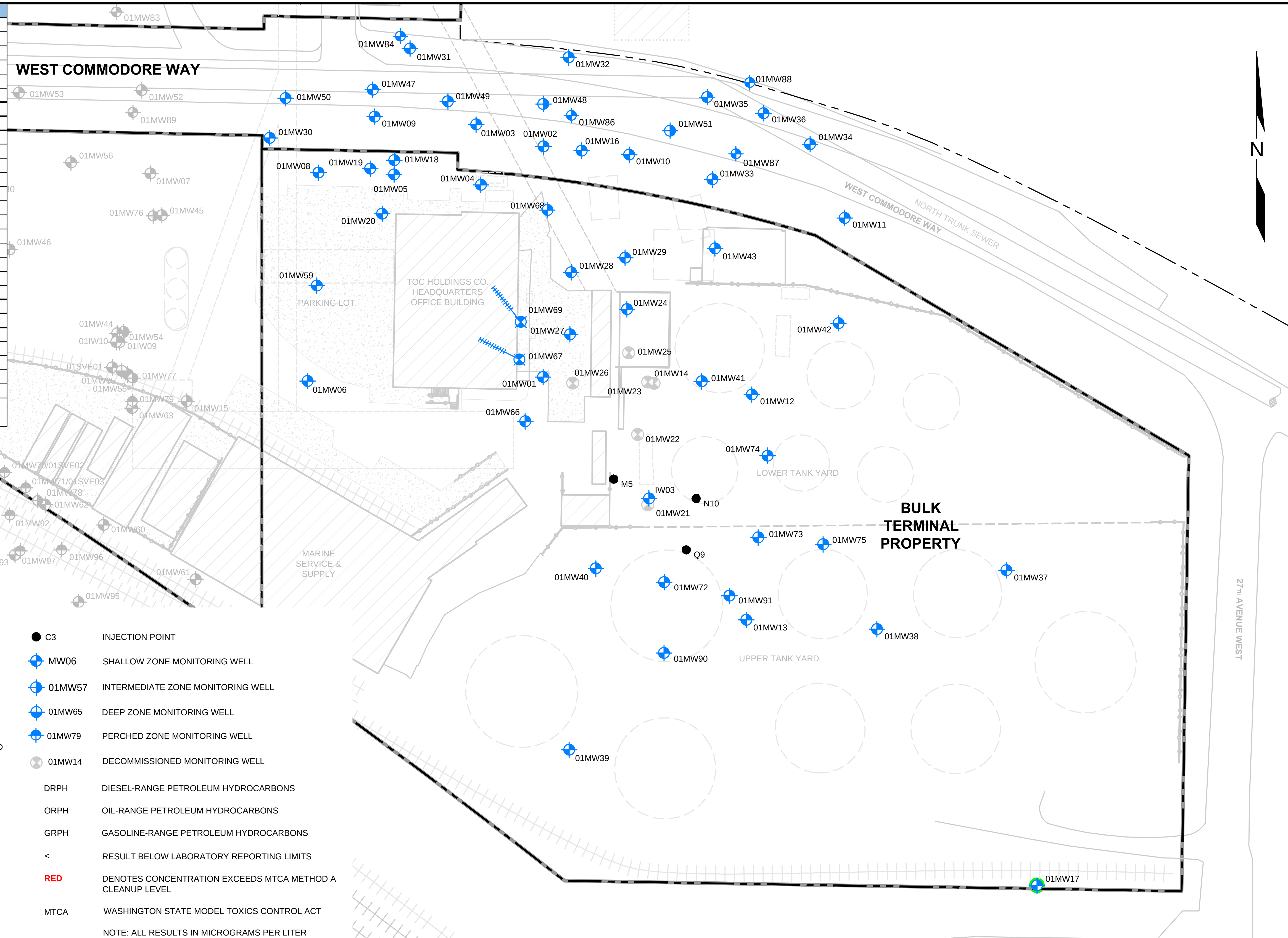
CITY, STATE: SEATTLE, WASHINGTON

REGION:

0 30 60 120
APPROXIMATE SCALE IN FEET

FIGURE 15
HISTORICAL MEASURED LNAPL PLUME

Well ID	DRPH	ORPH	GRPH	Benzene
01MW01	<50	<250	<100	<1
01MW02	5,400	290	28,000	8,300
01MW04	300	<250	750	170
01MW06	55	<250	<100	<1
01MW11	400	<250	<100	<1
01MW13	2,900	440	<100	<1
01MW17	360	<250	<100	<1
01MW19	2,400	<250	16,000	3,200
01MW27	3,800	<250	2,500	730
01MW30	200	<250	<100	<1
01MW32	<50	<250	<100	<1
01MW37	340	<250	<100	<1
01MW40	500	<250	<100	<1
01MW42	350	<250	<100	<1
01MW50	290	<250	<100	<1
01MW59	420	<250	<100	<1
01MW66	250	<250	<100	<1
01MW67	110	<250	<100	<1
01MW69	270	<250	440	4.6
01MW74	11,000	1,600	19,000	4,800
01MW75	960	<250	<100	<1
01MW84	410	<250	2,200	4.1
01MW86	5,600	550	7,700	3,400
IW03	1,700	550	<100	<1
M5IW01	740	<250	<100	<1
N10IW01	1,800	310	110	10
Q9IW01	2,600	940	<100	<1
MTCA Method A Cleanup Level	**500**	**500**	**800**	**5**



LEGEND

PROPERTY BOUNDARY FOR THE SEATTLE TERMINAL PROPERTIES	
BOUNDARY BETWEEN UPPER AND LOWER TANK YARDS	
RETAINING WALL	
BURLINGTON NORTHERN SANTA FE RAILROAD	
FORMER RAIL SPUR	
ABOVEGROUND STRUCTURE	
BELOW-GROUND STRUCTURE	
CONCRETE	
FORMER ABOVEGROUND STORAGE TANK	
FORMER ABOVEGROUND OR UNDERGROUND STORAGE TANK	

C3	INJECTION POINT
MW06	SHALLOW ZONE MONITORING WELL
01MW57	INTERMEDIATE ZONE MONITORING WELL
01MW65	DEEP ZONE MONITORING WELL
01MW79	PERCHED ZONE MONITORING WELL
01MW14	DECOMMISSIONED MONITORING WELL
DRPH	DIESEL-RANGE PETROLEUM HYDROCARBONS
ORPH	OIL-RANGE PETROLEUM HYDROCARBONS
GRPH	GASOLINE-RANGE PETROLEUM HYDROCARBONS
<	RESULT BELOW LABORATORY REPORTING LIMITS
RED	DENOTES CONCENTRATION EXCEEDS MTCA METHOD A CLEANUP LEVEL
MTCA	WASHINGTON STATE MODEL TOXICS CONTROL ACT

NOTE: ALL RESULTS IN MICROGRAMS PER LITER

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

REGION:

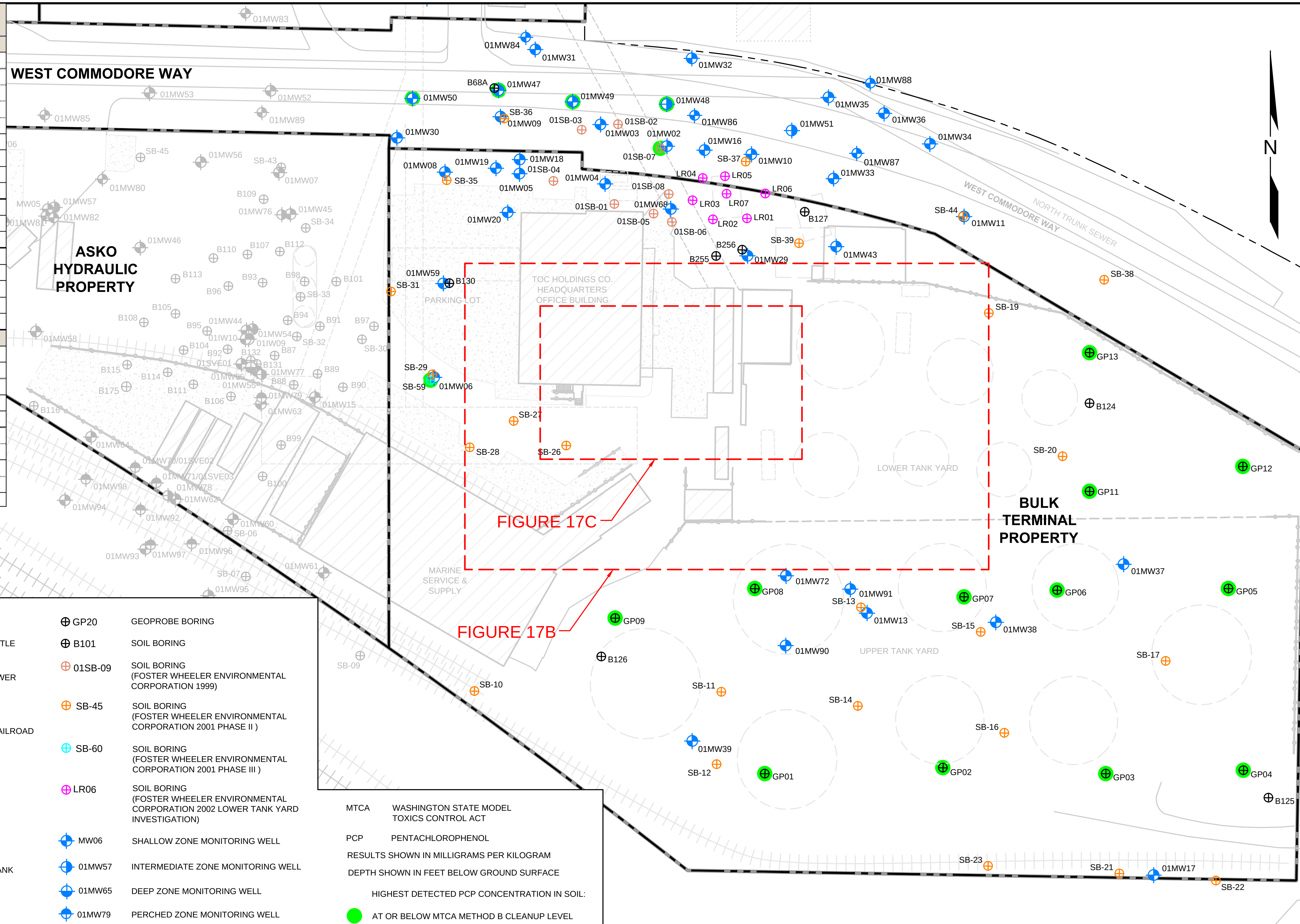
0 30 60 120
APPROXIMATE SCALE IN FEET

FIGURE 16

GROUNDWATER ANALYTICAL RESULTS FOR DRPH, ORPH, GRPH, AND BENZENE
BULK TERMINAL PROPERTY
(OCTOBER 2012)

P:\0440 TOC HOLDINGS CO\01-600 SEATTLE TERMINAL\TECHNICAL\CAD\2014\BTP\FS\01-600_2014FS_GD_DOGB_F.DWG 7/14/2014

Sample Location	Date Sampled	Sample Depth	PCP
Bulk Terminal Property			
SB-59	07/19/01	2	<0.0500
		5	<0.500
		10	<0.0500
		15	<0.0500
		20	0.148
GP01	08/31/06	8	<0.0651
GP02	08/31/06	8	<0.0623
GP03	08/31/06	6	<0.0623
GP04	08/31/06	8	<0.0588
GP05	08/31/06	8	<0.0596
GP06	08/31/06	2	<2.93
GP07	08/31/06	5.5	<0.0606
GP08	08/31/06	2.5	<1.2
GP09	09/01/06	8	<0.0617
GP11	09/01/06	8	<0.579
GP12	09/01/06	12	<0.0599
GP13	09/01/06	8	<0.0550
West Commodore Way			
01SB07	06/06/99	5	<0.25
01MW47/B68	11/29/06	20	<5
		25	<0.1
01MW48/B69	11/30/06	28	<0.1
01MW49/B70	12/21/06	13	<1
		18	<0.1
		33	<0.1
01MW50/B71	12/21/06	18	<0.1
		33	<0.1
MTCA Method B Cleanup Level			**2.5**



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DRAWN BY: NAC
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CAD FILE: 01-600_2014FS_SD_PCP

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

REGION:

0 30 60 120
APPROXIMATE SCALE IN FEET

FIGURE 17A
HISTORICAL SOIL ANALYTICAL RESULTS FOR PCP

6/20/2014 P:\0440 TOC HOLDINGS CO\01-600 SEATTLE TERMINAL\TECHNICAL\CAD\2014\BTP\FS\01-600_2014FS_SD_PCP_F.DWG

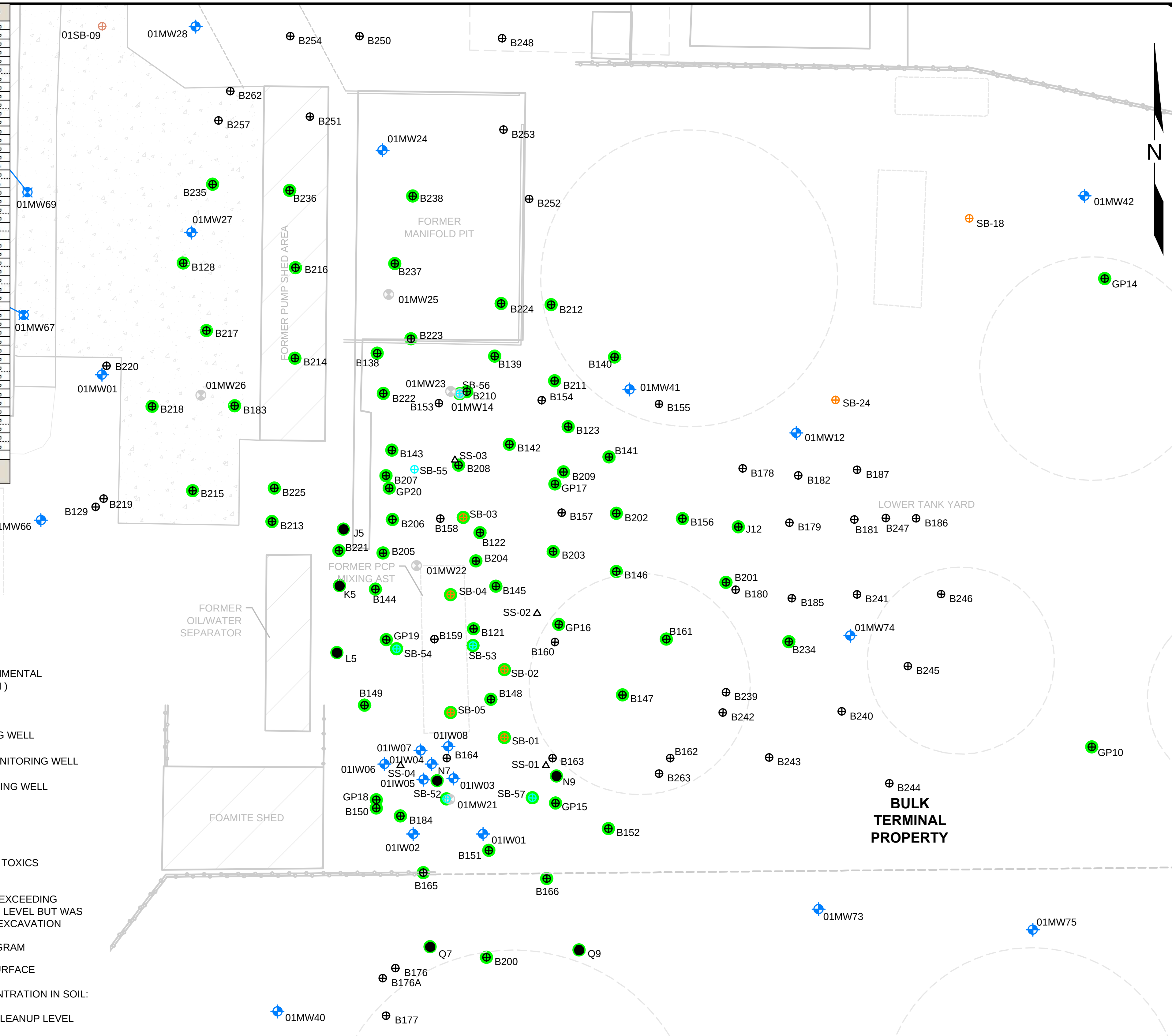
6/18/2014

Sample Location	Date Sampled	Sample Depth	PCP
SB-01	11/00	0.5	0.95
		2	<0.250
		5	0.0871
		10	0.0812
		14	0.0578
SB-02	11/00	0.5	1.15
		2	<0.250
		5	0.0615
		10	0.0615
		14	0.0585
SB-03	11/00	0.5	202
		2	<0.5
SB-04	11/00	0.5	803
		2	1.26
		5	20.9
		10	0.235
SB-05	11/00	0.5	2.18
		2	0.0761
		5	0.264
		10	0.0981
SB-52	07/16/01	2.5	<0.0500
		6	<0.0500
		10	0.129
SB-53	07/16/01	2	0.0916
		5	<0.0500
		10	<0.0500
SB-54	07/16/01	2	0.181
		5	<0.0500
		10	0.0780
SB-55	07/16/01	2.5	<0.0500
		6	0.174
		10	0.0770
01MW14/SB-56	07/17/01	2.5	<0.500
		5	8.88
		10	0.0765
SB-57	07/2001	1.5	<0.0500
GP10	09/01/06	4	<0.0599
GP14	09/01/06	7	<1.19
GP15	09/05/06	4	<0.0579
		10	<0.0602
GP16	09/05/06	4	<0.0617
		5.5	<0.0629
		9.5	<0.0577
GP17	09/05/06	6	<0.0595
		8	3.44
		12	<0.0611
GP18	09/05/06	4	<0.0618
		8	<0.0627
		15	<0.0619
GP19	09/05/06	7	0.185
		12	0.162
		15	<0.0605
MTCA Method B Cleanup Level			2.5

Sample Location	Date Sampled	Sample Depth	PCP
GP20	09/05/06	8	2.92
		12	<0.298
		15	<0.0637
B121	12/28/09	0.5	<0.2
		2.5	<0.2
		4.5	<0.2
		7.5	<0.2
B122	12/28/09	0.5	<0.2
		4.5	2.7
		7.5	<0.2
B123	12/28/09	0.5	<0.2
		2.5	<0.2
		4.5	<0.2
		7.5	<0.2
B128	12/29/09	1.5	<0.2
		4.5	<0.2
		7.5	<0.2
		12.5	<0.2
B138	05/01/10	0.5	<0.2
		2.5	<0.2
		4.5	<0.2
B139	05/01/10	0.5	<0.2
		2.5	<0.2
		4.5	<0.2
B140	05/01/10	0.5	<0.2
		2.5	<0.2
		4.5	<0.2
B141	05/01/10	0.5	<0.2
		2.5	<0.2
		4.5	<0.2
B142	05/01/10	0.5	<0.2
		2.5	<0.2
		4.5	<0.2
B143	05/01/10	0.5	<0.2
		2.5	<0.2
		4.5	<0.2
B144	05/01/10	0.5	<0.2
		2.5	<0.1
		4.5	0.26
B145	05/01/10	0.5	<0.2
		2.5	<0.2
		4.5	0.38
B146	05/01/10	0.5	<0.2
		2.5	1.4
		4.5	0.49
B147	05/01/10	0.5	<0.2
		2.5	<0.2
		4.5	<0.2
B148	05/01/10	0.5	<0.2
		2.5	<0.2
		4.5	<0.2
MTCA Method B Cleanup Level			2.5

Sample Location	Date Sampled	Sample Depth	PCP
B149	05/01/10	0.5	<0.2
		2.5	<0.2
		4.5	<0.2
B150	05/01/10	0.5	<0.2
		4.5	<0.2
B151	05/01/10	0.5	4.1
		2.5	0.55
		4.5	4.0
		6	<0.1
B152	05/01/10	0.5	<0.2
		2.5	<0.2
		4.5	<0.2
B156	05/02/10	0.5	<0.2
		2.5	<0.2
		4.5	<0.2
B161	05/02/10	0.5	<0.2
		2.5	<0.2
		4.5	<0.2
B165	05/02/10	0.5	<0.2
		2.5	<0.2
		4.5	<0.2
B166	05/02/10	0.5	<0.2
		2.5	<0.2
		4.5	<0.2
L5	05/19/10	1	<0.2
		2.5	<0.2
		4.5	0.28
J5	05/20/10	0.5	<0.2
		2	<0.2
		3.5	0.46
K5	05/20/10	1	<0.2
		2.5	<0.2
		4.5	<0.1
N7	05/26/10	1	<0.1
		2.5	<0.1
		4.5	<0.1
N9	05/25/10	1	<0.1
		2.5	<0.1
		4.5	<0.1
Q7	06/01/10	0.5	<0.1
		2.5	<0.1
		4.5	<0.1
Q9	06/02/10	0.5	<0.1
		2.5	<0.1
		4.5	<0.1
J12	06/09/10	0.5	0.12
		2.5	<0.1
		4.5	<0.1
B183	04/14/11	4.5	<0.1
		6	0.40
B184	04/14/11	0.5	<0.1
		2.5	<0.1
MTCA Method B Cleanup Level			2.5

Sample Location	Date Sampled	Sample Depth	PCP
B200	05/28/12	0.5	<0.10
		2.5	<0.10
B201	05/28/12	0.5	<0.10
B202	04/05/12	12.5	<0.10
B203	04/06/12	12.5	<0.10
B204	04/06/12	10	<0.10
		12.5	<0.10
B205	04/05/12	12.5	<0.10
B206	04/05/12	10	<0.10
B207	04/05/12	8	<0.10
		12.5	<0.10
B208	04/05/12	12.5	<0.10
B209	04/05/12	10	<0.10
B210	05/29/12	12.5	<0.10
B211	05/29/12	12.5	<0.10
B212	05/29/12	12.5	<0.10
B213	05/29/12	0.5	0.66
B214	05/30/12	0.5	<0.10
		2.5	0.16
		4.5	<0.10
B215	05/30/12	2.5	<0.10
		4.5	<0.10
		6.5	<0.10
B216	05/30/12	0.5	2.6
		2.5	8.2
		4.5	<0.10
B217	05/30/12	2.5	<0.10
		4.5	<0.10
		6.5	<0.10
B218	05/30/12	2.5	<0.10
		4.5	<0.10
		6.5	<0.10
B221	04/06/12	8	1.4
		12.5	<0.10
B222	04/06/12	12.5	<0.10
B223	04/06/12	12.5	<0.10
B224	04/06/12	12.5	<0.10
B225	04/11/12	2.5	<0.10
		6.5	<0.10
		8	<0.10
		10	<0.10
B234	05/11/12	0.5	<0.10
B235	05/11/12	2.5	<0.10
B236	05/11/12	0.5	<0.10
		2.5	<0.10
B237	05/14/12	0.5	<0.10
		2.5	<0.10
B238	05/14/12	0.5	<0.10
		2.5	<0.10
MTCA Method B Cleanup Level			2.5



LEGEND

BOUNDARY BETWEEN UPPER AND LOWER TANK YARDS

RETAINING WALL

ABOVEGROUND STRUCTURE

CONCRETE

FORMER ABOVEGROUND STORAGE TANK

FORMER ABOVEGROUND OR UNDERGROUND STORAGE TANK

PCP — PENTACHLOROPHENOL

AST — ABOVEGROUND STORAGE TANK

01SB-09 — SOIL BORING (FOSTER WHEELER ENVIRONMENTAL CORPORATION 1999)

SB-03 — SOIL BORING (FOSTER WHEELER ENVIRONMENTAL CORPORATION 2001 PHASE II)

SB-57 — SOIL BORING (FOSTER WHEELER ENVIRONMENTAL CORPORATION 2001 PHASE III)

SS-01 — SURFACE SAMPLE (FOSTER WHEELER ENVIRONMENTAL CORPORATION 2001 PHASE II)

INJECTION POINT

MW06 — SHALLOW ZONE MONITORING WELL

01MW69 — ANGLED SHALLOW ZONE MONITORING WELL

01MW14 — DECOMMISSIONED MONITORING WELL

GP20 — GEOPROBE BORING

B101 — SOIL BORING

MTCA — WASHINGTON STATE MODEL TOXICS CONTROL ACT

BLUE — DENOTES CONCENTRATION EXCEEDING APPLICABLE MTCA CLEANUP LEVEL BUT WAS REMOVED DURING A PRIOR EXCAVATION

RESULTS SHOWN IN MILLIGRAMS PER KILOGRAM

DEPTH SHOWN IN FEET BELOW GROUND SURFACE

HIGHEST DETECTED PCP CONCENTRATION IN SOIL:

AT OR BELOW MTCA METHOD B CLEANUP LEVEL

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

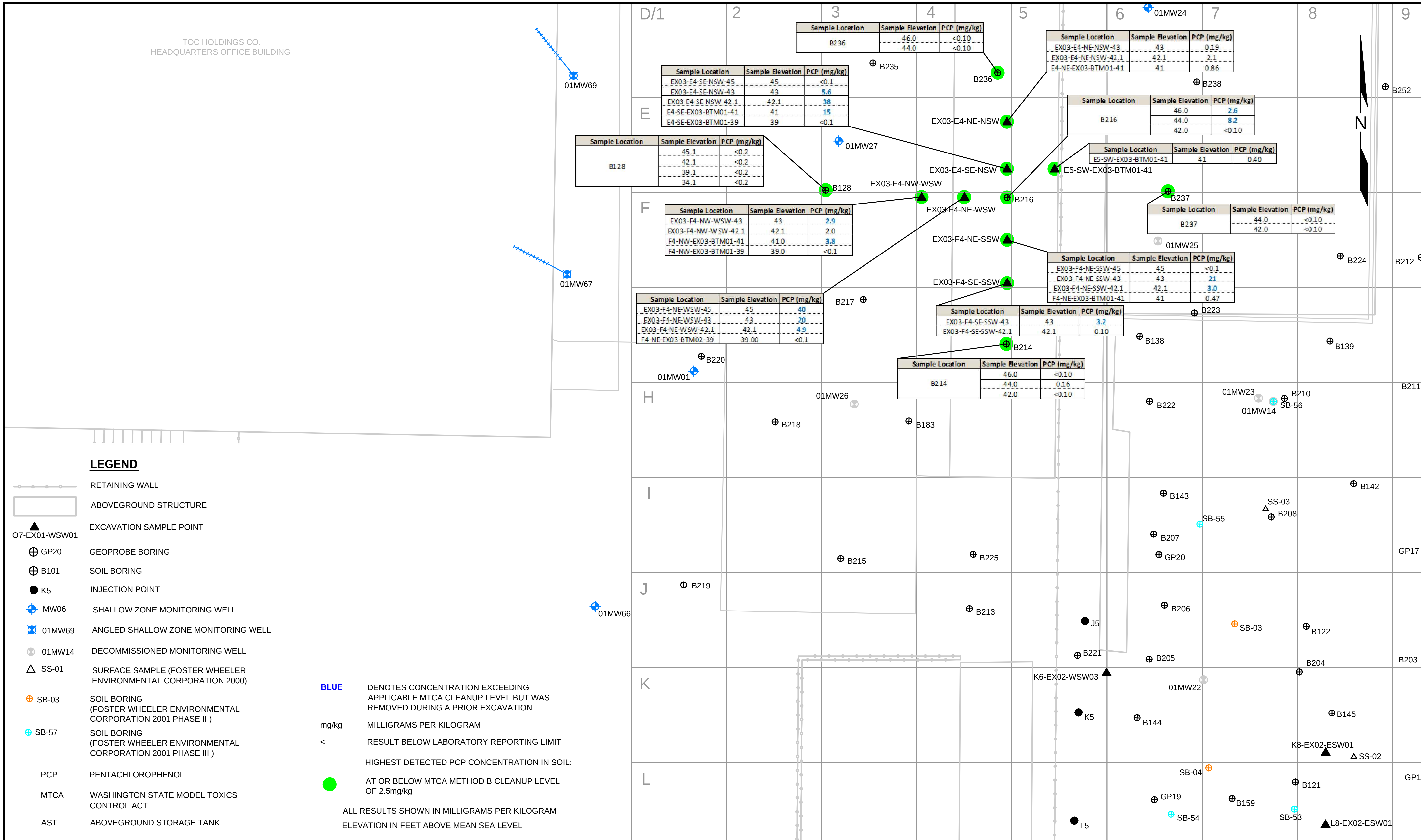
REGION:

0 10 20 40
APPROXIMATE SCALE IN FEET

FIGURE 17B
HISTORICAL SOIL ANALYTICAL RESULTS FOR PCP

P:\0440 TOC HOLDINGS CO\01-600 SEATTLE TERMINAL\TECHNICAL\CAD\2014\BTP\FS\01-600_2014FS_SD_PCP_Z_F.DWG

6/18/2014



Sample Location	Sample Elevation	PCP (mg/kg)
B236	46.0	<0.10
	44.0	<0.10

Sample Location	Sample Elevation	PCP (mg/kg)
EX03-E4-SE-NSW-45	45	<0.1
EX03-E4-SE-NSW-43	43	5.6
EX03-E4-SE-NSW-42.1	42.1	38
E4-SE-EX03-BTM01-41	41	15
E4-SE-EX03-BTM01-39	39	<0.1

Sample Location	Sample Elevation	PCP (mg/kg)
B128	45.1	<0.2
	42.1	<0.2
	39.1	<0.2
	34.1	<0.2

Sample Location	Sample Elevation	PCP (mg/kg)
EX03-E4-NE-NSW-43	43	0.19
EX03-E4-NE-NSW-42.1	42.1	2.1
E4-NE-EX03-BTM01-41	41	0.86

Sample Location	Sample Elevation	PCP (mg/kg)
B216	46.0	2.6
	44.0	8.2
	42.0	<0.10

Sample Location	Sample Elevation	PCP (mg/kg)
E5-SW-EX03-BTM01-41	41	0.40

Sample Location	Sample Elevation	PCP (mg/kg)
B237	44.0	<0.10
	42.0	<0.10

Sample Location	Sample Elevation	PCP (mg/kg)
EX03-F4-NW-WSW-43	43	2.9
EX03-F4-NW-WSW-42.1	42.1	2.0
F4-NW-EX03-BTM01-41	41.0	3.8
F4-NW-EX03-BTM01-39	39.0	<0.1

Sample Location	Sample Elevation	PCP (mg/kg)
EX03-F4-NE-SSW-45	45	<0.1
EX03-F4-NE-SSW-43	43	21
EX03-F4-NE-SSW-42.1	42.1	3.0
F4-NE-EX03-BTM01-41	41	0.47

Sample Location	Sample Elevation	PCP (mg/kg)
EX03-F4-NE-WSW-45	45	40
EX03-F4-NE-WSW-43	43	20
EX03-F4-NE-WSW-42.1	42.1	4.9
F4-NE-EX03-BTM02-39	39.00	<0.1

Sample Location	Sample Elevation	PCP (mg/kg)
EX03-F4-SE-SSW-43	43	3.2
EX03-F4-SE-SSW-42.1	42.1	0.10

Sample Location	Sample Elevation	PCP (mg/kg)
B214	46.0	<0.10
	44.0	0.16
	42.0	<0.10

LEGEND

	RETAINING WALL
	ABOVEGROUND STRUCTURE
O7-EX01-WSW01	EXCAVATION SAMPLE POINT
GP20	GEOPROBE BORING
B101	SOIL BORING
K5	INJECTION POINT
MW06	SHALLOW ZONE MONITORING WELL
01MW69	ANGLED SHALLOW ZONE MONITORING WELL
01MW14	DECOMMISSIONED MONITORING WELL
SS-01	SURFACE SAMPLE (FOSTER WHEELER ENVIRONMENTAL CORPORATION 2000)
SB-03	SOIL BORING (FOSTER WHEELER ENVIRONMENTAL CORPORATION 2001 PHASE II)
SB-57	SOIL BORING (FOSTER WHEELER ENVIRONMENTAL CORPORATION 2001 PHASE III)
PCP	PENTACHLOROPHENOL
MTCA	WASHINGTON STATE MODEL TOXICS CONTROL ACT
AST	ABOVEGROUND STORAGE TANK

BLUE — DENOTES CONCENTRATION EXCEEDING APPLICABLE MTCA CLEANUP LEVEL BUT WAS REMOVED DURING A PRIOR EXCAVATION

mg/kg — MILLIGRAMS PER KILOGRAM

< — RESULT BELOW LABORATORY REPORTING LIMIT

HIGHEST DETECTED PCP CONCENTRATION IN SOIL:

AT OR BELOW MTCA METHOD B CLEANUP LEVEL OF 2.5mg/kg

ALL RESULTS SHOWN IN MILLIGRAMS PER KILOGRAM

ELEVATION IN FEET ABOVE MEAN SEA LEVEL

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

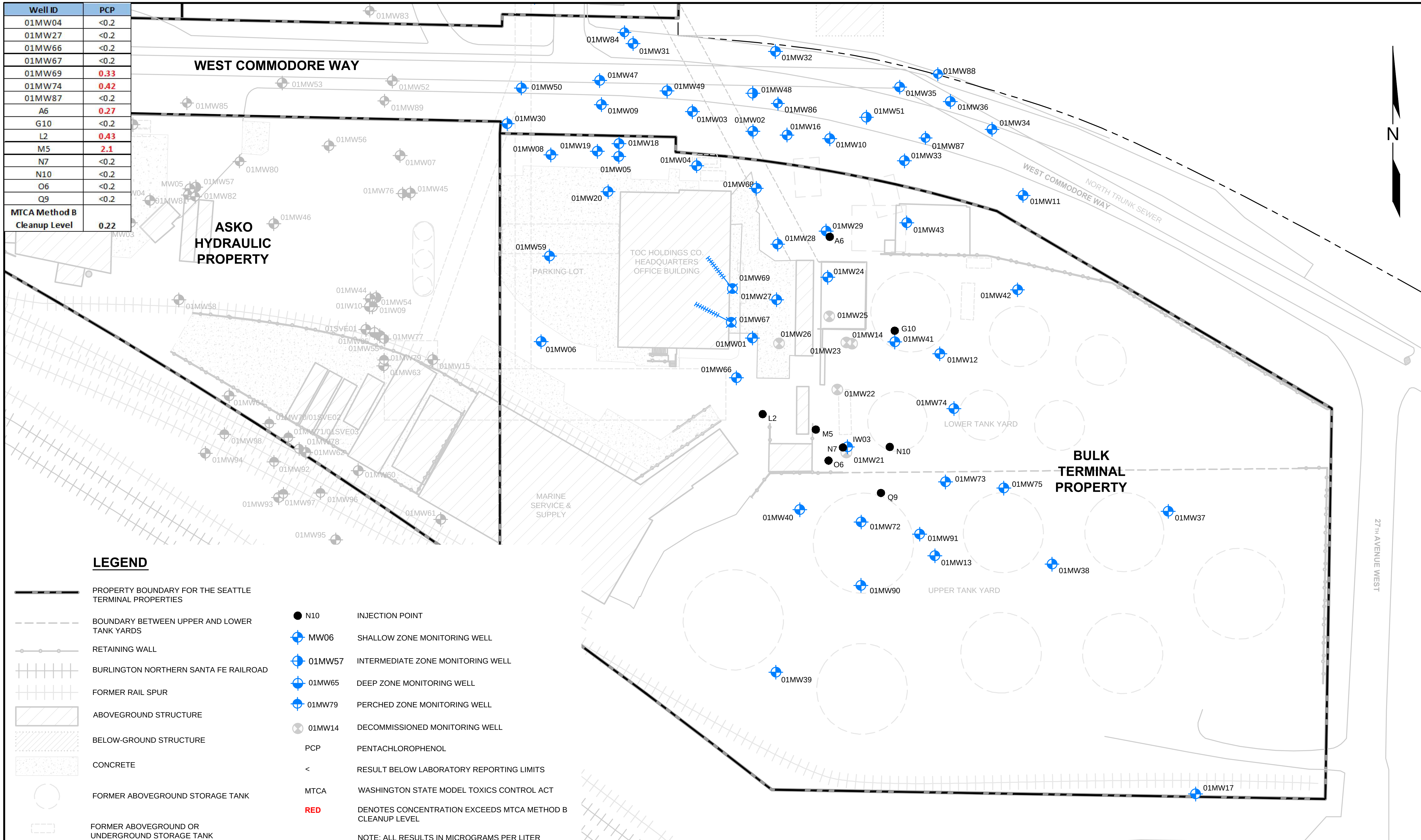
REGION:

0 5 10 20
APPROXIMATE SCALE IN FEET

FIGURE 17C
HISTORICAL SOIL ANALYTICAL RESULTS FOR PCP

P:\0440 TOC HOLDINGS CO\01-600 SEATTLE TERMINAL\TECHNICAL\CAD\2014\BTP\FS\01-600_2014FS_SD_PCP_ZB_F.DWG

Well ID	PCP
01MW04	<0.2
01MW27	<0.2
01MW66	<0.2
01MW67	<0.2
01MW69	0.33
01MW74	0.42
01MW87	<0.2
A6	0.27
G10	<0.2
L2	0.43
M5	2.1
N7	<0.2
N10	<0.2
O6	<0.2
Q9	<0.2
MTCA Method B Cleanup Level	0.22



LEGEND

	PROPERTY BOUNDARY FOR THE SEATTLE TERMINAL PROPERTIES
	BOUNDARY BETWEEN UPPER AND LOWER TANK YARDS
	RETAINING WALL
	BURLINGTON NORTHERN SANTA FE RAILROAD
	FORMER RAIL SPUR
	ABOVEGROUND STRUCTURE
	BELOW-GROUND STRUCTURE
	CONCRETE
	FORMER ABOVEGROUND STORAGE TANK
	FORMER ABOVEGROUND OR UNDERGROUND STORAGE TANK

N10	INJECTION POINT
MW06	SHALLOW ZONE MONITORING WELL
01MW57	INTERMEDIATE ZONE MONITORING WELL
01MW65	DEEP ZONE MONITORING WELL
01MW79	PERCHED ZONE MONITORING WELL
01MW14	DECOMMISSIONED MONITORING WELL
PCP	PENTACHLOROPHENOL
<	RESULT BELOW LABORATORY REPORTING LIMITS
MTCA	WASHINGTON STATE MODEL TOXICS CONTROL ACT
RED	DENOTES CONCENTRATION EXCEEDS MTCA METHOD B CLEANUP LEVEL

NOTE: ALL RESULTS IN MICROGRAMS PER LITER

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

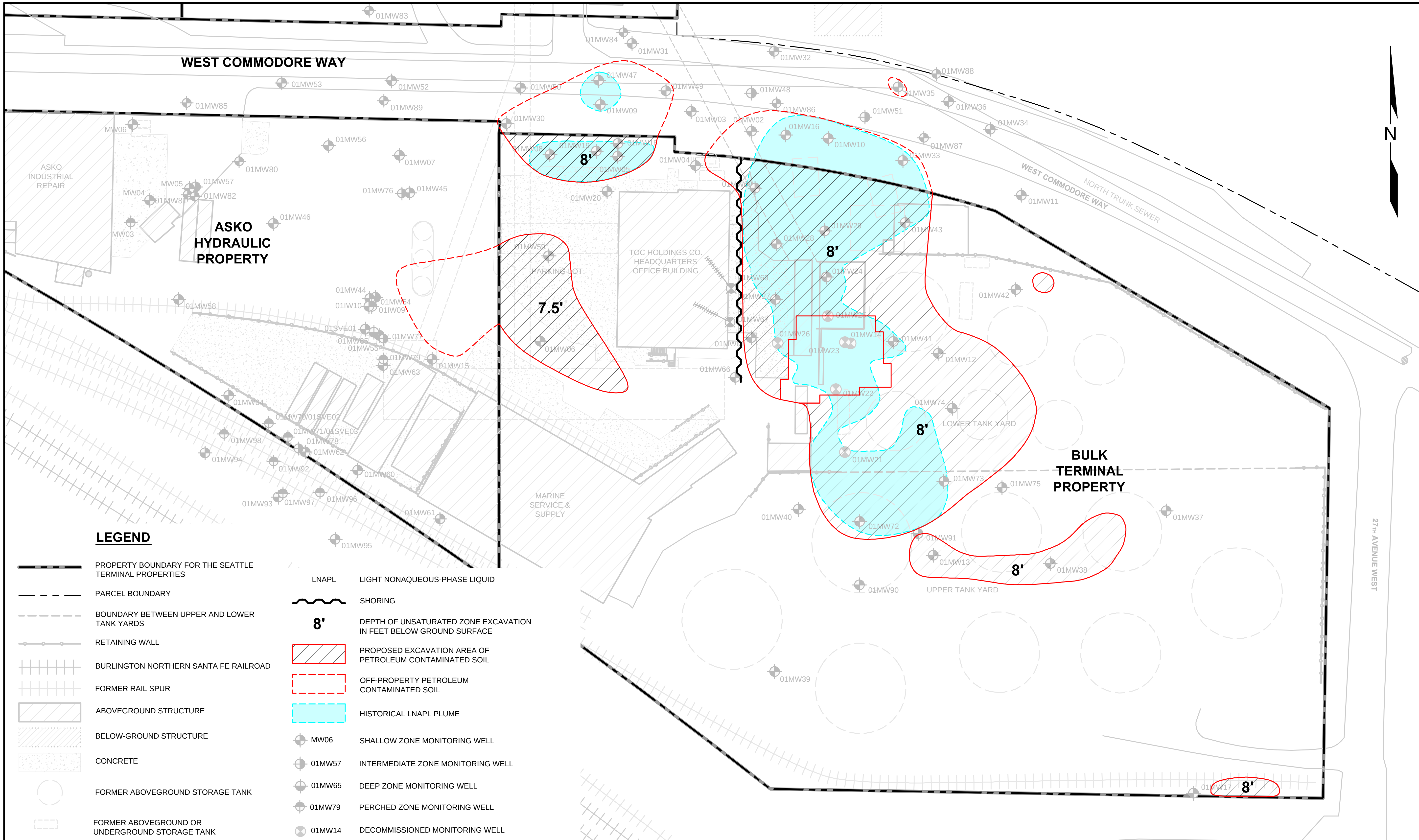
REGION:

0 30 60 120
APPROXIMATE SCALE IN FEET

FIGURE 18
GROUNDWATER ANALYTICAL RESULTS - PCP
BULK TERMINAL PROPERTY
(FIRST QUARTER 2013 EVENT)

7/14/2014

P:\0440 TOC HOLDINGS CO\01-600 SEATTLE TERMINAL\TECHNICAL\CAD\2014\BTP\FS\01-600_2014FS_GD_PCP_F.DWG



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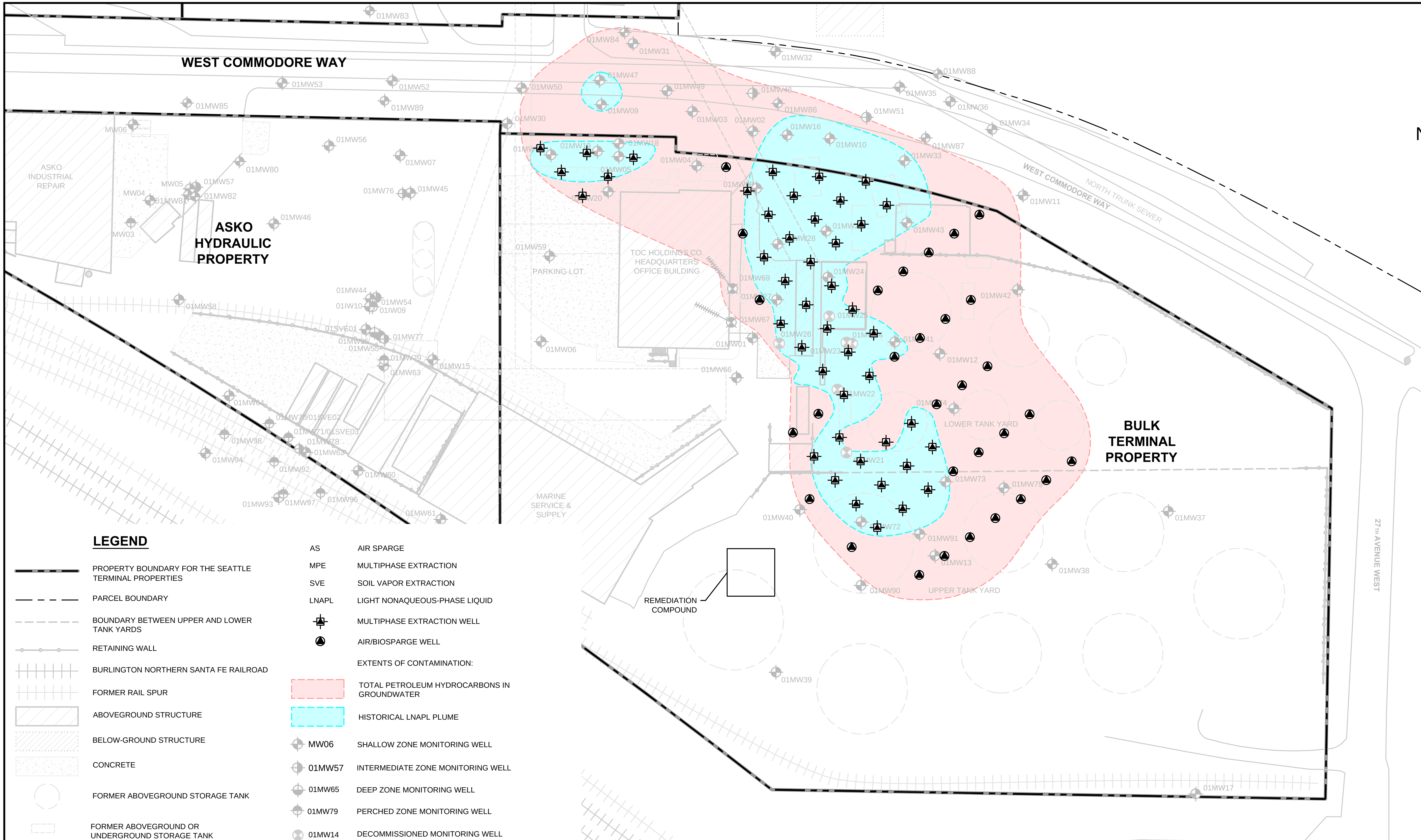
SES PROJECT NUMBER: 0440-004
STREET ADDRESS: 2737 WEST COMMODORE WAY
CITY, STATE: SEATTLE, WASHINGTON

FIGURE 19A
BULK TERMINAL PROPERTY
CLEANUP ACTION ALTERNATIVE 1; PHASE 1
EXCAVATION FOR OFF-SITE
LAND DISPOSAL

P:\0440 TOC HOLDINGS CO\01-600 SEATTLE TERMINAL\TECHNICAL\CAD\2014\BTP\FS\01-600_2014FS_CA1_1_F.DWG 7/14/2014



P:\0440 TOC HOLDINGS CO\01-600 SEATTLE TERMINAL\TECHNICAL\CAD\2014\BTP\FS\01-600_2014FS_CA1_2_F.DWG 7/14/2014

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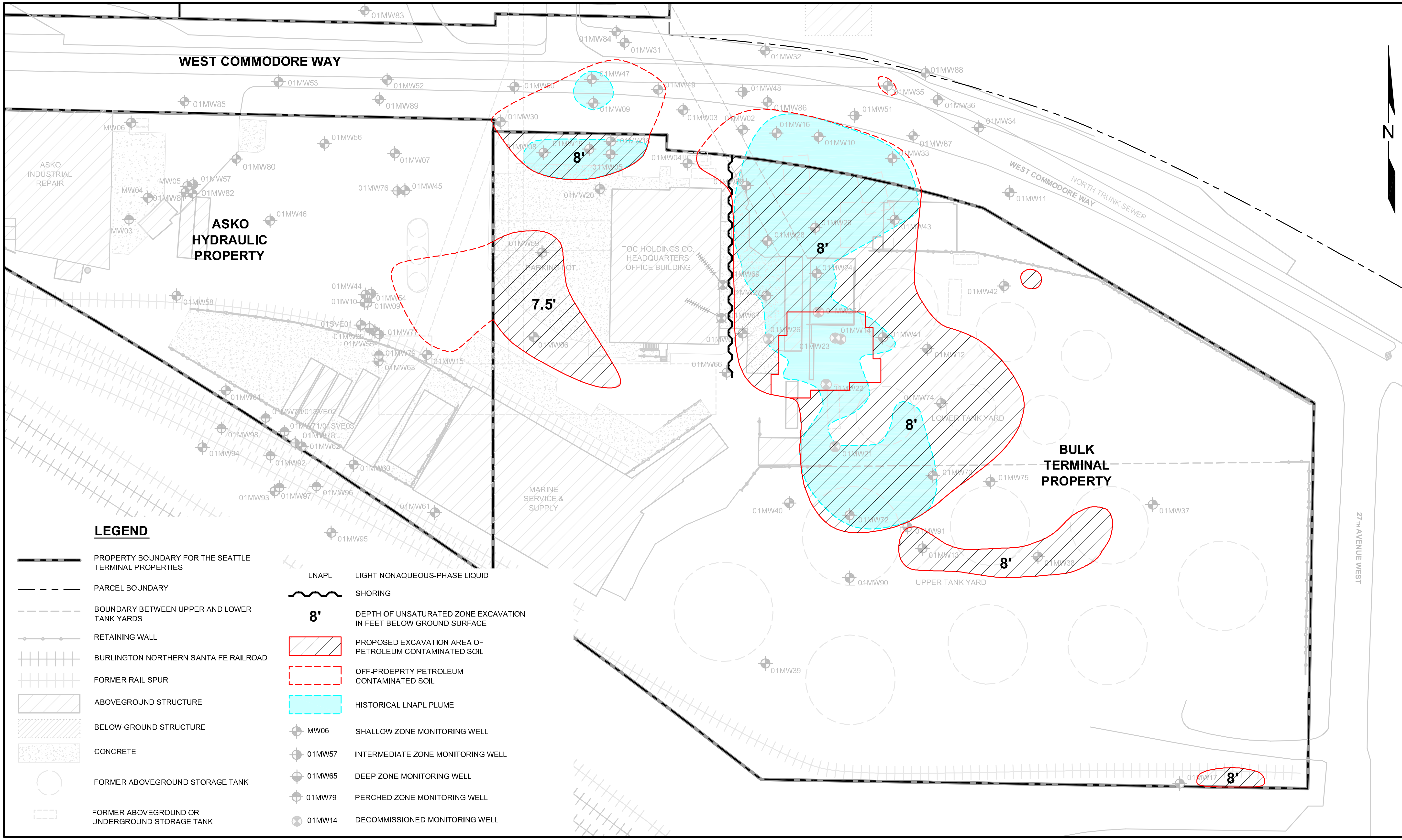
PROJECT NAME: TOC HOLDINGS CO. BULK TERMINAL PROPERTY
SES PROJECT NUMBER: 0440-004
STREET ADDRESS: 2737 WEST COMMODORE WAY
CITY, STATE: SEATTLE, WASHINGTON

REGION:

0 30 60 120
APPROXIMATE SCALE IN FEET

FIGURE 19B
BULK TERMINAL PROPERTY
CLEANUP ACTION ALTERNATIVE1, PHASE 2
MPE, BIOSPARGING, AS, AND SVE



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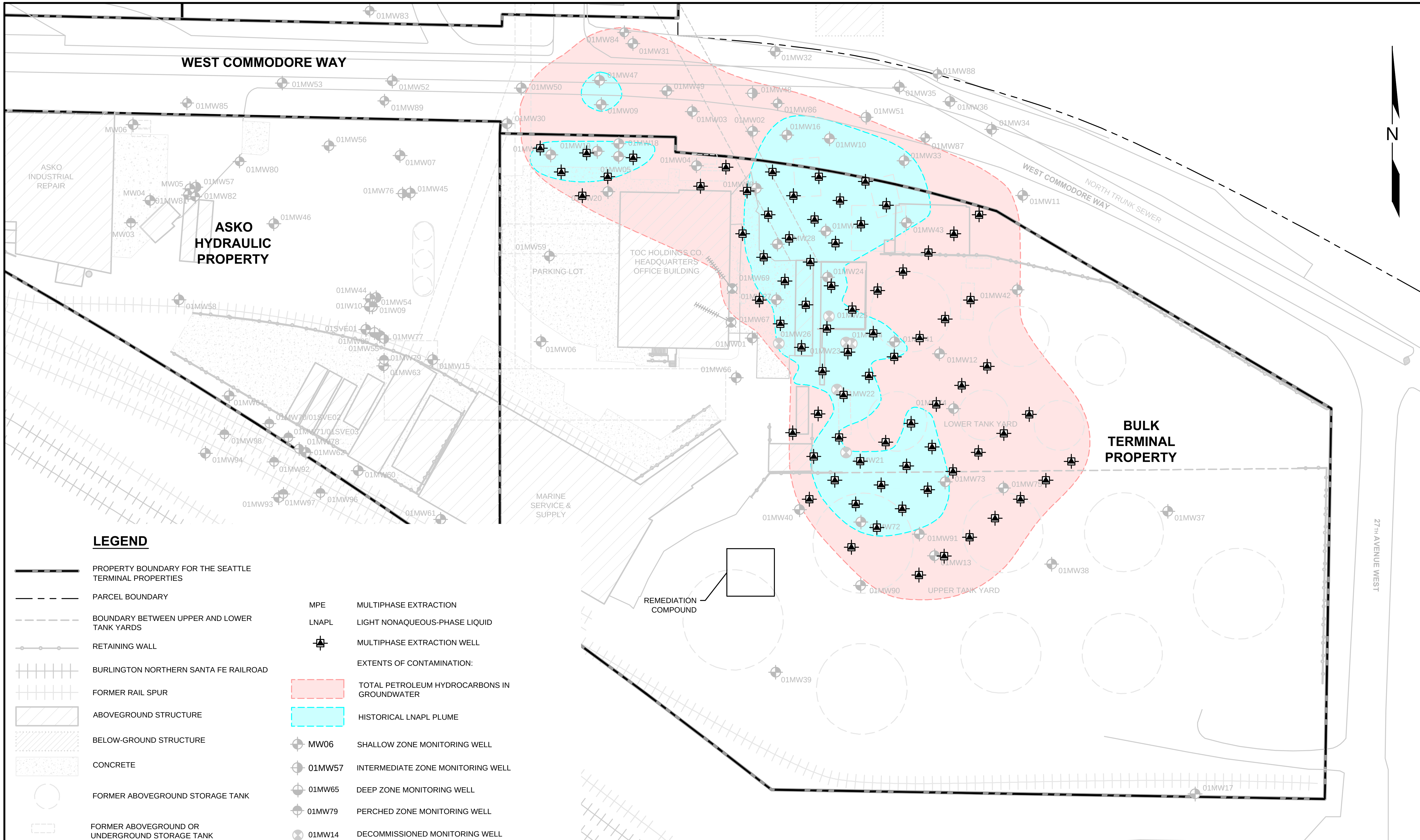
SES PROJECT NUMBER: 0440-004
STREET ADDRESS: 2737 WEST COMMODORE WAY
CITY, STATE: SEATTLE, WASHINGTON

FIGURE 20A
BULK TERMINAL PROPERTY
CLEANUP ACTION ALTERNATIVE 2, PHASE 1
EXCAVATION FOR OFF-SITE
LAND DISPOSAL

P:\0440 TOC HOLDINGS CO\01-600 SEATTLE TERMINAL\TECHNICAL\CAD\2014\BTP\FS\01-600_2014FS_CA2_1_F.DWG
7/14/2014



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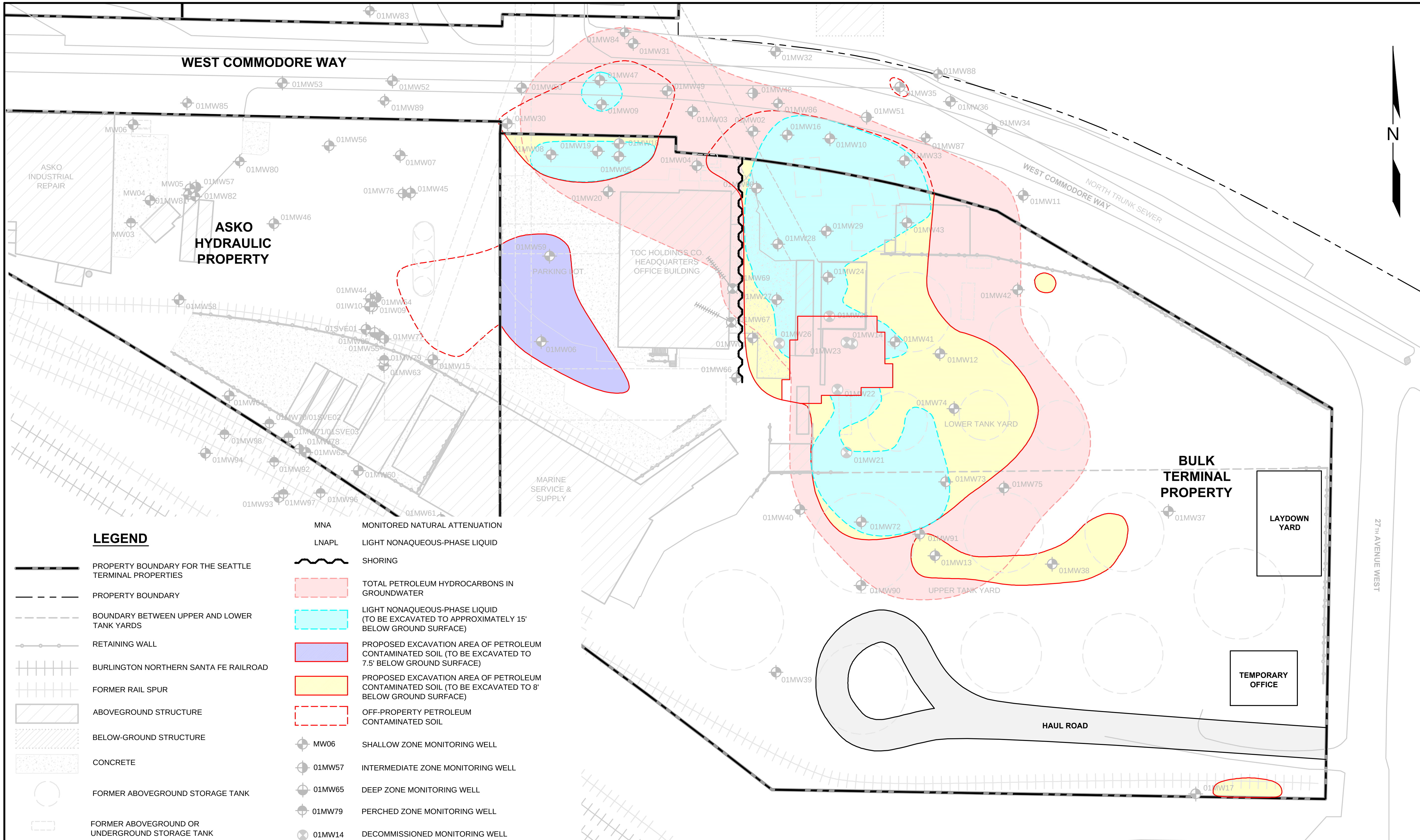
SES PROJECT NUMBER:	0440-004
STREET ADDRESS:	2737 WEST COMMODORE WAY
CITY, STATE:	SEATTLE, WASHINGTON

REGION:

0 30 60 120
APPROXIMATE SCALE IN FEET

FIGURE 20B
BULK TERMINAL PROPERTY
CLEANUP ACTION ALTERNATIVE 2,
PHASE 2, MPE



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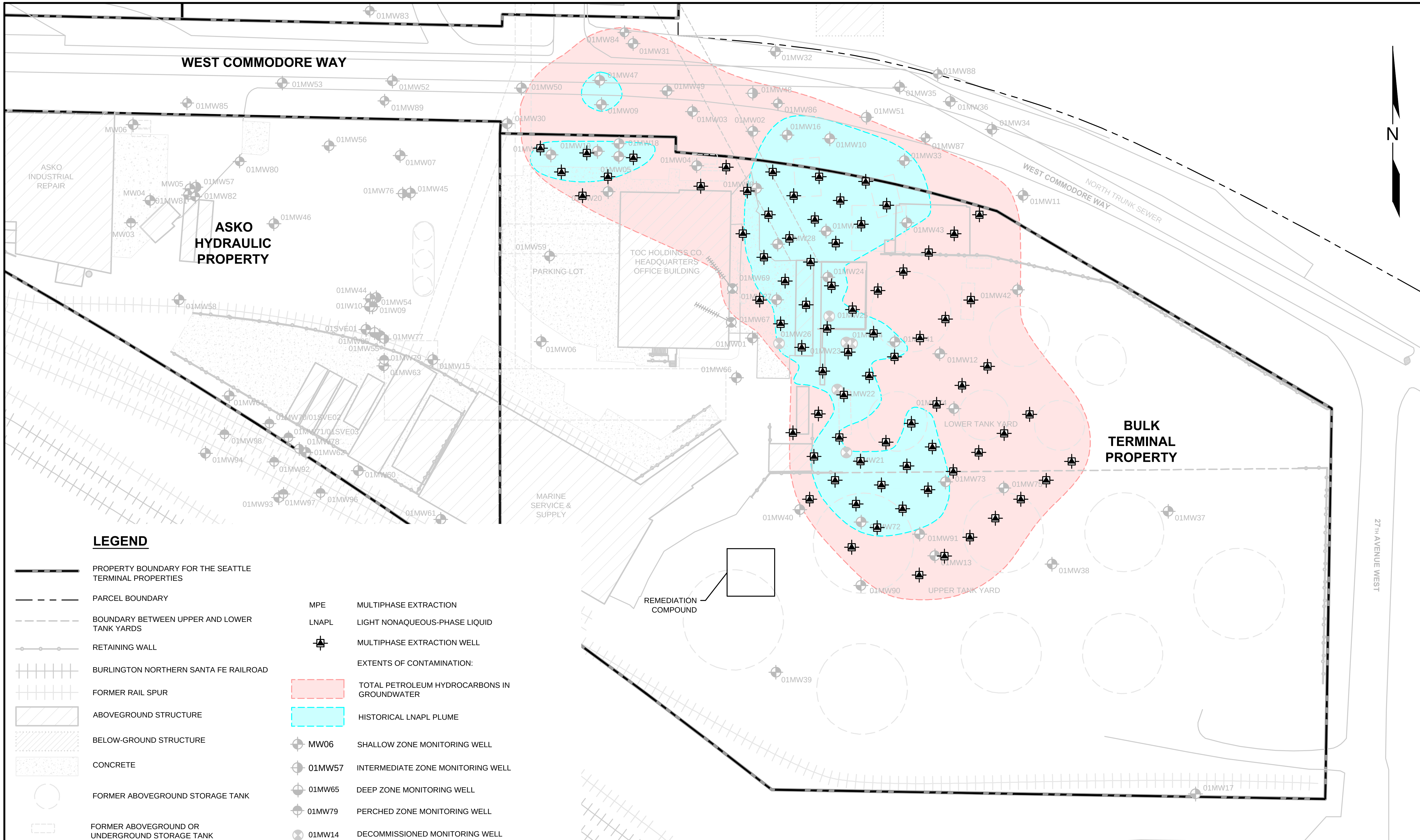
PROJECT NAME: TOC HOLDINGS CO. BULK TERMINAL PROPERTY
SES PROJECT NUMBER: 0440-004
STREET ADDRESS: 2737 WEST COMMODORE WAY
CITY, STATE: SEATTLE, WASHINGTON

REGION:

FIGURE 21

BULK TERMINAL PROPERTY
CLEANUP ACTION ALTERNATIVE 3
EXCAVATION OF SOILS & LNAPL, MNA



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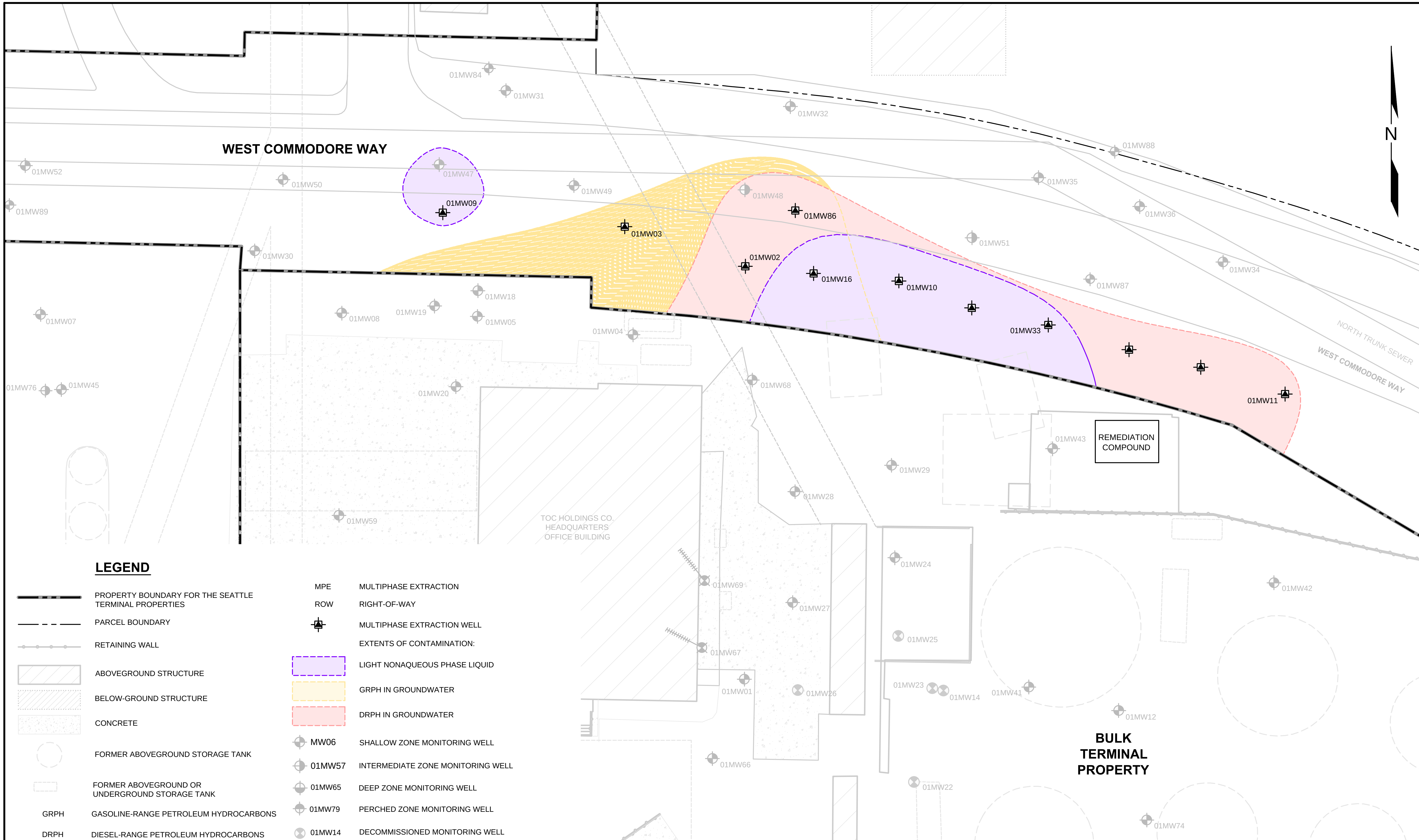
PROJECT NAME: TOC HOLDINGS CO. BULK TERMINAL PROPERTY
SES PROJECT NUMBER: 0440-004
STREET ADDRESS: 2737 WEST COMMODORE WAY
CITY, STATE: SEATTLE, WASHINGTON

REGION:

0 30 60 120
APPROXIMATE SCALE IN FEET

FIGURE 22
BULK TERMINAL PROPERTY
CLEANUP ACTION ALTERNATIVE 4
MPE

P:\0440 TOC HOLDINGS CO\01-600 SEATTLE TERMINAL\TECHNICAL\CAD\2014\BTP\FS\01-600_2014FS_CA4_F.DWG 7/14/2014



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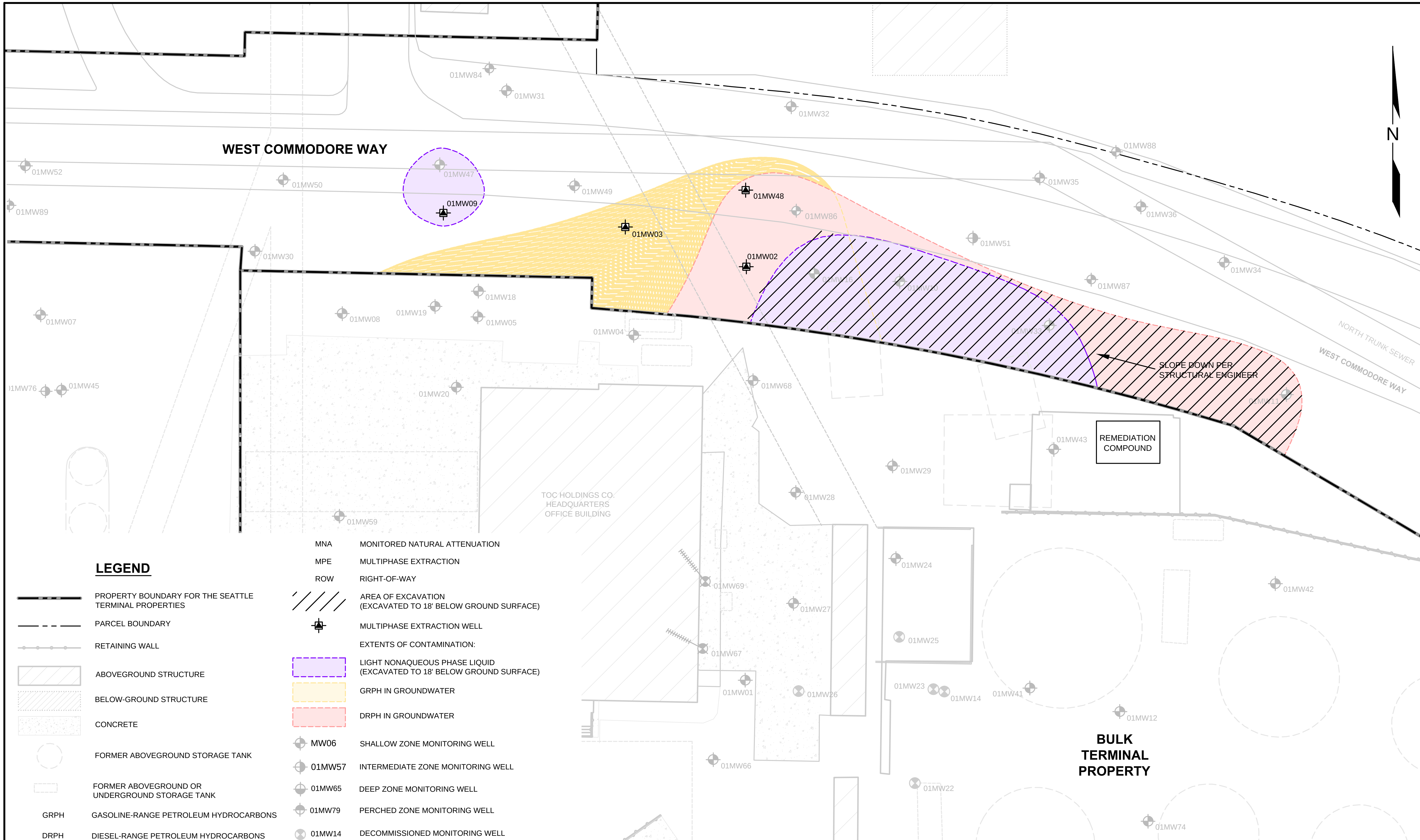
CAD FILE: 01-600_2014FS_WCW_CA1

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

FIGURE 23
WEST COMMODORE WAY ROW
CLEANUP ACTION ALTERNATIVE 1
MPE

7/14/2014
P:\0440 TOC HOLDINGS CO\01-600 SEATTLE TERMINAL\TECHNICAL\CAD\2014\BTP\FS\01-600_2014FS_WCW_CA1.DWG



LEGEND

- PROPERTY BOUNDARY FOR THE SEATTLE TERMINAL PROPERTIES
- PARCEL BOUNDARY
- RETAINING WALL
- ABOVEGROUND STRUCTURE
- BELOW-GROUND STRUCTURE
- CONCRETE
- FORMER ABOVEGROUND STORAGE TANK
- FORMER ABOVEGROUND OR UNDERGROUND STORAGE TANK
- GRPH — GASOLINE-RANGE PETROLEUM HYDROCARBONS
- DRPH — DIESEL-RANGE PETROLEUM HYDROCARBONS
- MNA — MONITORED NATURAL ATTENUATION
- MPE — MULTIPHASE EXTRACTION
- ROW — RIGHT-OF-WAY
- AREA OF EXCAVATION (EXCAVATED TO 18' BELOW GROUND SURFACE)
- MULTIPHASE EXTRACTION WELL
- EXTENTS OF CONTAMINATION:
- LIGHT NONAQUEOUS PHASE LIQUID (EXCAVATED TO 18' BELOW GROUND SURFACE)
- GRPH IN GROUNDWATER
- DRPH IN GROUNDWATER
- MW06 — SHALLOW ZONE MONITORING WELL
- 01MW57 — INTERMEDIATE ZONE MONITORING WELL
- 01MW65 — DEEP ZONE MONITORING WELL
- 01MW79 — PERCHED ZONE MONITORING WELL
- 01MW14 — DECOMMISSIONED MONITORING WELL

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

REGION:

0 15 30 60
APPROXIMATE SCALE IN FEET

FIGURE 24
WEST COMMODORE WAY ROW
CLEANUP ACTION ALTERNATIVE 2
EXCAVATION, MPE, AND MNA

P:\0440 TOC HOLDINGS CO\01-600 SEATTLE TERMINAL\TECHNICAL\CAD\2014\BTP\FS\01-600_2014FS_WCW_CA2.DWG
7/14/2014

TABLES

Table 1
Preliminary Cleanup Levels
TOC Holdings Co. Facility No. 01-600
Bulk Terminal Property
2737 West Commodore Way
Seattle, Washington

SOIL	
Chemicals of Concern	**Cleanup Levels (mg/kg)**
Gasoline-Range Petroleum Hydrocarbons	30(1)
Diesel-Range Petroleum Hydrocarbons	2,000(1)
Oil-Range Petroleum Hydrocarbons	2,000(1)
Benzene	0.03(1)
Toluene	7(1)
Ethylbenzene	6(1)
Total Xylenes	9(1)
PCE	0.05(1)
TCE	0.03(1)
cis-1,2-Dichloroethene	160(2)
trans-1,2-Dichloroethene	1,600(2)
1,1-Dichloroethene	4,000(2)
1,2-Dichloroethane	11(3)
Vinyl Chloride	0.67(3)
MTBE	0.1(1)
1,2-Dibromoethane	0.005(1)
1,2,4-Trimethylbenzene	NE
1,3,5-Trimethylbenzene	800(2)
Acetone	72,000(2)
Isopropylbenzene	8,000(2)
Naphthalene	5(1)
n-Butylbenzene	NE
n-Propylbenzene	NE
p-Isopropyltoluene	NE
sec-Butylbenzene	NE
tert-Butylbenzene	NE
2-Butanone	48,000(2)
Arsenic	20(1)
Barium	16,000(2)
Cadmium	2(1)
Chromum	2,000(1)
Lead	250(1)
Mercury	2(1)
Selenium	400(2)
Silver	400(2)
Ethanol	NE
Pentachlorophenol	2.5(3)
1-Methylnaphthalene	5(1)
2-Methylnaphthalene	5(1)
Acenaphthene	4,800(2)
Acenaphthylene	NE
Fluorene	3,200(2)
Phenanthrene	NE
Anthracene	24,000(2)
Fluoranthene	3,200(2)
Pyrene	2,400(2)

Table 1
Preliminary Cleanup Levels
TOC Holdings Co. Facility No. 01-600
Bulk Terminal Property
2737 West Commodore Way
Seattle, Washington

SOIL	
Chemicals of Concern	**Cleanup Levels (mg/kg)**
Benzo(g,h,i)perylene	NE
Benzo(a) anthracene	NE
Chrysene	NE
Benzo(a)pyrene	0.1(1)
Benzo(b) fluoranthene	NE
Benzo(k) fluoranthene	NE
Indeno(1,2,3-cd)pyrene	NE
Dibenz(a,h) anthracene	NE
Phenol	24,000(2)
2-Chlorophenol	400(2)
2,4- and 2,3-Dichlorophenol	240(2)
2,6-Dichlorophenol	NE
3-and 4-Chlorophenol	NE
2,5-Dichlorophenol	NE
2,3,5-Trichlorophenol	NE
2,4,6-Trichlorophenol	91(3)
2,4,5-Trichlorophenol	8,000(2)
2,3,4-Trichlorophenol	NE
3,5-Dichlorophenol	NE
2,3,6-Trichlorophenol	NE
3,4-Dichlorophenol	NE
2,3,4,6-Tetrachlorophenol	2,400(2)
2,3,4,5- and 2,3,5,6-Tetrahlorophenol	NE
3,4,5-Trichlorophenol	NE
GROUNDWATER	
Chemicals of Concern	**Cleanup Levels (µg/L)**
Gasoline-Range Petroleum Hydrocarbons	800(4)
Diesel-Range Petroleum Hydrocarbons	500(4)
Oil-Range Petroleum Hydrocarbons	500(4)
Benzene	5(4)
Toluene	1,000(4)
Ethylbenzene	700(4)
Total Xylenes	1,000(4)
PCE	5(4)
TCE	5(4)
cis-1,2-Dichloroethene	16(5)
trans-1,2-Dichloroethene	160(5)
1,1-Dichloroethene	400(5)
1,2-Dichloroethane	5(4)
Pentachlorophenol	0.22(6)
Vinyl Chloride	0.2(4)
MTBE	20(4)
1,2-Dibromoethane	0.01(4)
1,2,4 Trimethylbenzene	NE
1,3,5 Trimethylbenzene	80(5)

Table 1
Preliminary Cleanup Levels
TOC Holdings Co. Facility No. 01-600
Bulk Terminal Property
2737 West Commodore Way
Seattle, Washington

GROUNDWATER	
Chemicals of Concern	**Cleanup Levels (µg/L)**
Naphthalene	160[(4)]
Acetone	7,200[(5)]
Isopropylbenzene	800[(5)]
Ethanol	NE
Total and Dissolved Lead	15[(4)]
Total and Dissolved Arsenic	5[(4)]
Total and Dissolved Barium	3,200[(5)]
Total and Dissolved Cadmium	5[(4)]
Total and Dissolved Chromium	50[(4)]
Total and Dissolved Mercury	2[(4)]
Total and Dissolved Selenium	80[(5)]
Total and Dissolved Silver	80[(5)]
Benz(a) anthracene	NE
Chrysene	NE
Benzo(a)pyrene	0.1[(4)]
Benzo(b) fluoranthene	NE
Benzo(k) fluoranthene	NE
Indeno(1,2,3-cd)pyrene	NE
Dibenz(a,h) anthracene	NE

NOTES:

[(1)]MTCA Method A Soil Cleanup Levels for Unrestricted Land Uses, Table 740-1 of Section 900 of Chapter 173-340 of the Washington Administrative Code, revised November 2007.

[(2)]CLARC, Soil, Method B Cleanup Levels, Non-Carcinogen, Standard Formula Value, Direct Contact (ingestion only), CLARC website <https://fortress.wa.gov/ecy/clarc/CLARCHome.aspx>.

[(3)]CLARC, Soil, Method B Cleanup Levels, Carcinogen, Standard Formula Value, Direct Contact (ingestion only), CLARC website <https://fortress.wa.gov/ecy/clarc/CLARCHome.aspx>.

[(4)]MTCA Method A Cleanup Levels for Ground Water, Table 720-1 of Section 900 of Chapter 173-340 of the Washington Administrative Code, revised November 2007.

[(5)]CLARC, Groundwater, Method B Cleanup Levels, Non-Carcinogen, Standard Formula Value, CLARC website <https://fortress.wa.gov/ecy/clarc/CLARCHome.aspx>.

[(6)]MTCA Cleanup Regulation, CLARC, Ground Water Method B, Carcinogen, Standard Formula Value, CLARC website <https://fortress.wa.gov/ecy/clarc/CLARCHome.aspx>.

µg/L = micrograms per liter
CLARC = Cleanup Levels and Risk Calculation
mg/kg = milligrams per kilogram
MTCA = Washington State Model Toxics Control Act
MTBE = methyl t-butyl ether
NE = not established
PCE = tetrachloroethene
TCE = trichloroethene

SoundEarth Strategies

Table 2
Remedial Component Screening Matrix
TOC Holdings Co. Facility No. 01-600
Bulk Terminal Property and West Commodore Way ROW
2737 West Commodore Way
Seattle, WA

Component Group	Component Options	Retained for Inclusion in Cleanup Action Alternatives?	Rationale for Inclusion or Exclusion
Passive Remediation			
	No Further Action	No	Not retained because the current Site conditions pose unacceptable risks that require remediation.
	Monitored Natural Attenuation	Yes	Retained as a component of all cleanup action alternatives. Not retained for use as a sole administrative or engineering control.
	Low Permeability Containment Cap	No	Not retained because the existence of a cap is not currently compatible with prospective future land uses.
	Environmental Covenant	No	Not retained because does not meet current remedial action objectives to comply with ARARs and Site-specific cleanup standards to demonstrate compliance and obtain an NFA determination from Ecology for unrestricted land uses.
	Passive Treatment Wall (Activated Carbon/PRB)	No	Technology is temporarily effective for COPCs in groundwater but does not address soil contamination.
In Situ Physical Treatment			
	Soil Vapor Extraction	Yes	Retained because SVE is a demonstrated technology for remediation of volatile COPCs in soil and Site conditions are favorable for effective use of this technology.
	Air Sparging	Yes	Retained because air sparging is a demonstrated technology for remediation of COPCs in soil and Site conditions are favorable for effective use of this technology.
	Surfactant Washing	No	Not retained because this technology is mediated in the saturated zone and is not effective in treating unsaturated zone soil contamination.
	Cosolvent Washing	No	Not retained because this technology is mediated in the saturated zone and is not effective in treating unsaturated zone soil contamination.
	Pump and Treat	No	Not retained because this technology is mediated in the saturated zone and is not effective in treating unsaturated zone soil contamination.
	Dual-phase or Multiphase Extraction	Yes	Retained because technology is demonstrated to be effective for remediation of COPCs and Site conditions are favorable for use of this technology.
In Situ Thermal			
	Resistive Thermal with SVE	No	In situ thermal remedial components are not retained because they are costly to implement and do not effectively treat all of the COPCs including TPH in soil and groundwater as a stand-alone technology.
	Conductive Thermal with SVE	No	
	Radio Frequency/Electromagnetic Thermal with SVE	No	
	Steam Injection with SVE and Groundwater Extraction	No	
	Hot Air Injection with SVE	No	
	Hot Water Injection with SVE and Groundwater Extraction	No	
Source Removal			
	Excavation without Shoring	Yes	Retained because there are areas where excavation without shoring is feasible to implement.
	Excavation with Shoring		
	Secant Pile Wall - Impervious Wall	No	Not considered necessary - an impervious shoring system is not needed at the Site due to the planned use of a dewatering system.
	Sheet Pile Wall - Impervious Wall	No	Not considered necessary - an impervious shoring system is not needed at the Site due to the planned use of a dewatering system.
	Soldier Pile Wall - Non-Impervious Wall	Yes	Retained as the selected shoring alternative due to the anticipated excavation and dewatering methods near the TOC Headquarters Office Building.
Ex Situ Source Treatment			
	Surfactant Washing	No	Not retained because these components are not cost competitive with other technologies at this scale and would result in another waste stream requiring disposal.
	Cosolvent Washing	No	
	Chemical Oxidation	No	
	Landfill Disposal with Thermal Desorption	No	Not retained as Land Disposal is more cost-competitive.
	Land Disposal	Yes	Retained for petroleum-contaminated soil. This technology is more cost-competitive because there are more available permitted land disposal facilities. It is assumed that the majority of the waste stream will be designated as non-hazardous waste and Ecology will accept a petition to remove the RCRA waste designation of F027.

SoundEarth Strategies

Table 2
Remedial Component Screening Matrix
TOC Holdings Co. Facility No. 01-600
Bulk Terminal Property and West Commodore Way ROW
2737 West Commodore Way
Seattle, WA

Component Group	Component Options	Retained for Inclusion in Cleanup Action Alternatives?	Rationale for Inclusion or Exclusion
In Situ Chemical Oxidation			
	Heated Sodium Persulfate	No	Not retained because of poor effectiveness in treating diesel-range petroleum hydrocarbons.
	Hydrogen Peroxide	No	Insufficient oxidation potential for direct treatment.
	Ozone	No	Would be implemented by gas injection which is considered less effective than use of Fenton's Reagent for COPCs.
	Permanganate	No	Not retained because of poor effectiveness in treating COPCs.
	Fenton's Reagent	No	Difficult process to control and costly to implement compared to other technologies.
Containment/Immobilization			
	Bituminization	No	Not retained because these technologies reduce the mobility of hazardous substances but not their toxicity or volume. The technologies are typically implemented ex situ.
	Emulsified Asphalt	No	
	Modified Sulfur Cement	No	
	Polyethylene Extrusion	No	Not retained because this technology is not well developed.
	Pozzolan/Portland Cement	No	Not retained because the technology reduces the mobility of hazardous substances but not the toxicity or volume. The technology is typically implemented ex situ.
	Vitrification/Molten Glass	No	Not retained because it is not cost competitive with our technologies in this group and is difficult to implement. This technology also presents an increased short-term risk of injury during installation and operation.
	Slurry Wall Containment	No	Not retained because these technologies reduce the mobility of hazardous substances but not their toxicity or volume. The technologies are typically implemented ex situ.
	Sheet Pile Wall Containment	No	
	Pump and Treat for Hydraulic Containment	No	Not retained because this component will not address soil contamination.
Phytoremediation			
	Hydraulic Control	No	Not retained because these technologies are unable to remediate groundwater contamination due to the depth of contamination, nor are they compatible with the future land use at the Site.
	Phyto-Degradation	No	
	Phyto-Volatilization	No	
	Phyto-Accumulation	No	
	Phyto-Stabilization	No	
	Enhanced Rhizosphere Biodegradation	No	
In Situ Bioremediation			
	Aerobic Bioremediation	Yes	Retained in conjunction with SVE for treatment of affected environmental media.
	Anaerobic Bioremediation	No	Not retained because of poor effectiveness in treating volatile COPCs.

NOTES:

ARAR = applicable or relevant and appropriate requirement
COPC = chemical of potential concern
LNAPL = light nonaqueous-phase liquid
NFA = No Further Action
SVE = soil vapor extraction
TPH = total petroleum hydrocarbons

Table 3
Cleanup Action Alternative 1
Feasibility Level Cost Estimate
Unsaturated Zone Excavation; MPE for LNAPL;
Biosparge and AS/SVE for TPH in Groundwater
Bulk Terminal Property
2737 West Commodore Way
Seattle, WA

PRESENT CAPITAL COST ITEM	QTY	UNIT	UNIT PRICE	COST	TOTALS
Direct Capital					
Remedial Excavation					
Geotechnical Oversight	1	ls	$ 30,000	$ 30,000	
Shoring	1,200	sf	$ 75	$ 90,000	
Well Abandonment	40	each	$ 500	$ 20,000	
Site Controls (fencing)	500	lf	$ 7.50	$ 3,750	
Temporary Dewatering Treatment	1	ls	$ 75,000	$ 75,000	
Excavating, Handling, and Segregation of PCS (Non-hazardous)	21,200	ton	$ 24	$ 508,800	
Transportation of PCS	16,250	ton	$ 25	$ 406,250	
Land Disposal of PCS at a Permitted Facility	16,250	ton	$ 38	$ 617,500	
Clean Backfill and Compaction	16,250	ton	$ 20	$ 325,000	
Backfill and Compact Clean Overburden	4,950	ton	$ 4	$ 19,800	
Subtotal Remedial Excavation					$ 2,096,100
Multi-Phase Extraction, Biosparge, Air Sparge, and SVE System					
Multi Phase Extraction Wells, Installed	45	each	$ 4,000	$ 180,000	
Air and Biosparge Wells, Installed	30	each	$ 3,000	$ 90,000	
Soil Vapor Extraction Wells, Installed	20	each	$ 3,000	$ 60,000	
Trenches including Piping, Fittings, and Backfill	1	ls	$ 330,000	$ 330,000	
Total Fluids pumps for MPE	45	each	$ 2,800	$ 126,000	
Remediation Slab, Equipment, and Enclosure	1	ls	$ 200,000	$ 200,000	
Transportation of Trench Cuttings to CEMEX	450	ton	$ 25	$ 11,250	
Disposal of Trench Cuttings	450	ton	$ 38	$ 17,100	
Subtotal MPE, Biosparge, AS and SVE System					$ 1,014,350
Compliance Monitoring					
Well Installation for Quarterly Groundwater Monitoring	12	each	$ 2,500	$ 30,000	
Compliance Monitoring Subtotal					$ 30,000
Subtotal Direct Capital					$ 3,140,450
Indirect Capital (as percentages of Direct Capital)					
Design, Permitting, and Work Plans (5%)				$ 157,100	
Mobilization (1%)				$ 31,500	
Professional Labor for Construction Oversight (10%)				$ 314,100	
Field Equipment and Supplies (1%)				$ 31,500	
Laboratory Testing (field verification and waste profiling) (3%)				$ 94,300	
Site Restoration and Demobilization (1%)				$ 31,500	
Regulatory Reporting (4%)				$ 125,700	
Subtotal Indirect Capital					$ 785,700
Total Capital					$ 3,926,200

Table 3
Cleanup Action Alternative 1
Feasibility Level Cost Estimate
Unsaturated Zone Excavation; MPE for LNAPL;
Biosparge and AS/SVE for TPH in Groundwater
Bulk Terminal Property
2737 West Commodore Way
Seattle, WA

FUTURE O&M, AND OTHER DIRECT COST ITEMS[1]	ANNUAL COST[2]	PRESENT WORTH OF ANNUAL AND FUTURE CAPITAL COST	
	Discount Rate = 0.1%	n (years)= 10	
Quarterly Groundwater Monitoring (assumes 20 wells)	$ 60,000	$ 596,700	
Monthly Operation and Maintenance	$ 140,000	$ 1,392,300	
Post-remediation Confirmation Soil Sampling		$ 25,000	
Decommission Monitoring Wells (20 @ $350 each)		$ 10,500	
Decommission SVE, AS, and DPE Wells (95 wells @ $350 each)		$ 33,250	
Decommission System		$ 45,000	
Present Worth Cost of Annual and Future Capital Cost			$ 2,102,750
TOTAL PRESENT WORTH COST (Sum of Total Capital and Present Worth of Annual and Future Capital Cost)[3][4][5]			$ 6,029,000

NOTES:

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[2]Annual cost is year 2013 cost.

[3]This feasibility level cost should not be considered a design cost estimate or guaranteed cost.

[4]Excludes electrical costs for all systems.

[5]Cost rounded up to nearest $1,000.

AS = air sparge

DFCR = Preliminary Draft for Client Review

DPE = duel-phase extraction

lf = linear feet

ls = lump sum

MPE = multiphase extraction

n = number of years

O&M = operation and maintenance

PCS = petroleum-contaminated soil

QTY = quantity

sf = square feet

SVE = soil vapor extraction

ton = number of bank cubic yards x 1.5 ton/bank cubic yard

Table 4
Cleanup Action Alternative 2
Feasibility Level Cost Estimate
Unsaturated Zone Excavation;
MPE for LNAPL and TPH in Groundwater
Bulk Terminal Property
2737 West Commodore Way
Seattle, WA

PRESENT CAPITAL COST ITEM	QTY	UNIT	UNIT PRICE	COST	TOTALS
Direct Capital					
Remedial Excavation					
Geotechnical Oversight	1	ls	$ 30,000	$ 30,000	
Shoring	1,200	sf	$ 75	$ 90,000	
Well Abandonment	40	each	$ 500	$ 20,000	
Site Controls (fencing)	500	lf	$ 7.5	$ 3,750	
Temporary Dewatering Treatment	1	ls	$ 75,000	$ 75,000	
Excavating, Handling, and Segregation of PCS (Non-hazardous)	21,200	ton	$ 24	$ 508,800	
Transportation of PCS	16,250	ton	$ 25	$ 406,250	
Land Disposal of PCS at a Permitted Facility	16,250	ton	$ 38	$ 617,500	
Clean Backfill and Compaction	16,250	ton	$ 20	$ 325,000	
Backfill and Compact Clean Overburden	4,950	ton	$ 4	$ 19,800	
Subtotal Remedial Excavation					$ 2,096,100
Multi Phase Extraction System					
Multiphase Extraction Wells, Installed	76	each	$ 4,000	$ 304,000	
Trenches Including Piping, Fittings, and Backfill	1	ls	$ 304,000	$ 304,000	
Total Fluids Pumps for DPE	76	each	$ 2,800	$ 212,800	
Remediation Slab, Equipment, and Enclosure	1	each	$ 180,000	$ 180,000	
Transportation of Trench Cuttings	450	ton	$ 25	$ 11,250	
Disposal of Trench Cuttings (Assumed non-hazardous, PCS)	450	ton	$ 38	$ 17,100	
Subtotal MPE System					$ 1,029,150
Compliance Monitoring					
Well Installation for Quarterly Groundwater Monitoring	12	each	$ 2,500	$ 30,000	
Compliance Monitoring Subtotal					$ 30,000
Subtotal Direct Capital					$ 3,125,250
Indirect Capital (as percentages of Direct Capital)					
Design, Permitting, and Work Plans (5%)				$ 156,300	
Mobilization (1%)				$ 31,300	
Professional Labor for Construction Oversight (10%)				$ 312,600	
Field Equipment and Supplies (1%)				$ 31,300	
Laboratory Testing (field verification and waste profiling) (3%)				$ 93,800	
Site Restoration and Demobilization (1%)				$ 31,300	
Regulatory Reporting (4%)				$ 125,100	
Subtotal Indirect Capital					$ 781,700
Total Capital					$ 3,906,950

Table 4
Cleanup Action Alternative 2
Feasibility Level Cost Estimate
Unsaturated Zone Excavation;
MPE for LNAPL and TPH in Groundwater
Bulk Terminal Property
2737 West Commodore Way
Seattle, WA

FUTURE O&M AND OTHER DIRECT COST ITEMS[1]	ANNUAL COST[2]	PRESENT WORTH OF ANNUAL AND FUTURE CAPITAL COST	
	Discount Rate = 0.1%	n (years)= 10	
Quarterly Groundwater Monitoring (assumes 20 wells)	$ 60,000	$ 596,700	
Monthly Operation and Maintenance	$ 120,000	$ 1,193,400	
Post-Remediation Confirmation Soil Sampling		$ 25,000	
Decommission Monitoring Wells (20 @ $350 each)		$ 7,000	
Decommission MPE Wells (76 wells @ $350 each)		$ 26,600	
Decommission MPE System		$ 40,000	
Present Worth Cost of Annual and Future Capital Cost			$ 1,888,700
TOTAL PRESENT WORTH COST (Sum of Total Capital and Present Worth of Annual and Future Capital Cost)[3][4][5]			$ 5,796,000

NOTES:

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[3]This feasibility level cost should not be considered a design cost estimate or guaranteed cost.

[4]Excludes electrical costs for all systems.

[5]Cost rounded up to nearest $1,000.

DFCR = Preliminary Draft for Client Review

lf = linear feet
ls = lump sum
LNAPL = light nonaqueous-phase liquid
MPE = multiphase extraction
n = number of years
O&M = operation and maintenance
PCS = petroleum-contaminated soil
QTY = quantity
sf = square feet
SVE = soil vapor extraction
ton = number of bank cubic yards x 1.5 ton/bank cubic yard

Table 5
Cleanup Action Alternative 3
Feasibility Level Cost Estimate
Excavate PCS and LNAPL;
MNA for TPH in GW
Bulk Terminal Property
2737 West Commodore Way
Seattle, WA

PRESENT CAPITAL COST ITEM	QTY	UNIT	UNIT PRICE	COST	TOTALS
Direct Capital					
Remedial Excavation					
Geotechnical Oversight	1	ls	$ 75,000	$ 75,000	
Shoring	2,250	sf	$ 75	$ 168,750	
Well Abandonment	40	each	$ 500	$ 20,000	
Site Controls (fencing)	500	lf	$ 7.50	$ 3,750	
Temporary Dewatering Treatment	1	ls	$ 100,000	$ 100,000	
Excavating, Handling, and Segregation of PCS (Non-hazardous)	29,200	ton	$ 24	$ 700,800	
Transportation of PCS	22,370	ton	$ 25	$ 559,250	
Land Disposal of PCS at a Permitted Facility	22,370	ton	$ 38	$ 850,060	
Clean Backfill and Compaction	22,370	ton	$ 20	$ 447,400	
Overburden Backfill and Compaction	6,830	ton	$ 4	$ 27,320	
Remedial Excavation Subtotal					$ 2,952,330
Compliance Monitoring					
Well Installation for Quarterly Groundwater Monitoring	12	each	$ 2,500	$ 30,000	
Compliance Monitoring Subtotal					$ 30,000
Subtotal Direct Capital					$ 2,982,330
Indirect Capital (as percentages of Direct Capital)					
Design, Permitting, and Work Plans (5%)				$ 149,200	
Mobilization (1%)				$ 29,900	
Professional Labor for Construction Oversight (10%)				$ 298,300	
Field Equipment and Supplies (1%)				$ 29,900	
Laboratory Testing (field verification and waste profiling) (3%)				$ 89,500	
Site Restoration and Demobilization (1%)				$ 29,900	
Regulatory Reporting (4%)				$ 119,300	
Subtotal Indirect Capital					$ 746,000
Total Capital					$ 3,728,330

FUTURE O&M AND OTHER DIRECT COST ITEMS(1)	ANNUAL COST(2)	PRESENT WORTH OF ANNUAL AND FUTURE CAPITAL COST	
	Discount Rate = 0.8%	n (years)= 20	
Quarterly Groundwater Monitoring for MNA (assumes 20 wells)	$ 60,000	$ 1,104,900	
Decommission Monitoring Wells (20 @ $350 each)		$ 7,000	
Present Worth Cost of Annual and Future Capital Cost			$ 1,111,900
TOTAL PRESENT WORTH COST (Sum of Total Capital and Present Worth of Annual and Future Capital Cost)(3)(4)(5)			$ 4,841,000

NOTES:

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(2)Annual cost is year 2013 cost.

(3)This feasibility level cost should not be considered a design cost estimate or guaranteed cost.

(4)Excludes electrical costs for all systems.

(5)Cost rounded up to nearest $1,000.

DFCR = Preliminary Draft for Client Review
lf = linear feet
LNAPL = light nonaqueous-phase liquid
ls = lump sum
MNA = Monitored Natural Attenuation
n = number of years
O&M = operation and maintenance
PCS = petroleum-contaminated soil
QTY= quantity
sf = square feet
ton = number of bank cubic yards x 1.5 ton/bank cubic yard

SoundEarth Strategies

Table 6
Cleanup Action Alternative 4
Feasibility Level Cost Estimate
MPE for Unsaturated Zone, LNAPL, and TPH in Groundwater
Bulk Terminal Property
2737 West Commodore Way
Seattle, WA

PRESENT CAPITAL COST ITEM	QTY	UNIT	UNIT PRICE	COST	TOTALS
Direct Capital					
Multi Phase Extraction System					
Multiphase Extraction Wells, Installed	76	each	$ 4,000	$ 304,000	
Trenches Including Piping, Fittings, and Backfill	1	ls	$ 304,000	$ 304,000	
Total Fluids Pumps for MPE	76	each	$ 2,800	$ 212,800	
Remediation Slab, Equipment, and Enclosure	1	each	$ 180,000	$ 180,000	
Transportation of Trench Cuttings	450	ton	$ 25	$ 11,250	
Disposal of Trench Cuttings (Assumed non-hazardous, PCS)	450	ton	$ 38	$ 17,100	
Subtotal MPE System					$ 1,029,150
Subtotal Direct Capital					$ 1,029,150
Indirect Capital (as percentages of Direct Capital)					
Design, Permitting, and Work Plans (5%)				$ 51,500	
Mobilization (0.5%)				$ 5,200	
Professional Labor for Construction Oversight (12%)				$ 123,500	
Field Equipment and Supplies (1%)				$ 10,300	
Laboratory Testing (field verification and waste profiling) (2%)				$ 20,600	
Site Restoration and Demobilization (0.5%)				$ 5,200	
Regulatory Reporting (4%)				$ 41,200	
Subtotal Indirect Capital					$ 257,500
Total Capital					$ 1,286,650

FUTURE O&M AND OTHER DIRECT COST ITEMS[1]	ANNUAL COST[2]	PRESENT WORTH OF ANNUAL AND FUTURE CAPITAL COST	
	Discount Rate = 0.5%	n (years)= 15	
Quarterly Groundwater Monitoring (assumes 20 wells)	$ 60,000	$ 865,000	
Monthly O&M	$ 120,000	$ 1,730,000	
Post-Remediation Confirmation Soil Sampling		$ 25,000	
Decommission Monitoring Wells (20@ $350 each)		$ 7,000	
Decommission MPE Wells (76 wells @ $350 each)		$ 26,600	
Decommission MPE System		$ 40,000	
Present Worth Cost of Annual and Future Capital Cost			$ 2,693,600
TOTAL PRESENT WORTH COST (Sum of Total Capital and Present Worth of Annual and Future Capital Cost)[3][4][5]			$ 3,980,000

NOTES:

[1]Additional direct costs such as project management, regulatory communications and reporting, and other technical support services not specifically listed are not included in any future annual costs.

[2]Annual cost is year 2013 cost.

[3]This feasibility level cost should not be considered a design cost estimate or guaranteed cost.

[4]Excludes electrical costs for all systems.

[5]Cost rounded up to nearest $1,000.

DFCR = Preliminary Draft for Client Review
ls = lump sum
LNAPL = light nonaqueous-phase liquid
MPE = multiphase extraction
n = number of years
O&M = operation and maintenance
PCS = petroleum-contaminated soil
QTY = quantity
ton = number of bank cubic yards x 1.5 ton/bank cubic yard
TPH = total petroleum hydrocarbons

SoundEarth Strategies

Table 7
Cleanup Action Alternative 1
Feasibility Level Cost Estimate
MPE for LNAPL and TPH in Groundwater
West Commodore Way ROW
2737 West Commodore Way
Seattle, WA

PRESENT CAPITAL COST ITEM	QTY	UNIT	UNIT PRICE	COST	TOTALS
Direct Capital					
Multi Phase Extraction System					
Site Controls (fencing)	300	lf	$ 7.5	$ 2,250	
Multiphase Extraction Wells, Installed	3	each	$ 4,000	$ 12,000	
Retrofit Existing Monitoring Wells as MPE Remediation Wells	8	each	$ 1,800	$ 14,400	
Trenches Including Piping, Fittings, and Backfill	1	ls	$ 44,000	$ 44,000	
Total Fluids Pumps for MPE	11	each	$ 2,800	$ 30,800	
Remediation Slab, Equipment, and Enclosure	1	each	$ 150,000	$ 150,000	
Transportation of Trench Cuttings	83	ton	$ 25	$ 2,080	
Disposal of Trench Cuttings (Assumed non-hazardous, PCS)	83	ton	$ 38	$ 3,160	
Right-of-Way Restoration	1	ls	$ 50,000	$ 50,000	
Subtotal MPE System					$ 308,690
Subtotal Direct Capital					$ 308,690
Indirect Capital (as percentages of Direct Capital)					
Design, Permitting, and Work Plans (15%)				$ 46,400	
Mobilization (1%)				$ 3,100	
Professional Labor for Construction Oversight (15%)				$ 46,400	
Field Equipment and Supplies (2%)				$ 6,200	
Laboratory Testing (field verification and waste profiling) (5%)				$ 15,500	
Site Restoration and Demobilization (2%)				$ 6,200	
Regulatory Reporting (10%)				$ 30,900	
Subtotal Indirect Capital					$ 154,700
Total Capital					$ 463,390
FUTURE O&M AND OTHER DIRECT COST ITEMS[1]	**ANNUAL COST[2]**		**PRESENT WORTH OF ANNUAL AND FUTURE CAPITAL COST**		
	Discount Rate = 0.5%		n (years)= 15		
Quarterly Groundwater Monitoring (assumes 20 wells)	$ 60,000			$ 865,000	
Monthly O&M	$ 110,000			$ 1,585,800	
Post-Remediation Confirmation Soil Sampling				$ 25,000	
Decommission Monitoring Wells (20@ $350 each)				$ 7,000	
Decommission MPE Wells (11 wells @ $350 each)				$ 3,850	
Decommission MPE System				$ 35,000	
Present Worth Cost of Annual and Future Capital Cost					$ 2,521,650
TOTAL PRESENT WORTH COST (Sum of Total Capital and Present Worth of Annual and Future Capital Cost)[3][4][5]					$ 2,986,000

NOTES:

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[4]Excludes electrical costs for all systems.

[5]Cost rounded up to nearest $1,000.

DFCR = Preliminary Draft for Client Review
lf = linear feet
ls = lump sum
GW = groundwater
LNAPL = light nonaqueous-phase liquid
MPE = multiphase extraction
n = number of years
O&M = operation and maintenance
PCS = petroleum-contaminated soil
QTY = quantity
SVE = soil vapor extraction
ton = number of bank cubic yards x 1.5 ton/bank cubic yard
TPH = total petroleum hydrocarbons

Table 8
Cleanup Action Alternative 2
Feasibility Level Cost Estimate
Excavate LNAPL; MPE and MNA for Residual LNAPL and TPH in GW
West Commodore Way ROW
2737 West Commodore Way
Seattle, WA

PRESENT CAPITAL COST ITEM	QTY	UNIT	UNIT PRICE	COST	TOTALS
Direct Capital					
Remedial Excavation					
Geotechnical Oversight	1	ls	$ 20,000	$ 20,000	
Well Abandonment	4	each	$ 500	$ 2,000	
Site Controls (fencing)	300	lf	$ 7.50	$ 2,250	
Temporary Dewatering Treatment	1	ls	$ 25,000	$ 25,000	
Excavating, handling, and Segregation of PCS (Nonhazardous)	2,710	ton	$ 24	$ 65,040	
Transportation of PCS	1,140	ton	$ 25	$ 28,500	
Thermal Desorption Treatment and Disposal of PCS	1,140	ton	$ 38	$ 43,320	
Clean Backfill and Compaction	1,140	ton	$ 20	$ 22,800	
Backfill and Compact Clean Overburden	1,570	ton	$ 4	$ 6,280	
Right-of-Way Restoration	1	ls	$ 75,000	$ 75,000	
Subtotal Remedial Excavation					$ 290,190
Multi Phase Extraction System					
Multi Phase Extraction Wells, Installed	1	each	$ 4,000	$ 4,000	
Retrofit Existing Monitoring Wells as MPE Remediation Wells	4	each	$ 1,800	$ 7,200	
Trenches including Piping, Fittings, and Backfill	1	ls	$ 20,000	$ 20,000	
Total Fluids pumps for MPE	5	each	$ 2,800	$ 14,000	
Remediation Slab, Equipment, and Enclosure	1	ls	$ 150,000	$ 150,000	
Transportation of Trench Cuttings	8	ton	$ 25	$ 200	
Disposal of Trench Cuttings (Assumed non-hazardous, PCS)	8	ton	$ 38	$ 310	
Subtotal MPE System					$ 195,710
Compliance Monitoring					
Well Installation for Quarterly Groundwater Monitoring	4	each	$ 2,500	$ 10,000	
Compliance Monitoring Subtotal					$ 10,000
Subtotal Direct Capital					$ 495,900
Indirect Capital (as percentages of Direct Capital)					
Design, Permitting, and Work Plans (12%)				$ 59,600	
Mobilization (2%)				$ 10,000	
Professional Labor for Construction Oversight (15%)				$ 74,400	
Field Equipment and Supplies (1%)				$ 5,000	
Laboratory Testing (field verification and waste Profiling) (3%)				$ 14,900	
Site Restoration and Demobilization (1%)				$ 5,000	
Regulatory Reporting (6%)				$ 29,800	
Subtotal Indirect Capital					$ 198,700
Total Capital					$ 694,600

Table 8
Cleanup Action Alternative 2
Feasibility Level Cost Estimate
Excavate LNAPL; MPE and MNA for Residual LNAPL and TPH in GW
West Commodore Way ROW
2737 West Commodore Way
Seattle, WA

FUTURE O&M AND OTHER DIRECT COST ITEMS[1]	ANNUAL COST[2]	PRESENT WORTH OF ANNUAL AND FUTURE CAPITAL COST	
	Discount Rate = 0.1%	n (years)= 10	
Quarterly Groundwater Monitoring for MNA (assumes 20 wells)	$ 60,000	$ 596,700	
Monthly Operations and Maintenance	$ 110,000	$ 1,094,000	
Post-Remediation Confirmation Soil Sampling		$ 25,000	
Decommission Monitoring Wells (20@ $350 each)		$ 7,000	
Decommission MPE Wells (5 wells @ $350 each)		$ 1,750	
Decommission MPE System		$ 35,000	
Present Worth Cost of Annual and Future Capital Cost			$ 1,759,450
TOTAL PRESENT WORTH COST (Sum of Total Capital and Present Worth of Annual and Future Capital Cost)[3][4][5]			$ 2,455,000

NOTES:

[1]Additional direct costs such as project management, regulatory communications and reporting, and other technical support services not specifically listed are not included in any future annual costs.

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[3]This feasibility level cost should not be considered a design cost estimate or guaranteed cost.

[4]Excludes electrical costs for all systems.

[5]Cost rounded up to nearest $1,000.

DFCR = Preliminary Draft for Client Review
GW = groundwater
lf = linear feet
LNAPL = light nonaqueous-phase liquid
ls = lump sum
MNA = monitored natural attenuation
MPE = multiphase extraction
n = number of years
O&M = operation and maintenance
PCS = petroleum-contaminated soil
QTY = quantity
ton = number of bank cubic yards x 1.5 ton/bank cubic yard
TPH = total petroleum hydrocarbons

Table 9
Cleanup Action Alternative Summary
Bulk Terminal Property and West Commodore Way ROW
TOC Holdings Co. Seattle Terminal Properties
2737 West Commodore Way
Seattle, WA

Cleanup Action Alternatives		Summary Description	Washington State Department of Ecology Evaluation Criteria/Relative Ranking (1 = Low 10 = High)						Ranking Score[1]	Estimated Present Worth Cost ($1,000)
			Protectiveness	Permanence	Effectiveness over the Long Term	Management of Short-Term Risks	Technical and Administrative Implementability	Consideration of Public Concerns		
Bulk Terminal Property	**Cleanup Action Alternative 1 - Unsaturated Zone Excavation with Off-Site Land Disposal; MPE for LNAPL; Biosparge and Air Sparge/SVE for TPH in Groundwater**	Install shoring on the east side of the TOC headquarters to enable the excavation of TPH-contaminated soils for off-site land disposal. Backfill and compact the excavated area to original grade with clean structural fill. Install air sparging and soil vapor extraction wells to treat dissolved-phase GRPH and to sustain the bioremediation of the dissolved-phase DRPH. Install multiphase extraction wells to remediate LNAPL. Life cycle of 10 years.	7	7	6	4	4	N/A	**28**	6,029
Bulk Terminal Property	**Cleanup Action Alternative 2 - Unsaturated Zone Excavation with Off-Site Land Disposal; MPE for TPH in Groundwater**	Install shoring on the east side of the TOC headquarters to enable the excavation of TPH-contaminated soils for off-site land disposal. Backfill and compact the excavated area to original grade with clean structural fill. Install multiphase extraction wells to recover groundwater, product, and soil vapor simultaneously for aboveground treatment. Life cycle of 10 years.	7	7	7	4	4	N/A	**29**	5,796
Bulk Terminal Property	**Cleanup Action Alternative 3 - Unsaturated Zone and LNAPL Excavation with Off-Site Land Disposal; MNA for TPH in Groundwater**	Excavate the unsaturated zone and a 7-foot thickness of the saturated zone containing residual LNAPL. Backfill to original site grade with clean structural fill. Rely on natural attenuation to restore and remediate groundwater containing residual dissolved phase petroleum hydrocarbons that are not excavated under this alternative. Life cycle of 5 years.	9	9	8	5	4	N/A	**35**	4,841
Bulk Terminal Property	**Cleanup Alternative 4 - MPE for Unsaturated Zone, LNAPL, and TPH in Groundwater**	Remediate soil, groundwater and LNAPL using MPE. Life cycle assumed to be 20 years.	6	6	6	7	8	N/A	**33**	3,980
West Commodore Way ROW	**Cleanup Alternative 1 - MPE for LNAPL and the TPH in Groundwater**	Use MPE to remediate approximately 6,300 square feet of LNAPL and dissolved phase TPH in the West Commodore Way ROW. Life cycle assumed to be 20 years.	6	6	6	7	8	N/A	**33**	2,986
West Commodore Way ROW	**Cleanup Alternative 2 - LNAPL Excavation for Off-Site Land Disposal; MPE for Residual LNAPL; and MNA for TPH in Groundwater**	Remove LNAPL to a depth of 17 feet below ground surface. Install three MPE wells to remediate LNAPL that is unable to be excavated. Employ MNA to remediate other residual dissolved phase hydrocarbons. Assumes the remaining clean overburden and imported clean fill will be compacted to original grade and repaved. Life cycle of 20 years.	9	9	8	5	4	N/A	**35**	2,455

NOTES:
[1]Ranking score is the sum of the individual criterion ranking scores.
AS = air sparge
DRPH = diesel-range petroleum hydrocarbons
GRPH = gasoline-range petroleum hydrocarbons
LNAPL = light nonaqueous-phase liquid
MNA = Monitored Natural Attenuation
MPE = multiphase extraction
N/A = not applicable
ROW = right-of way
SVE = soil vapor extraction
TOC = top of casing
TPH = total petroleum hydrocarbons

CHARTS

Chart 1
Cost and Relative Ranking of Bulk Terminal Cleanup Action Alternatives
Bulk Terminal Property and West Commodore Way ROW
TOC Holdings Co. Facility No. 01-600
Seattle, Washington

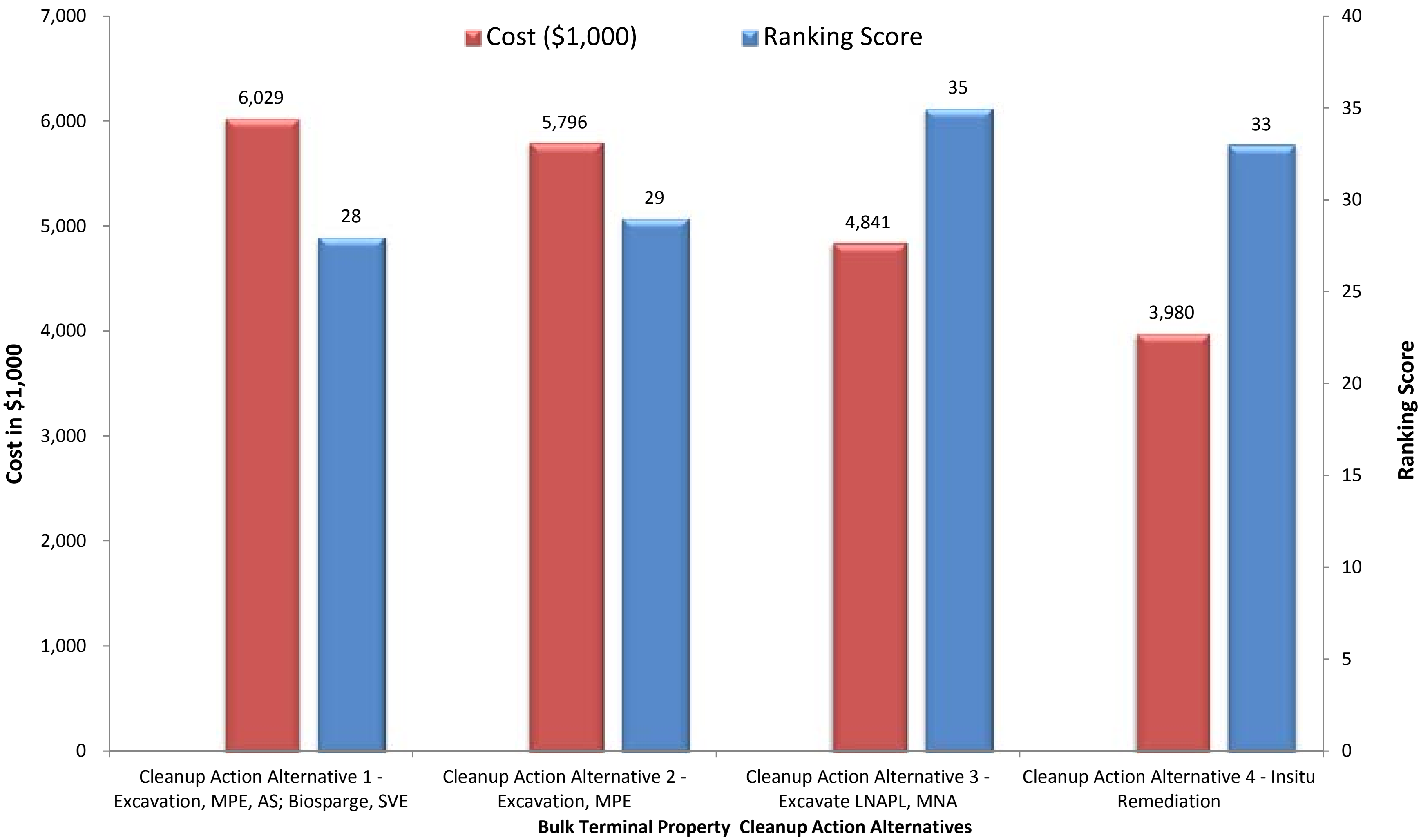


Chart 2
Cost-to-Benefit Ratios for Bulk Terminal Cleanup Action Alternatives
Bulk Terminal Property and West Commodore Way ROW
TOC Holdings Co. Facility No. 01-600
Seattle, Washington

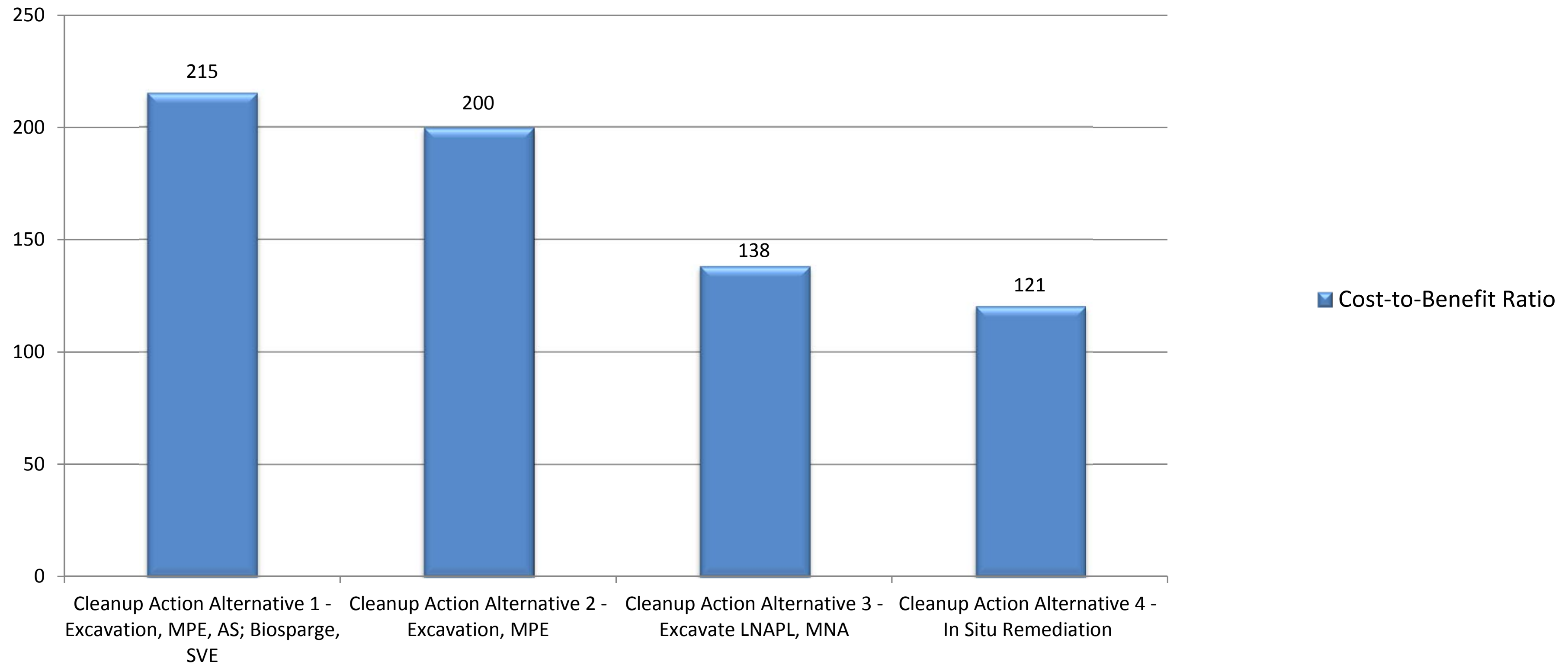


Chart 3
Cost and Relative Ranking of West Commodore Way ROW Cleanup Action Alternatives
Bulk Terminal Property and West Commodore Way ROW
TOC Holdings Co. Facility No. 01-600
Seattle, Washington

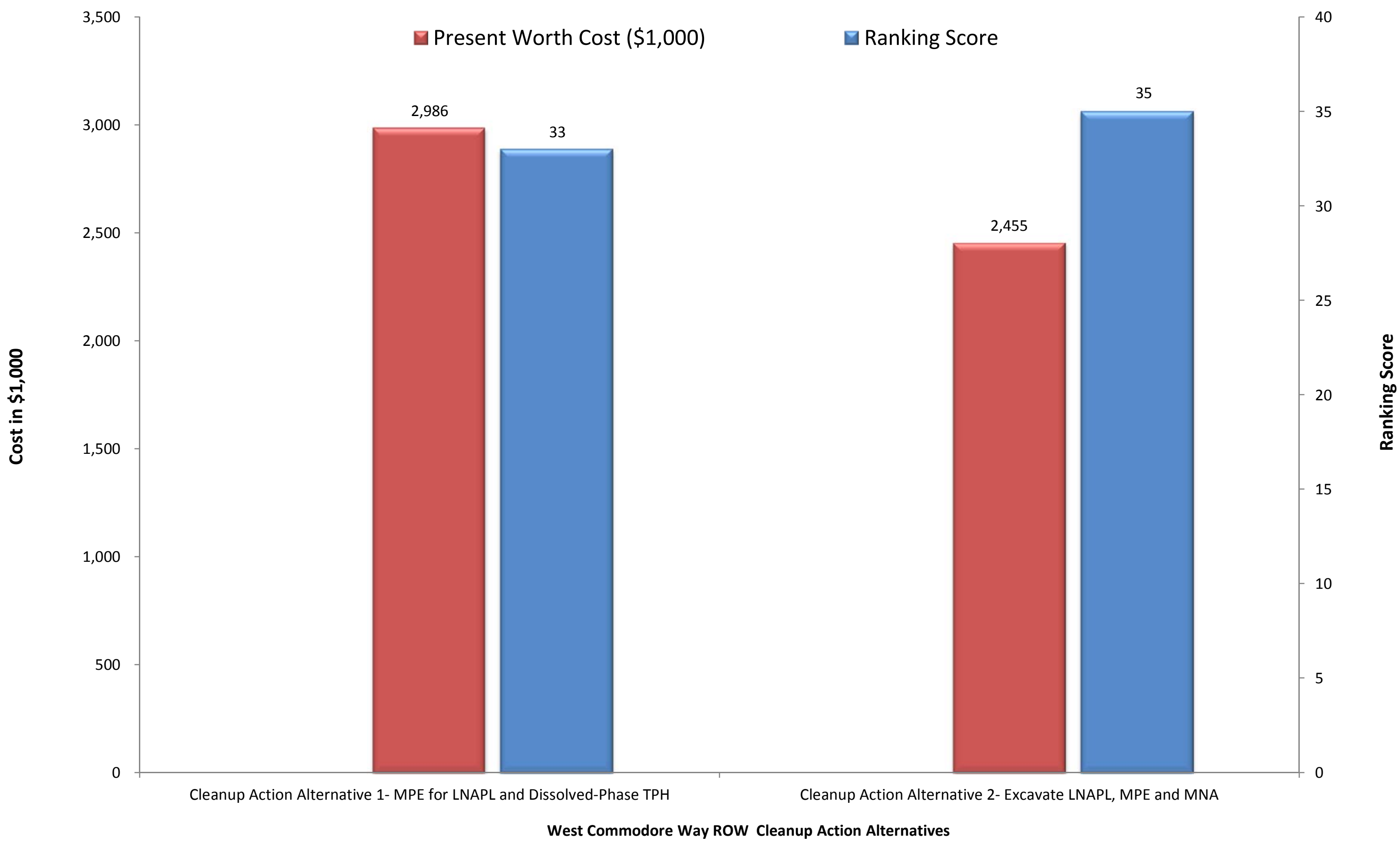
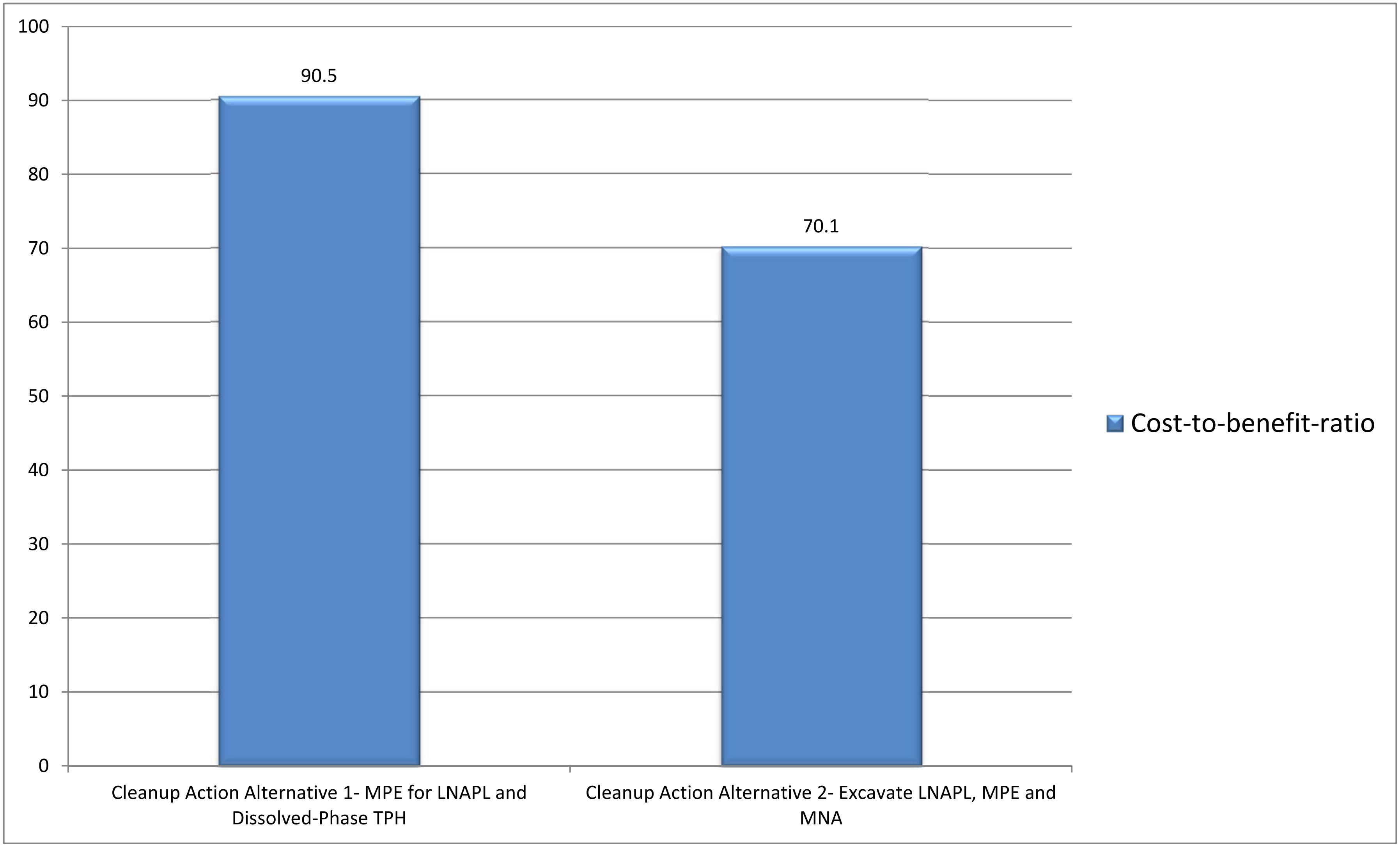


Chart 4
Cost-to-Benefit Ratios for West Commodore Way ROW Cleanup Action Alternatives
Bulk Terminal Property and West Commodore Way ROW
TOC Holdings Co. Facility No. 01-600
Seattle, Washington



APPENDIX A
AQUIFER TESTING DATA SUMMARY

Appendix A
Slug Testing Field Methods and Data Analysis

Table A1
Slug Testing - Field Methods and Data Analysis
TOC Holdings Co. Facility No. 01-600
2737 W. Commodore Way
Seattle, Washington

Date of test	Well ID[(1)]	Water-bearing zone	Top of Screen (ft bgs)	Bottom of Screen (ft bgs)	Initial DTW (ft btoc)	Screen Submerged	Saturated Screen length[(2)] (ft)	Estimated K-value[(3)] (cm/sec)	Estimated K-value[(3)] (ft/day)
Bulk Terminal Property Shallow Water-Bearing Zone									
3/27/2009	01MW03	Shallow	10	25	12.70	No	15.00	7.1E-04	2.0
8/10/2009	01MW21	Shallow	5.0	22.5	7.49	No	15.00	3.0E-05	0.085
3/27/2009	01MW38	Shallow	7.5	22.5	7.94	No	15.00	1.8E-03	5.1
3/27/2009	01MW40	Shallow	7.0	22.0	15.16	No	15.00	1.3E-03	3.7
3/27/2009	01MW59	Shallow	13	29	14.37	No	15.50	9.1E-04	2.6
ASKO Hydraulic Property Shallow Water-Bearing Zone									
3/27/2009	01MW44	Shallow	15	30	22.63	No	15.00	1.8E-03	5.1
3/27/2009	01MW44 (Test 2)	Shallow	15	30	22.63	No	15.00	1.6E-03	4.5
3/26/2009	01MW62	Shallow	24	39	31.16	No	15.00	1.2E-03	3.4
East Waterfront Property Shallow Water-Bearing Zone									
3/26/2009	02MW14	Shallow	4	15	10.10	No	11.00	2.0E-03	5.7
Geometric mean for shallow zone								1.6E-03	4.6
ASKO Hydraulic Property Intermediate Water-Bearing Zone									
3/26/2009	01MW57	Intermediate	35.5	41	26.75	Yes	5.50	1.0E-03	2.8
3/26/2009	01MW65	Deep	52.0	62.0	34.35	Yes	10.00	2.2E-03	6.24

NOTES:

Testing procedure used was Rising Head.

Analytical Method used was Bouwer and Rice, 1976.

Bouwer 1989. The Bouwer and Rice Slug Test - An Update. *Groundwater* 27 no 3: 304-309.

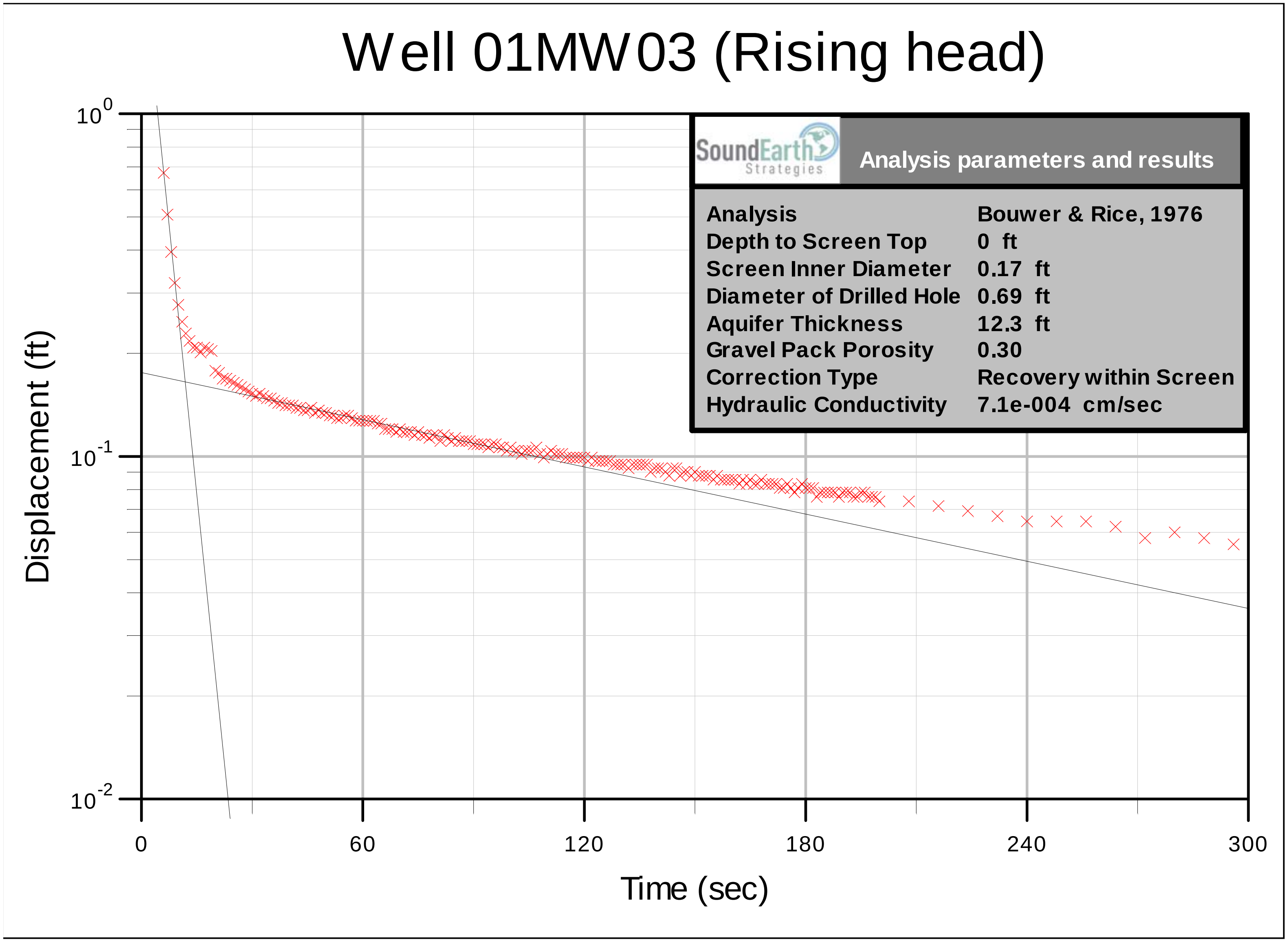
(1) All wells are 2-inch diameter, with 8.25-inch diameter sandpacks.

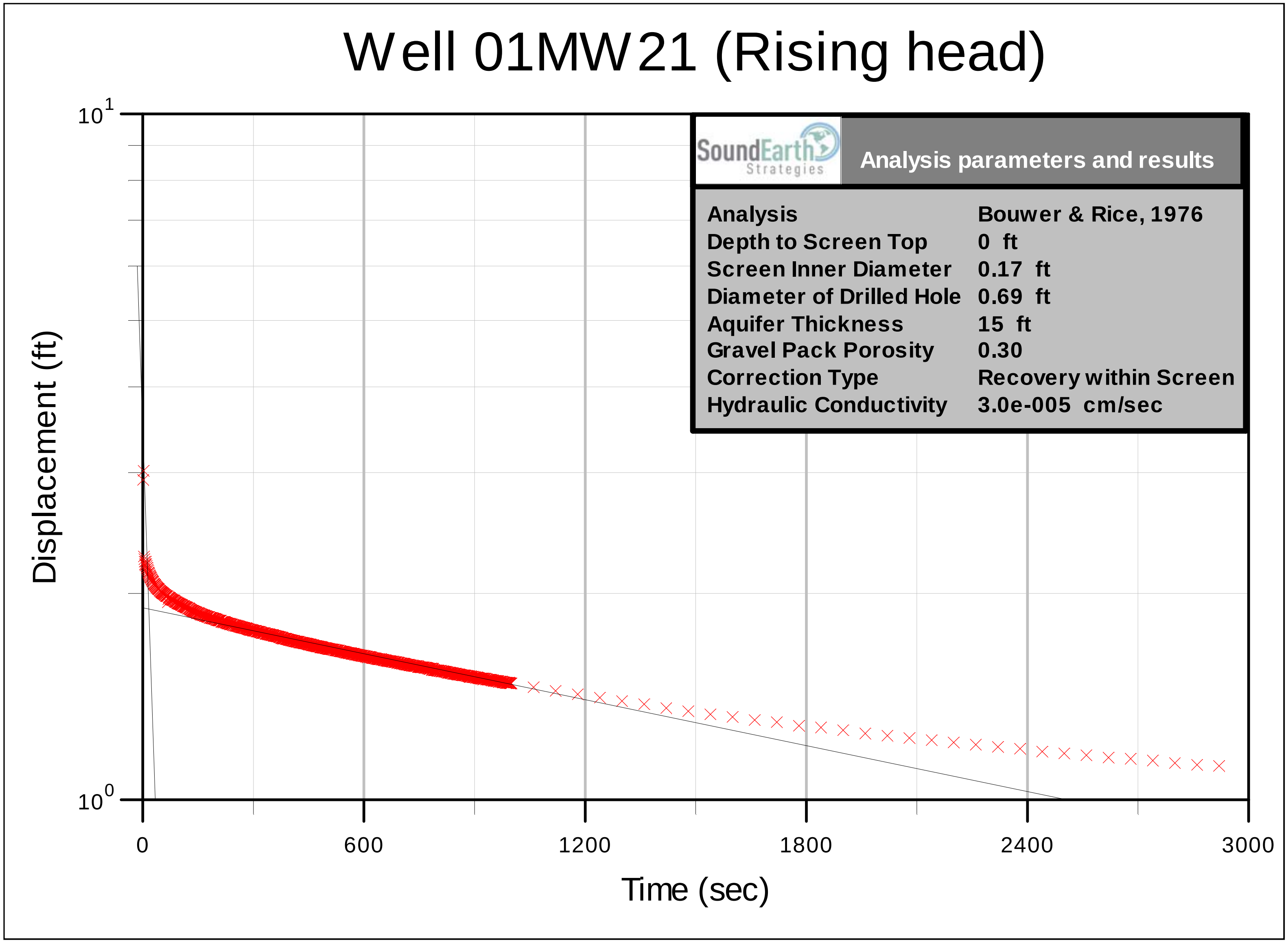
(2) All wells were assumed to be fully penetrating (Aquifer thickness=length of saturated screen). For the 01MW65 and 01MW57, the screened interval fully penetrates a sand layer bounded above and below by silt.

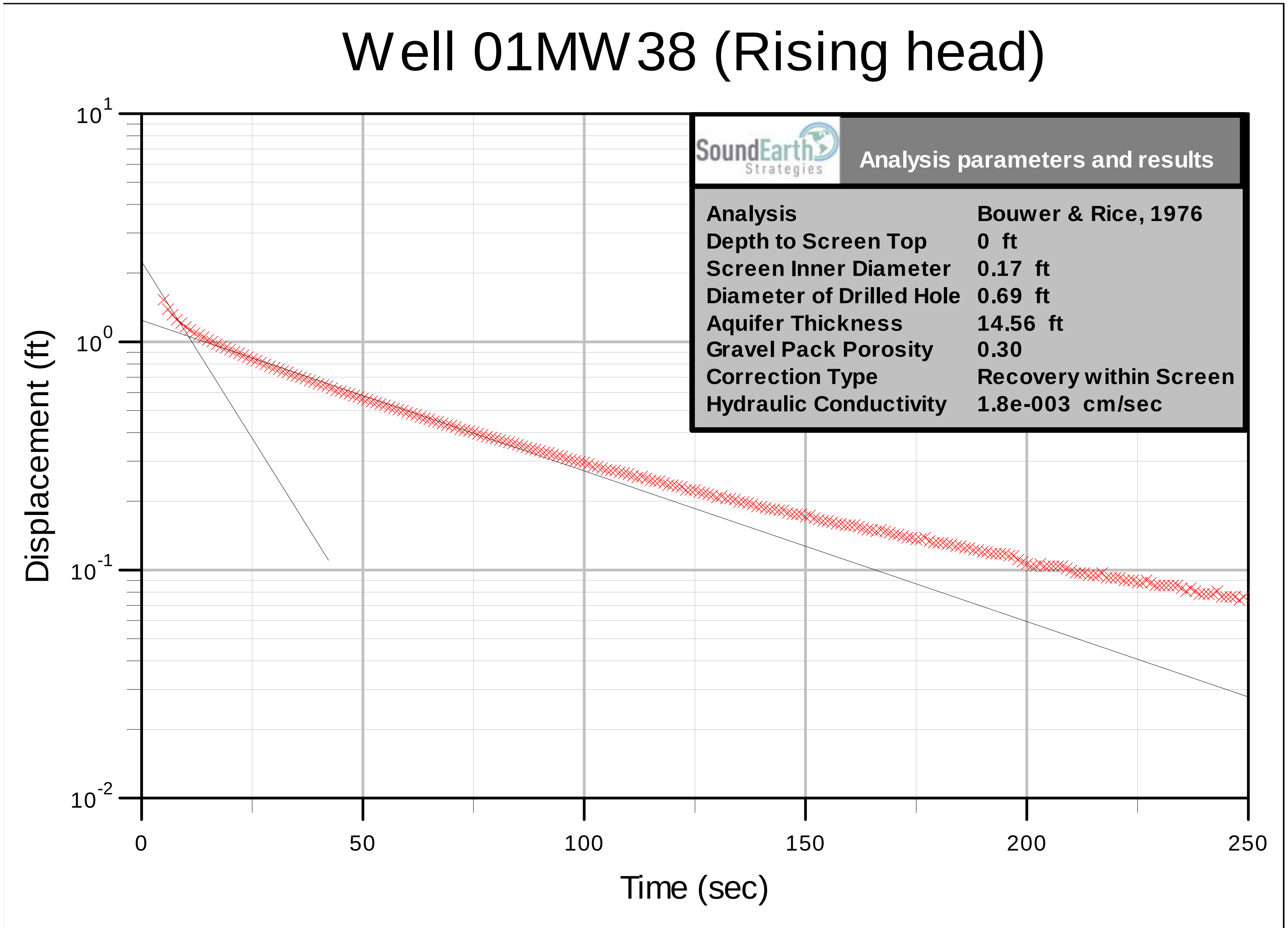
(3) For wells screened across the water table, the sand-pack recovery correction in the Bouwer and Rice analysis was used. Following Bouwer (1989), the first semi-log linear slope in the recovery data was assumed to represent sand pack drainage, and the immediately following curved portion of the data was interpreted to represent an intermediate transition into drainage from native material. The subsequent middle-time semi-log linear slope in the recovery data was used to estimate aquifer hydraulic conductivity. For wells 01MW65 and 01MW57 (submerged screens), the first semi-log slope was used to estimate hydraulic conductivity.

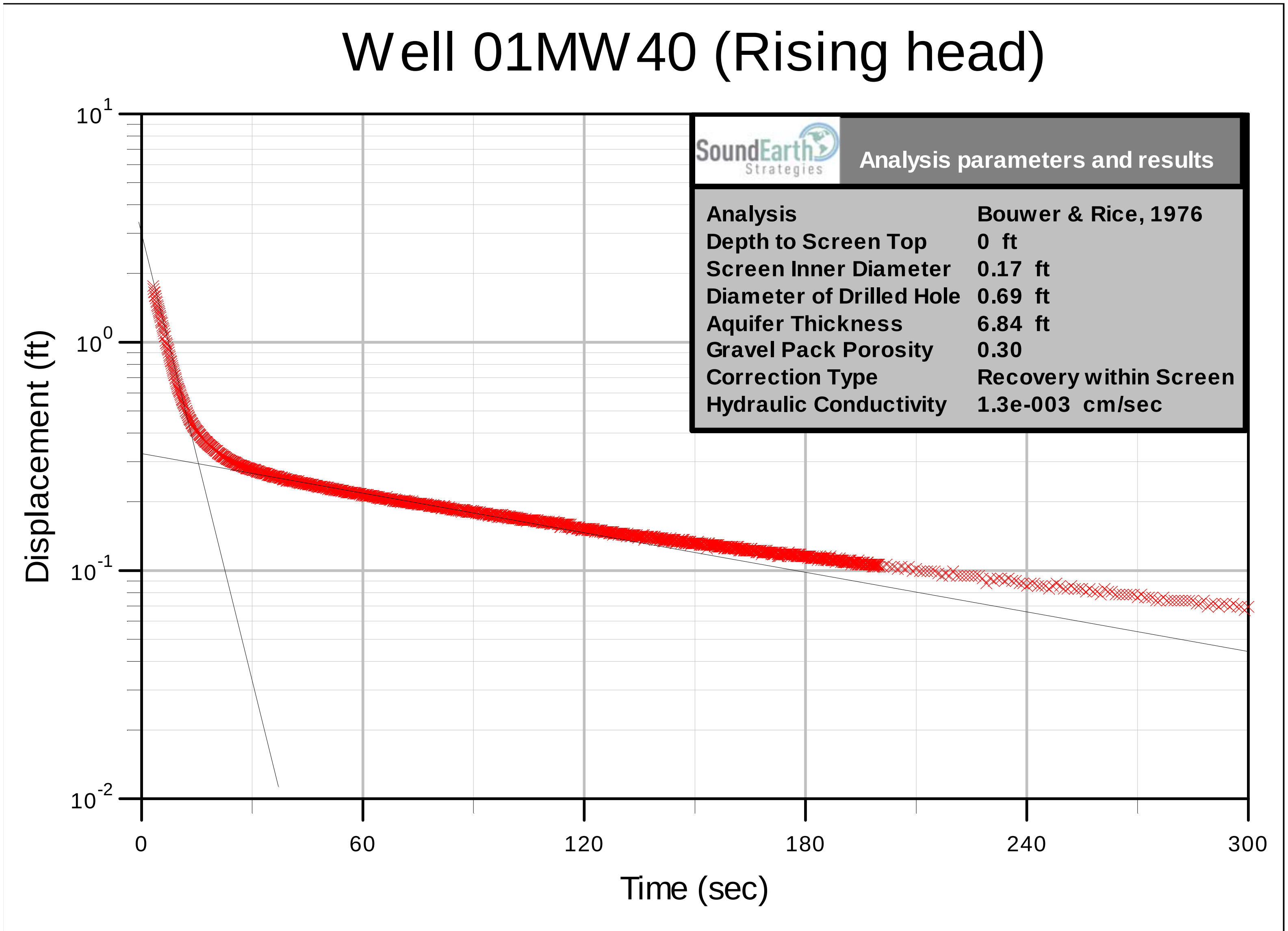
bgs = below ground surface
btoc = below top of casing
DTW = Depth to water
K = Hydraulic conductivity
ft = feet

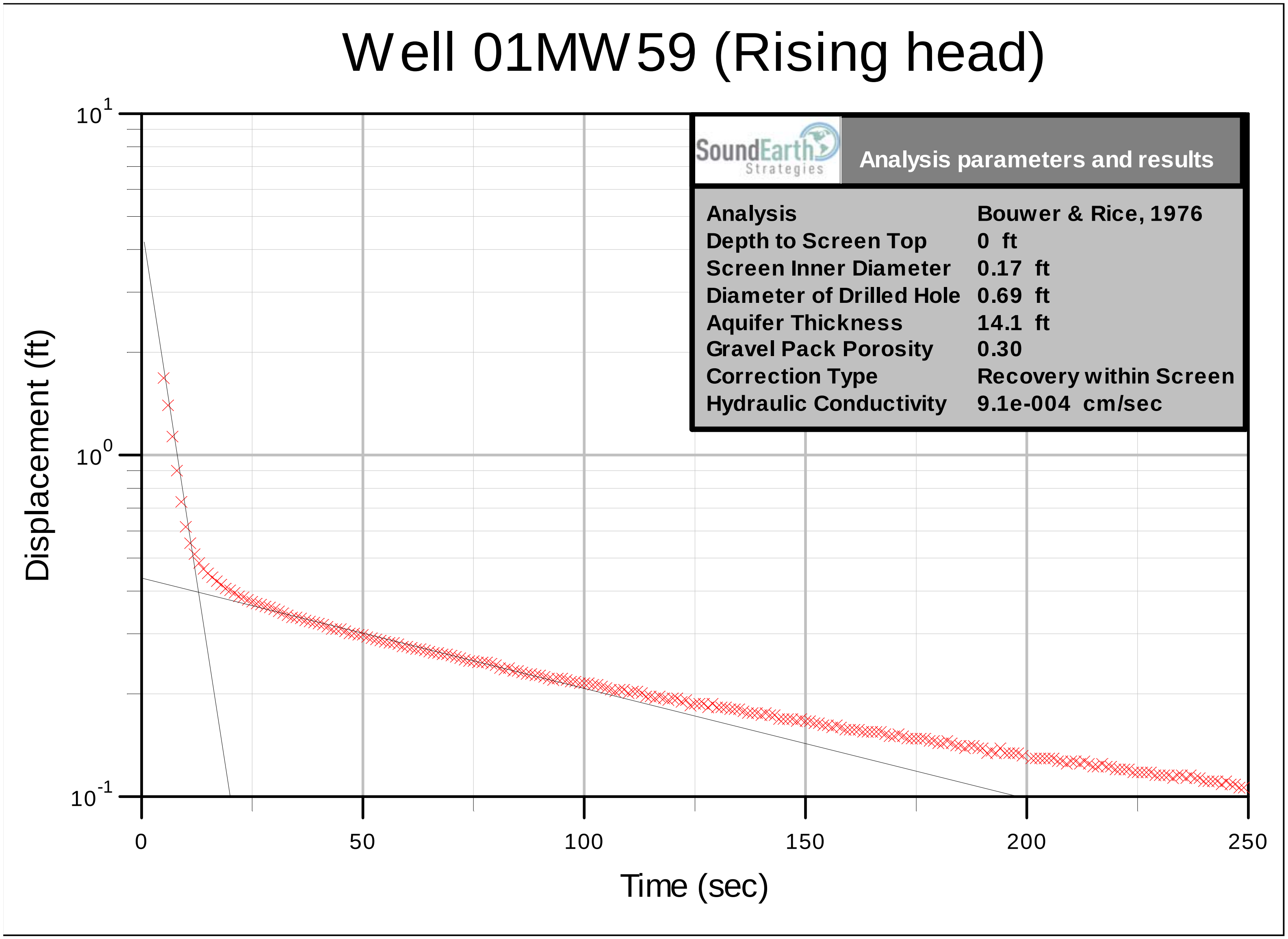
Slug Testing - Field Methods and Data Analysis
TOC Holdings Co. Facility No. 01-600
2737 W. Commodore Way
Seattle, Washington

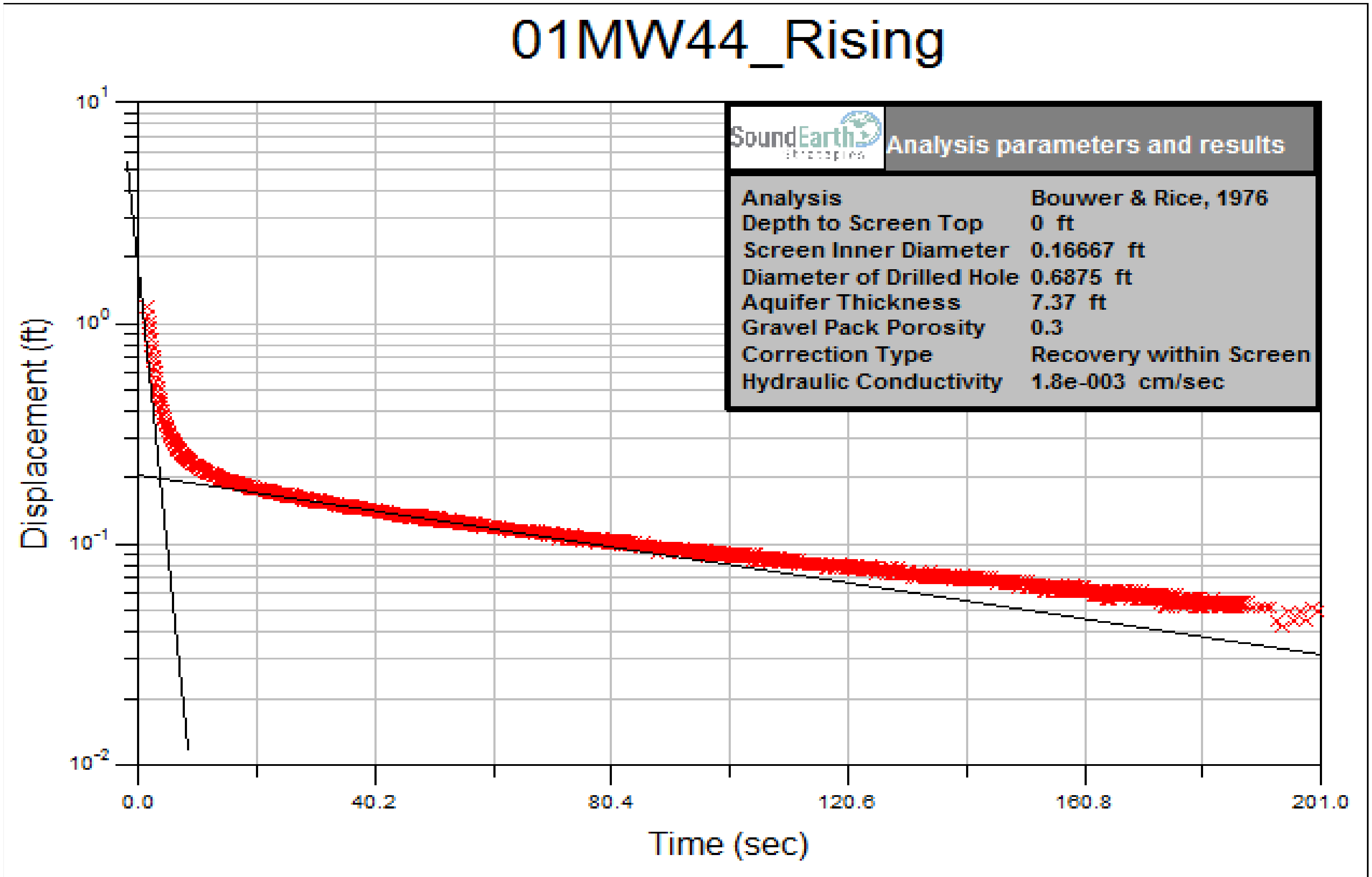


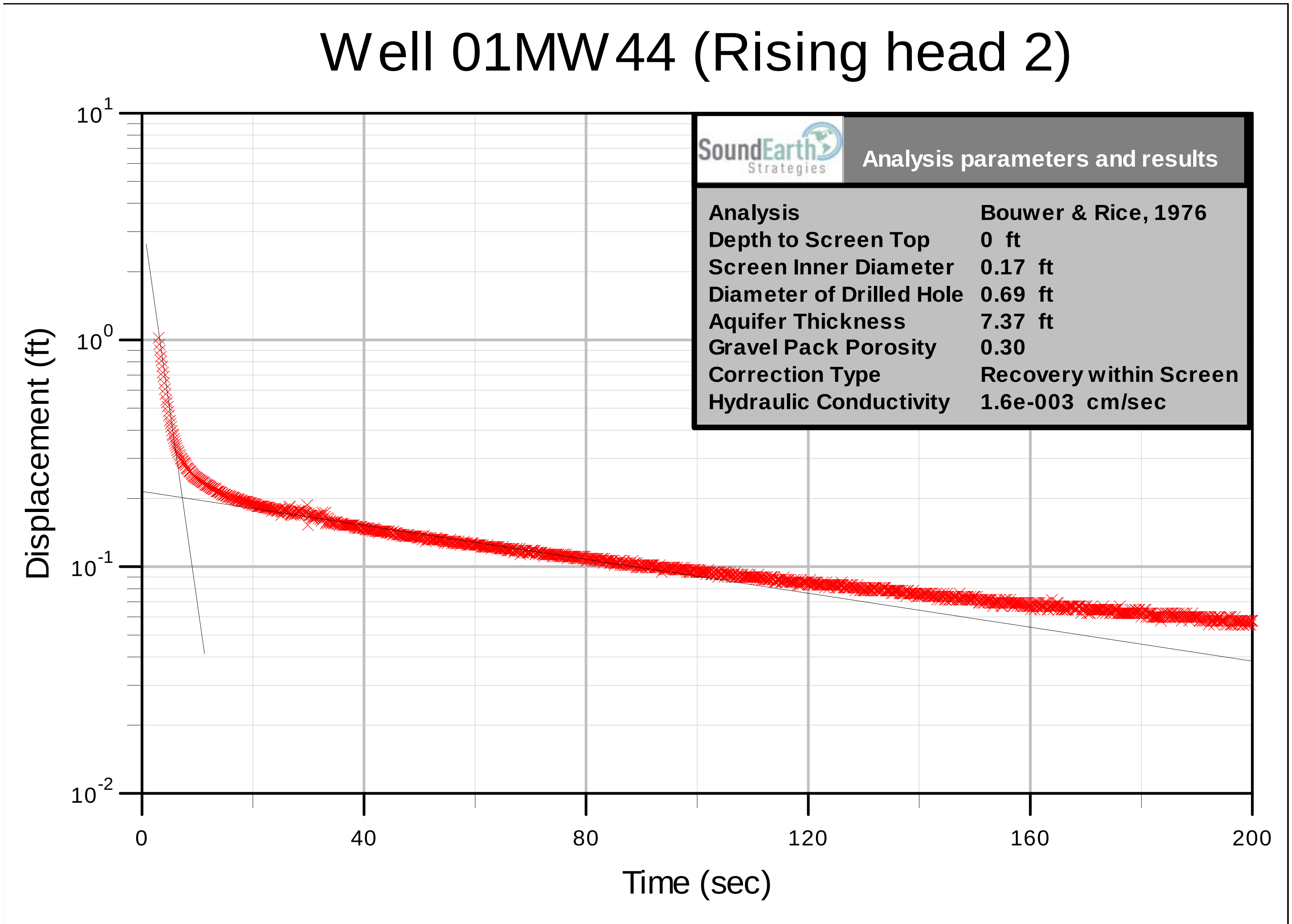

Well 01MW21 (Rising head)
Displacement (ft)
10^1
10^0
0
600
1200
1800
2400
3000
Time (sec)
Analysis parameters and results
Analysis Bouwer & Rice, 1976
Depth to Screen Top 0 ft
Screen Inner Diameter 0.17 ft
Diameter of Drilled Hole 0.69 ft
Aquifer Thickness 15 ft
Gravel Pack Porosity 0.30
Correction Type Recovery within Screen
Hydraulic Conductivity 3.0e-005 cm/sec

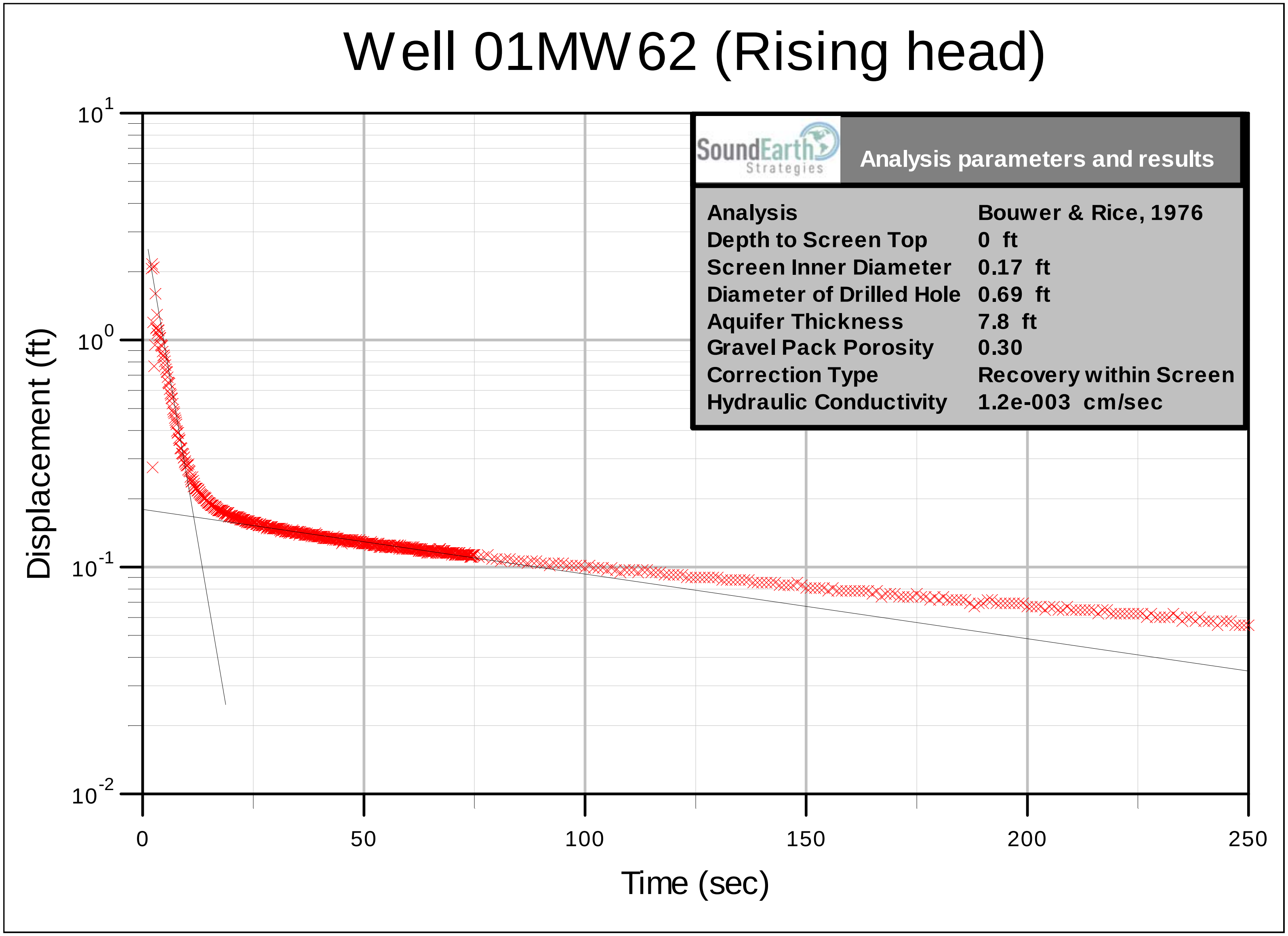

Well 01MW38 (Rising head)
Analysis parameters and results
Analysis Bouwer & Rice, 1976
Depth to Screen Top 0 ft
Screen Inner Diameter 0.17 ft
Diameter of Drilled Hole 0.69 ft
Aquifer Thickness 14.56 ft
Gravel Pack Porosity 0.30
Correction Type Recovery within Screen
Hydraulic Conductivity 1.8e-003 cm/sec
Displacement (ft)
Time (sec)
0
50
100
150
200
250


Well 01MW40 (Rising head)
Displacement (ft)
10^{1}
10^{0}
10^{-1}
10^{-2}
0
60
120
180
240
300
Time (sec)
Analysis parameters and results
Analysis Bouwer & Rice, 1976
Depth to Screen Top 0 ft
Screen Inner Diameter 0.17 ft
Diameter of Drilled Hole 0.69 ft
Aquifer Thickness 6.84 ft
Gravel Pack Porosity 0.30
Correction Type Recovery within Screen
Hydraulic Conductivity 1.3e-003 cm/sec

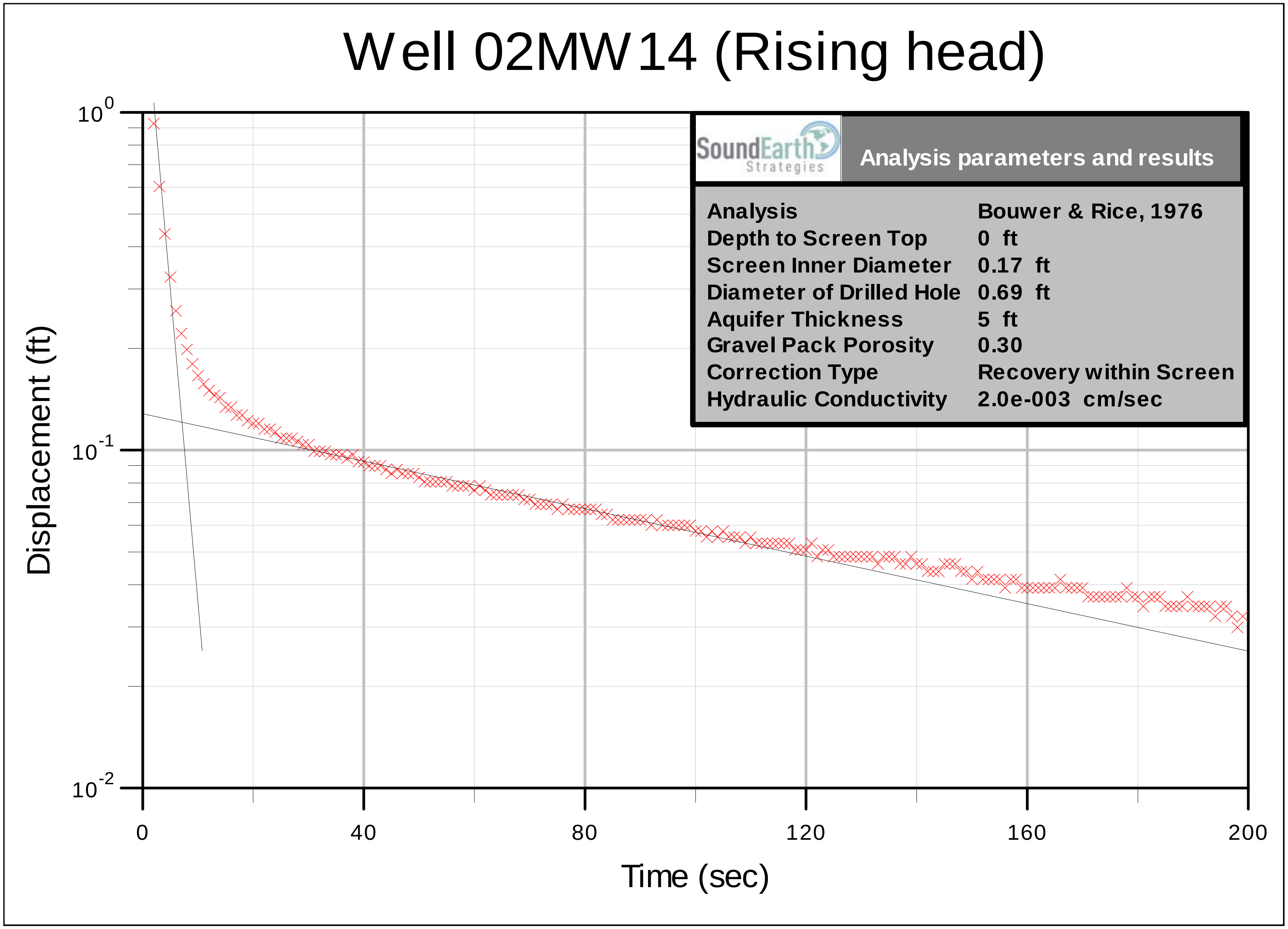

Well 01MW59 (Rising head)
Analysis parameters and results
Analysis Bouwer & Rice, 1976
Depth to Screen Top 0 ft
Screen Inner Diameter 0.17 ft
Diameter of Drilled Hole 0.69 ft
Aquifer Thickness 14.1 ft
Gravel Pack Porosity 0.30
Correction Type Recovery within Screen
Hydraulic Conductivity 9.1e-004 cm/sec
Displacement (ft)
10^1
10^0
10^-1
Time (sec)
0
50
100
150
200
250


01MW44_Rising
Analysis parameters and results
Analysis Bouwer & Rice, 1976
Depth to Screen Top 0 ft
Screen Inner Diameter 0.16667 ft
Diameter of Drilled Hole 0.6875 ft
Aquifer Thickness 7.37 ft
Gravel Pack Porosity 0.3
Correction Type Recovery within Screen
Hydraulic Conductivity 1.8e-003 cm/sec
Displacement (ft)
Time (sec)
0.0
40.2
80.4
120.6
160.8
201.0

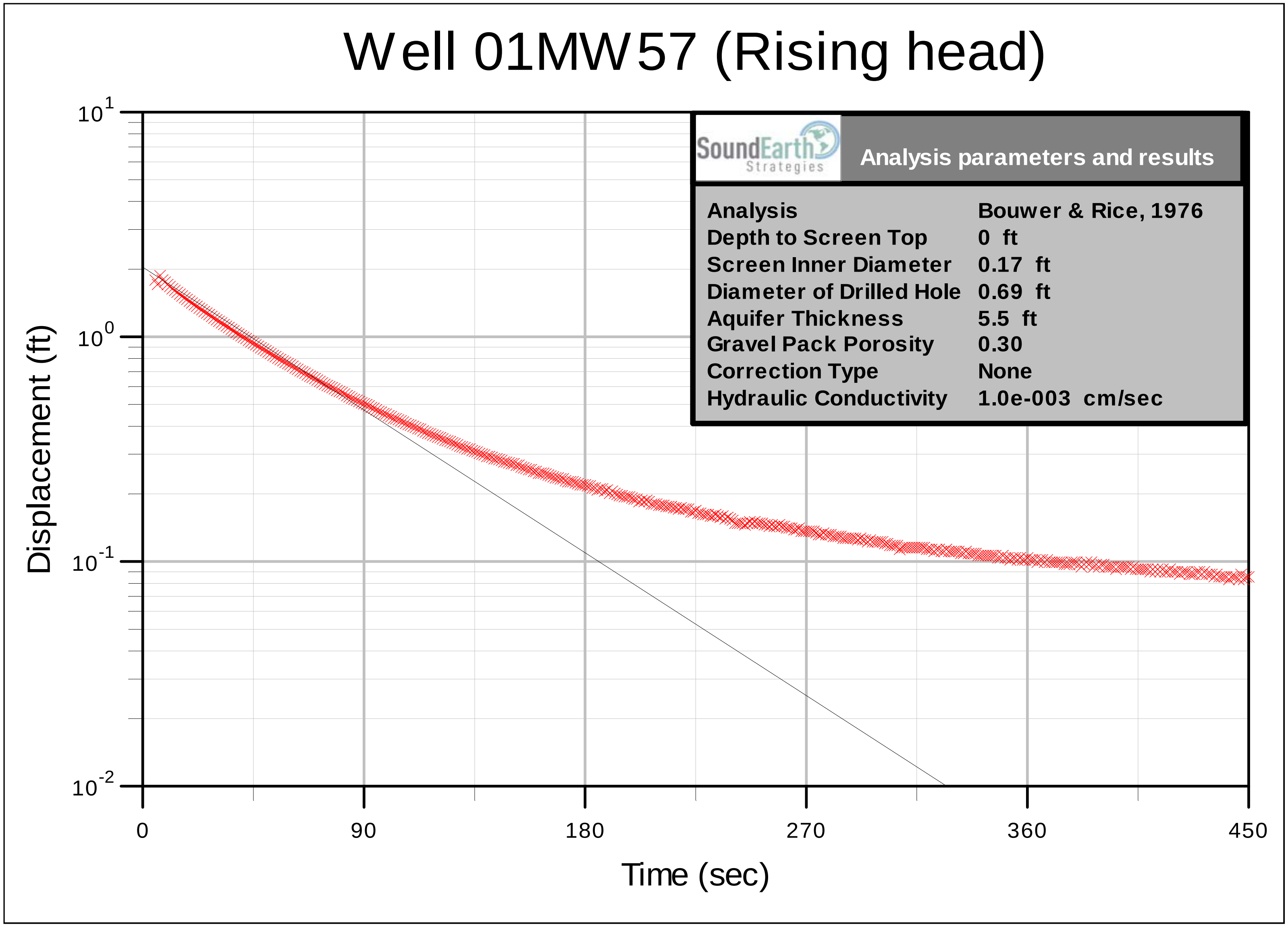

Well 01MW44 (Rising head 2)
Analysis parameters and results
Analysis Bouwer & Rice, 1976
Depth to Screen Top 0 ft
Screen Inner Diameter 0.17 ft
Diameter of Drilled Hole 0.69 ft
Aquifer Thickness 7.37 ft
Gravel Pack Porosity 0.30
Correction Type Recovery within Screen
Hydraulic Conductivity 1.6e-003 cm/sec
Displacement (ft)
Time (sec)
0
40
80
120
160
200


Well 01MW62 (Rising head)
Analysis parameters and results
Analysis Bouwer & Rice, 1976
Depth to Screen Top 0 ft
Screen Inner Diameter 0.17 ft
Diameter of Drilled Hole 0.69 ft
Aquifer Thickness 7.8 ft
Gravel Pack Porosity 0.30
Correction Type Recovery within Screen
Hydraulic Conductivity 1.2e-003 cm/sec
Displacement (ft)
Time (sec)
0
50
100
150
200
250

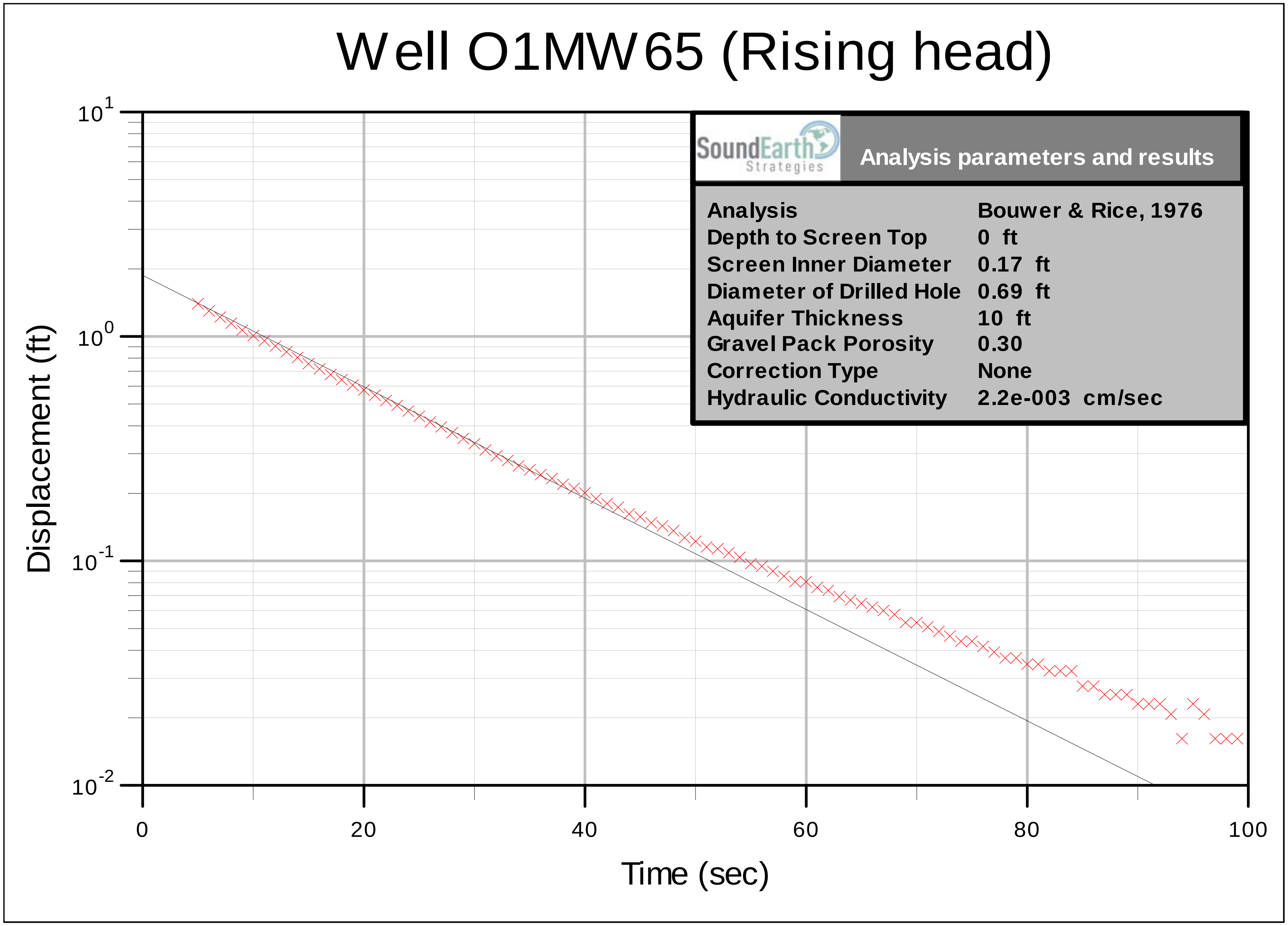
Slug Testing - Field Methods and Data Analysis
TOC Holdings Co. Facility No. 01-600
2737 W. Commodore Way
Seattle, Washington

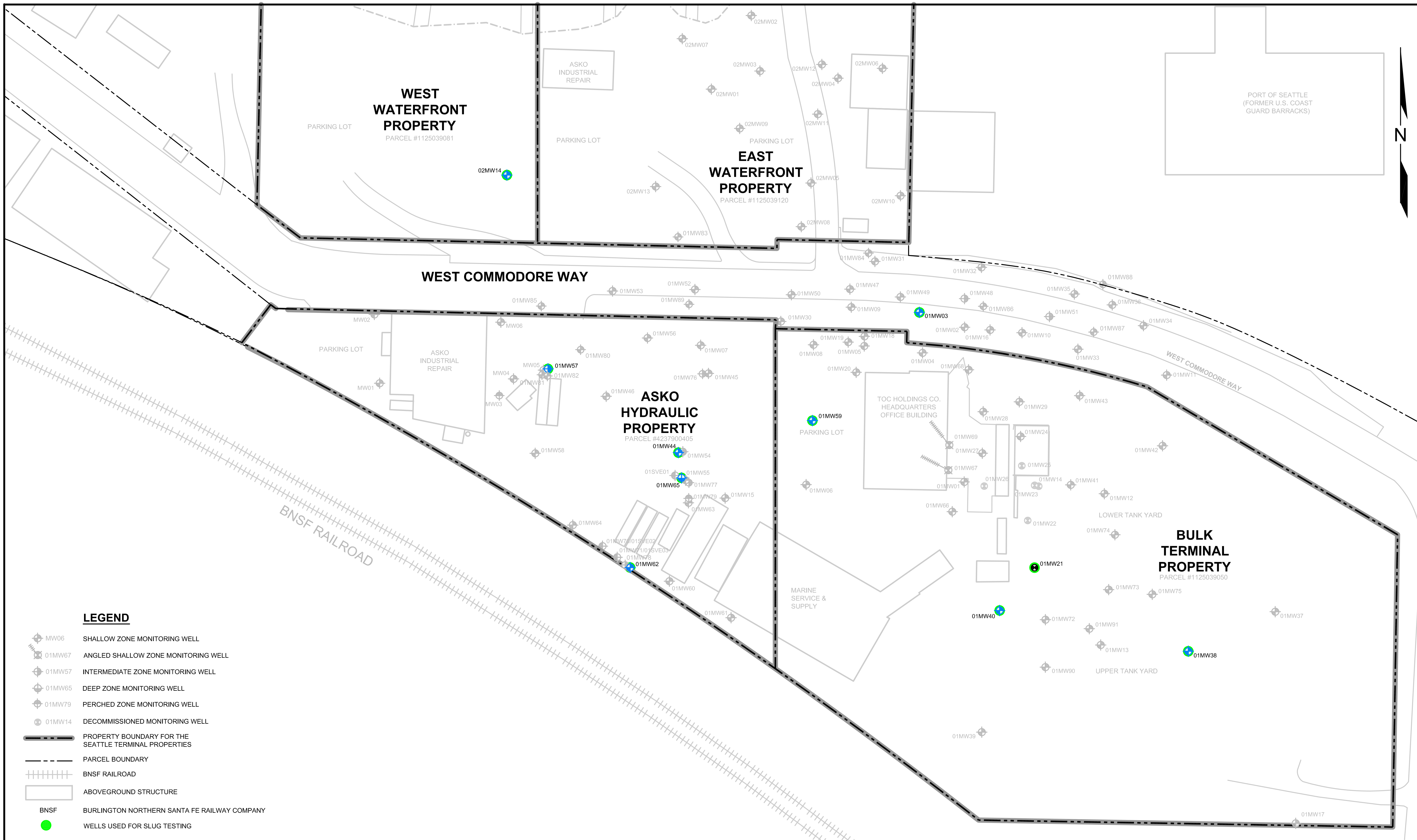


Slug Testing - Field Methods and Data Analysis
TOC Holdings Co. Facility No. 01-600
2737 W. Commodore Way
Seattle, Washington



Slug Testing - Field Methods and Data Analysis
TOC Holdings Co. Facility No. 01-600
2737 W. Commodore Way
Seattle, Washington





3/20/2014

P:\0440 TOC HOLDINGS CO\01-600 SEATTLE TERMINAL\DELIVERABLES\2013\BTP\FS\APPENDIX A\01-600_2013FS_SLUG.DWG

SoundEarth Strategies
WWW.SOUNDEARTHINC.COM

DATE: 06/25/13
DRAWN BY: NAC
CHECKED BY: PJK/TSB
CAD FILE: 01-600_2013FS_SLUG

PROJECT NAME: TOC HOLDINGS CO. SEATTLE TERMINAL PROPERTIES
PROJECT NUMBER: 0440-004
STREET ADDRESS: 2737, 2750, 2800, AND 2805 WEST COMMODORE WAY
CITY, STATE: SEATTLE, WASHINGTON

REGION:

0 40 80 160
APPROXIMATE SCALE IN FEET

FIGURE 1 - APPENDIX A
LOCATION OF WELLS USED FOR SLUG TESTING (MARCH & AUGUST 2009)

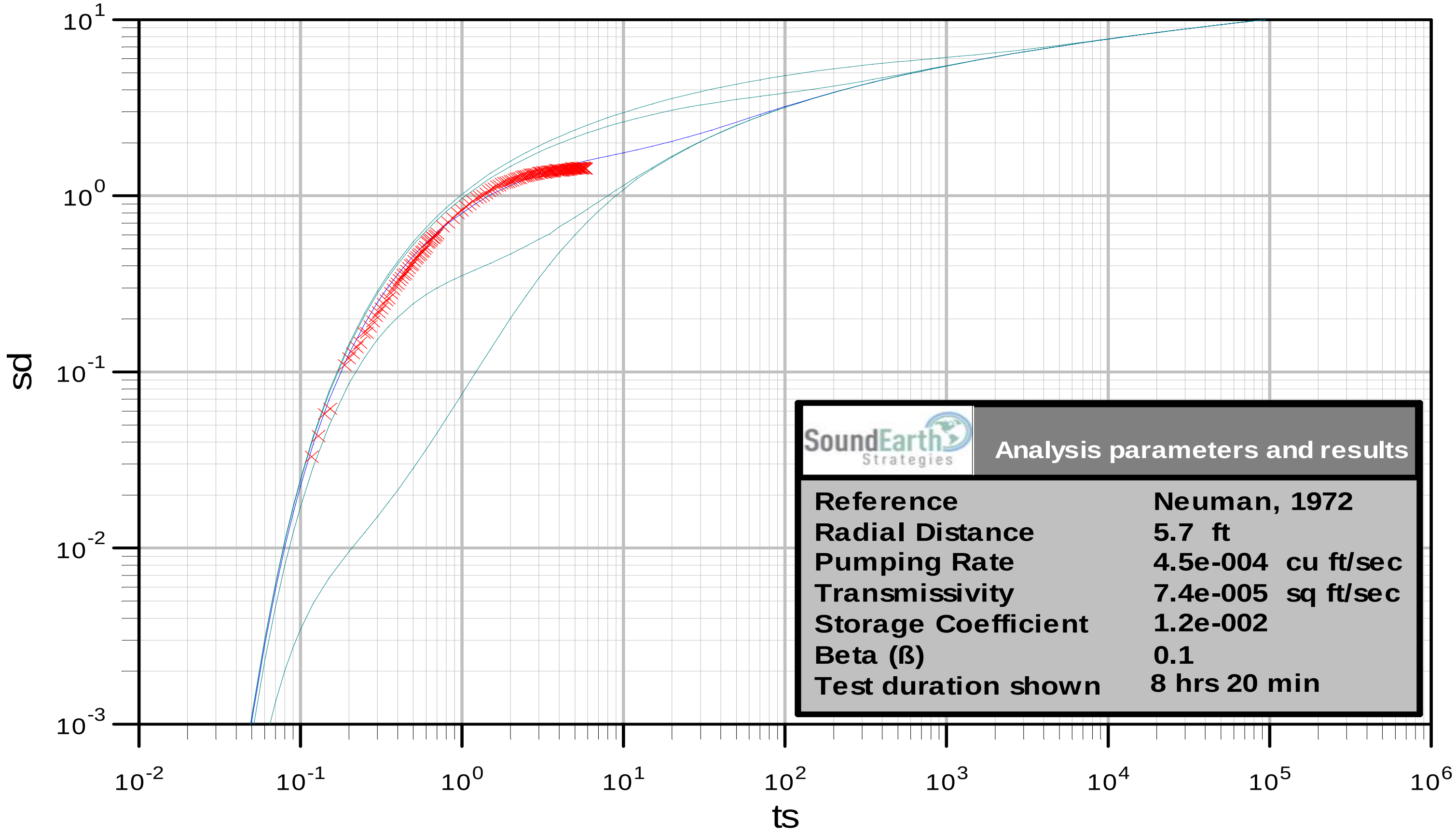
Appendix A
Pump Testing Data

Table A2
Pump Testing Data
TOC Holdings Co. Facility No. 01-600
2737 W. Commodore Way
Seattle, Washington

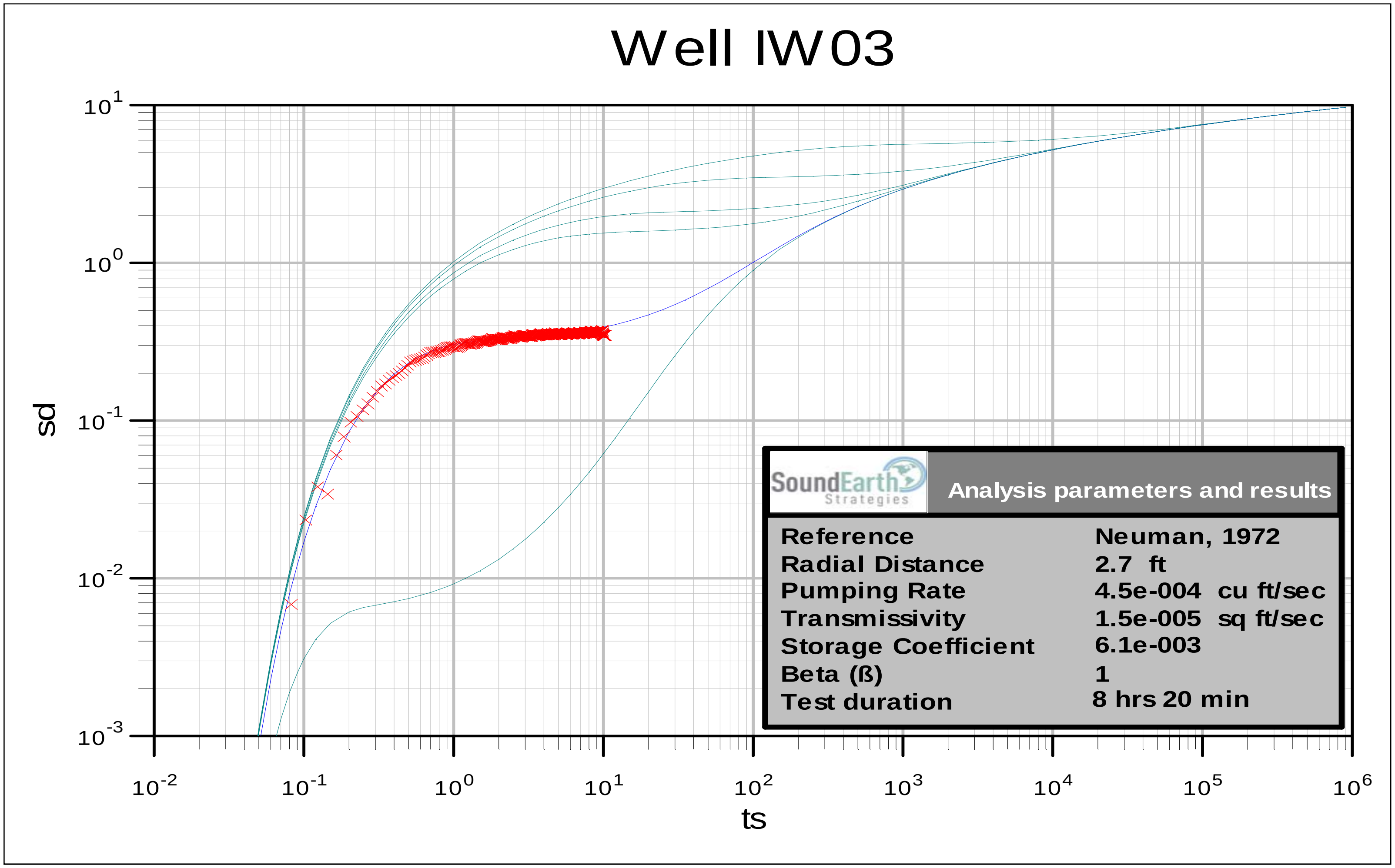
Date of Test	Water bearing zone	Pumping Well/ Screened Interval	Pumping Rate used in analysis (ft^3/s)	Duration of Test Used in Analysis (hh:mm)	Monitoring Well/ Observation Well	Distance from Pumping Well (ft)	Top of Screen (ft bgs)	Bottom of Screen (ft bgs)	Approximate Saturated Thickness (b; ft)	Transmissivity (T) (ft^2/s)	Estimated horizontal hydraulic conductivity K_h=T/b (cm/s)	Estimated horizontal hydraulic conductivity K_h=T/b (ft/d)	Storage coefficient* (S)
8/16/2011	Primary	N7 6-23 ft bgs	4.5E-04	8:20	01MW21	5.7	5	23	13	7.4E-05	1.7E-04	0.49	1.2E-02
				8:20	IW03	2.7	5	23	11	1.5E-05	4.2E-05	0.12	6.1E-03
				8:20	IW05	2.3	5	23	10	1.4E-05	4.3E-05	0.12	9.6E-03
				6:45	IW07	5.5	5	23	10	8.5E-05	2.6E-04	0.73	2.6E-02
Geometric mean										**3.4E-05**	**9.4E-05**	**0.27**	**1.2E-02**
9/1/2011	Primary	P8 5-20 ft bgs	9.1E-04	5:43	O8	7.55	6	21	9	2.6E-04	8.8E-04	2.5	3.7E-03
				6:11	P7	10.10	6	21	9	4.4E-04	1.5E-03	4.2	3.0E-03
				5:44	P9	9.25	6	21	9.5	3.8E-04	1.2E-03	3.5	4.3E-03
				5:45	Q8	10.95	6	21	9.5	3.6E-04	1.2E-03	3.3	2.7E-03
Geometric mean										**3.5E-04**	**1.2E-03**	**3.3**	**3.4E-03**

NOTES:
* Value represents the release of water from elastic storage, and is not representative of unconfined storage. Unconfined storage was not evaluated due to the short test duration.
b = saturated thickness in feet
bgs = below ground surface
cm/s = centimeters per second
ft = feet
ft/d = feet per day
ft^2/s = square feet per second
ft^3/s = cubic feet per second
gpm = gallons per minute
hh:mm = hours:minutes
K_h = horizontal hydraulic conductivity
S = storage coefficient
T = transmissivity

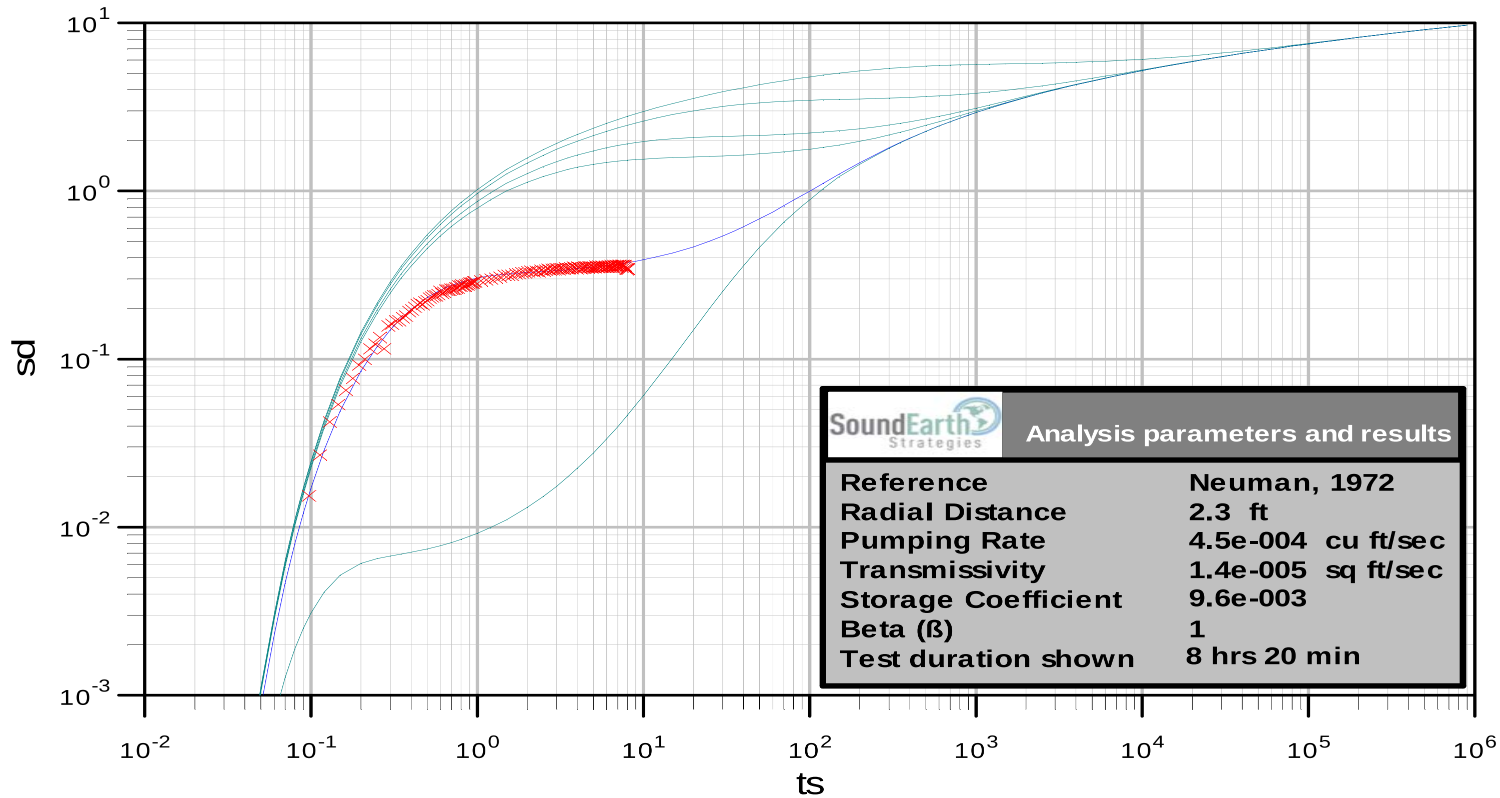
Well 01MW21



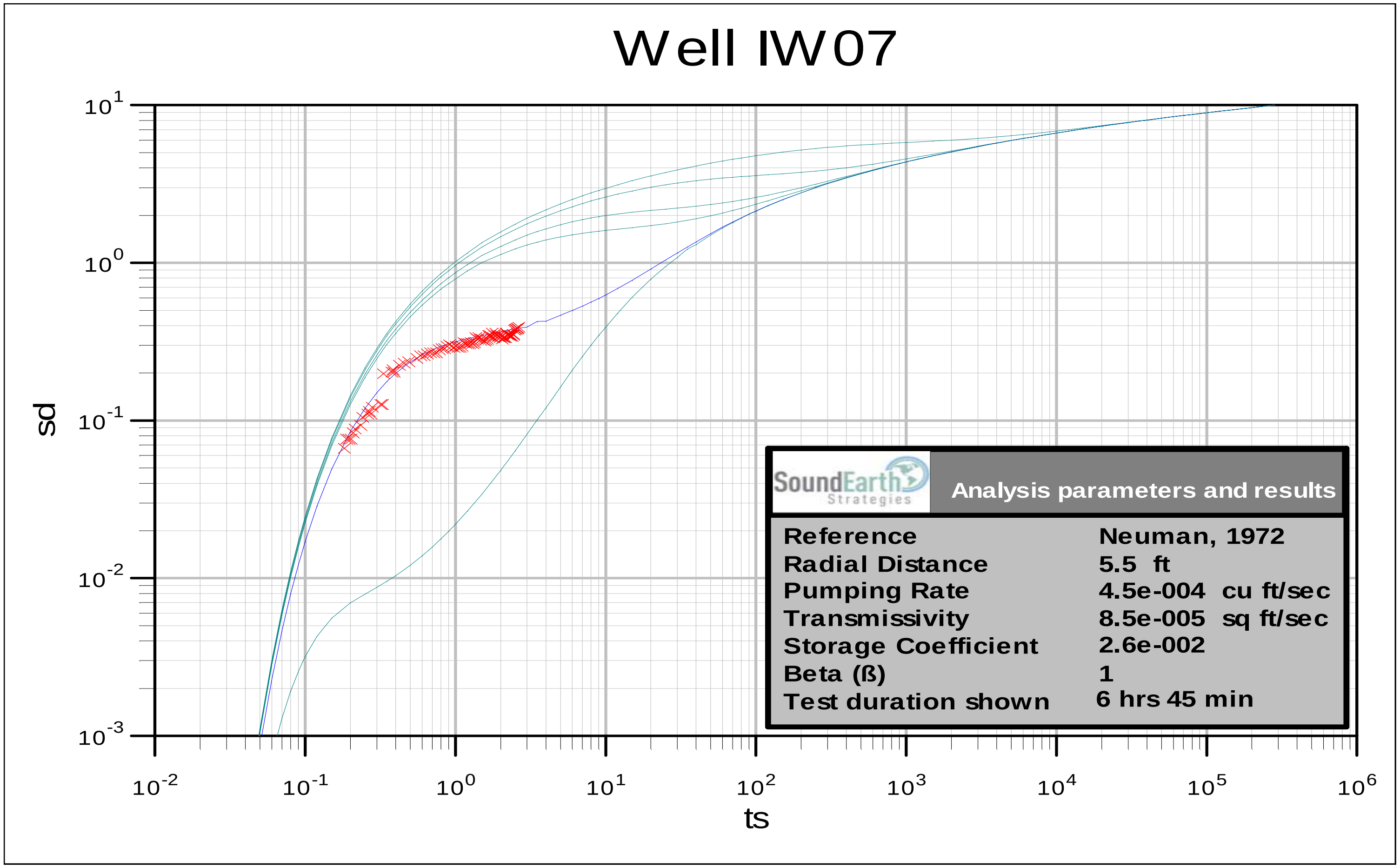
sd
ts
10^1
10^0
10^-1
10^-2
10^-3
10^-2
10^-1
10^0
10^1
10^2
10^3
10^4
10^5
10^6
SoundEarth Strategies
Analysis parameters and results
Reference Neuman, 1972
Radial Distance 5.7 ft
Pumping Rate 4.5e-004 cu ft/sec
Transmissivity 7.4e-005 sq ft/sec
Storage Coefficient 1.2e-002
Beta (ß) 0.1
Test duration shown 8 hrs 20 min


Well IW03
sd
ts
10^{1}
10^{0}
10^{-1}
10^{-2}
10^{-3}
10^{-2}
10^{-1}
10^{0}
10^{1}
10^{2}
10^{3}
10^{4}
10^{5}
10^{6}
SoundEarth Strategies
Analysis parameters and results
Reference Neuman, 1972
Radial Distance 2.7 ft
Pumping Rate 4.5e-004 cu ft/sec
Transmissivity 1.5e-005 sq ft/sec
Storage Coefficient 6.1e-003
Beta (ß) 1
Test duration 8 hrs 20 min

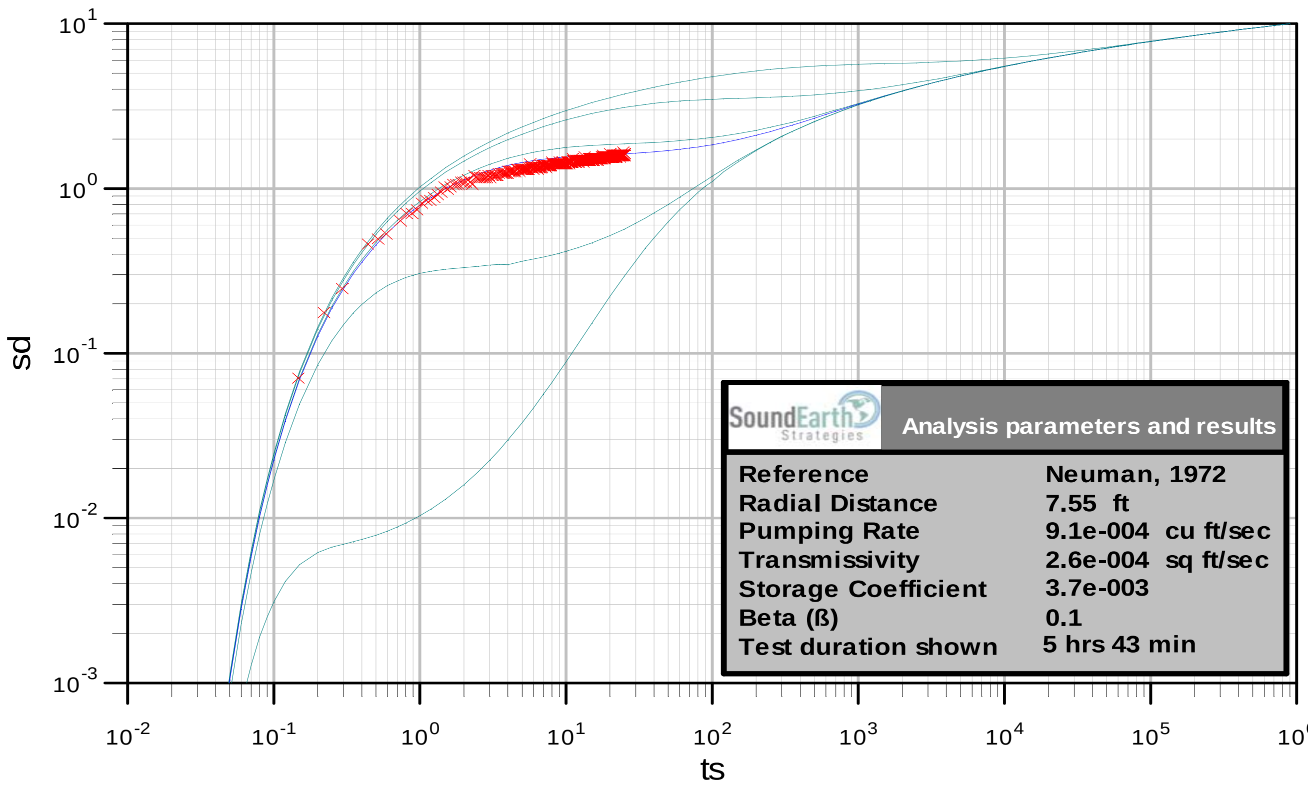
Well IW05



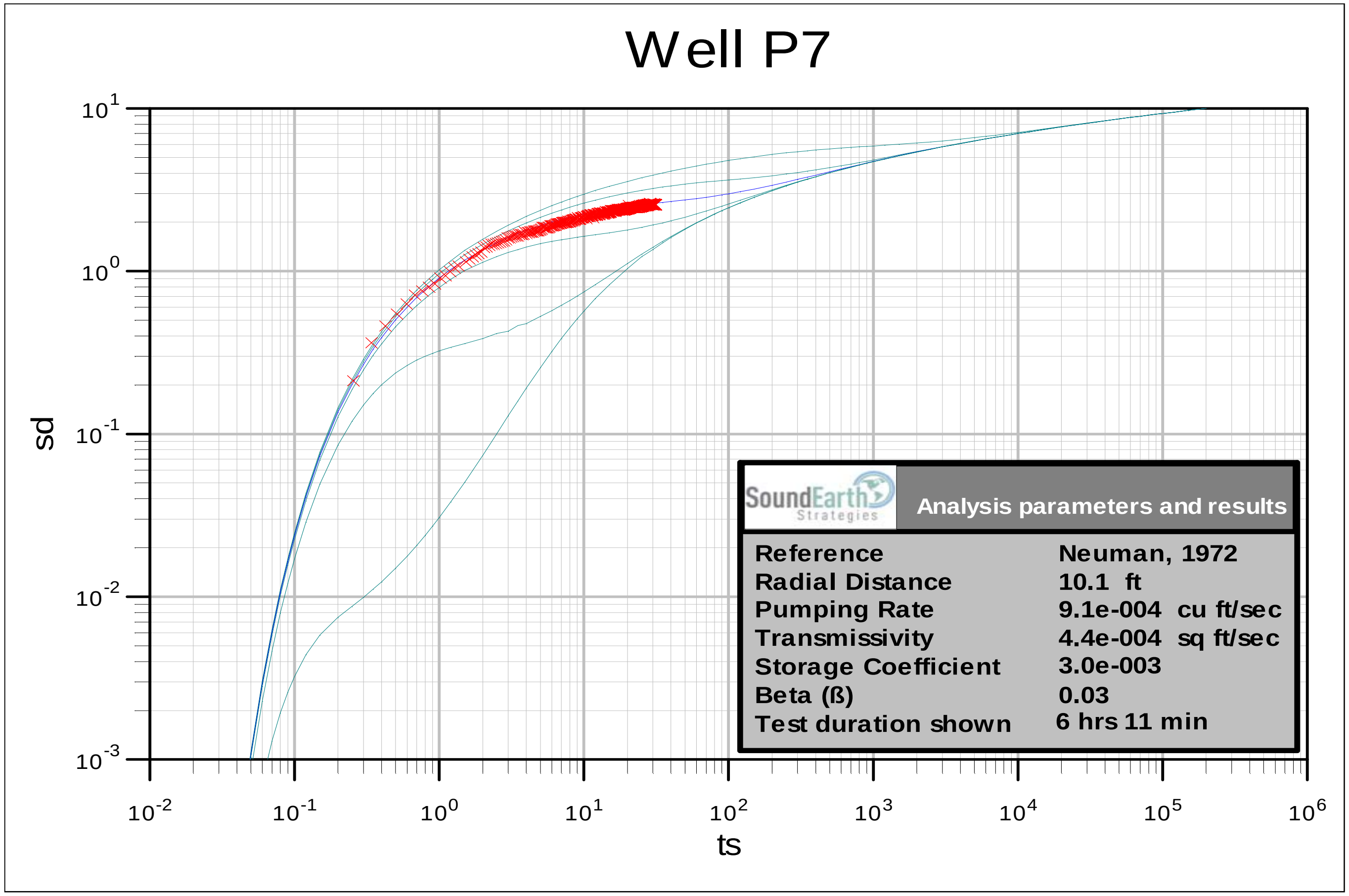
sd
ts
10^1
10^0
10^-1
10^-2
10^-3
10^-2
10^-1
10^0
10^1
10^2
10^3
10^4
10^5
10^6
SoundEarth Strategies
Analysis parameters and results
Reference Neuman, 1972
Radial Distance 2.3 ft
Pumping Rate 4.5e-004 cu ft/sec
Transmissivity 1.4e-005 sq ft/sec
Storage Coefficient 9.6e-003
Beta (ß) 1
Test duration shown 8 hrs 20 min


Well IW07
sd
ts
10^1
10^0
10^{-1}
10^{-2}
10^{-3}
10^{-2}
10^{-1}
10^0
10^1
10^2
10^3
10^4
10^5
10^6
SoundEarth Strategies
Analysis parameters and results
Reference Neuman, 1972
Radial Distance 5.5 ft
Pumping Rate 4.5e-004 cu ft/sec
Transmissivity 8.5e-005 sq ft/sec
Storage Coefficient 2.6e-002
Beta (ß) 1
Test duration shown 6 hrs 45 min

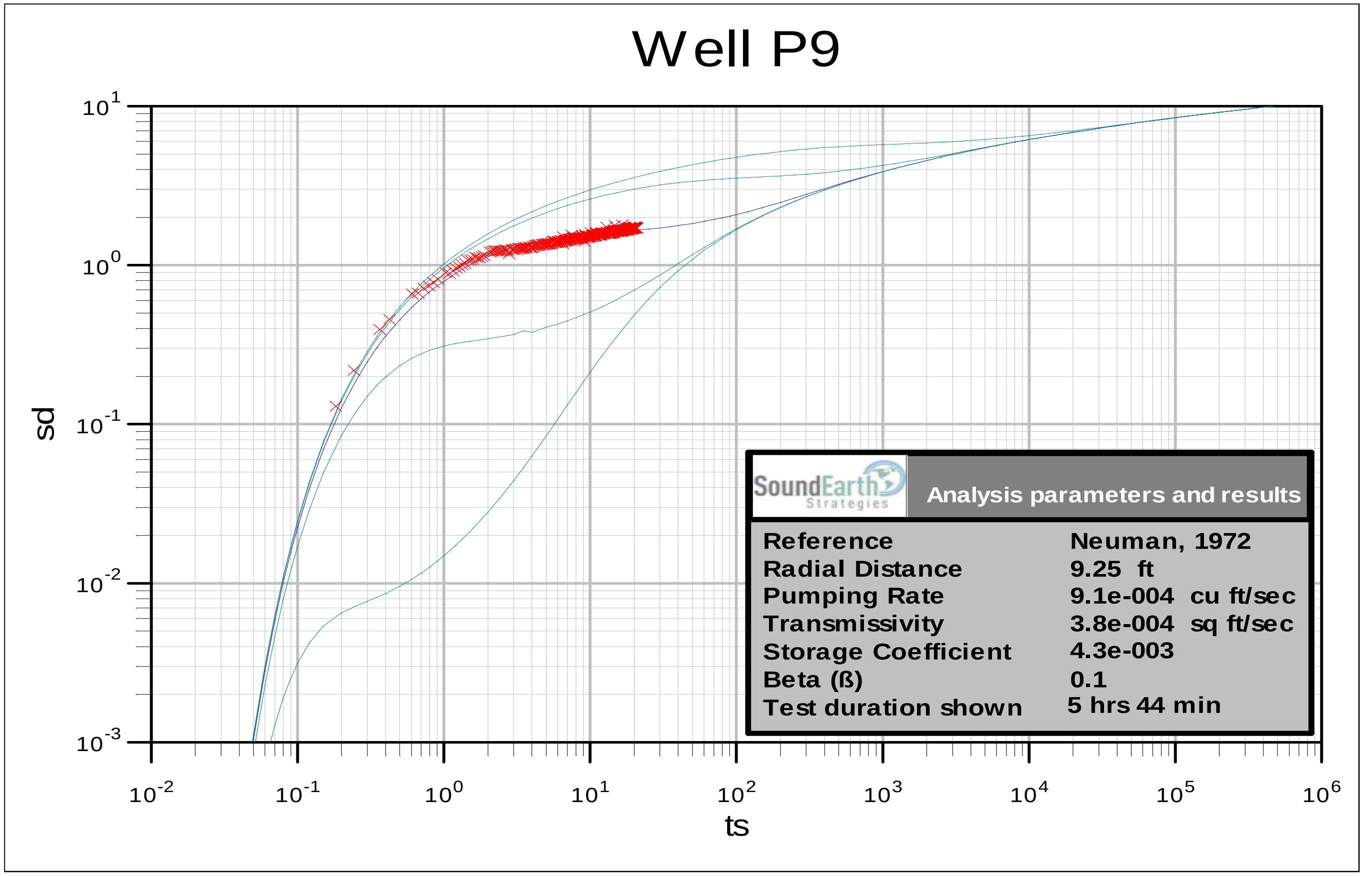
Well O8

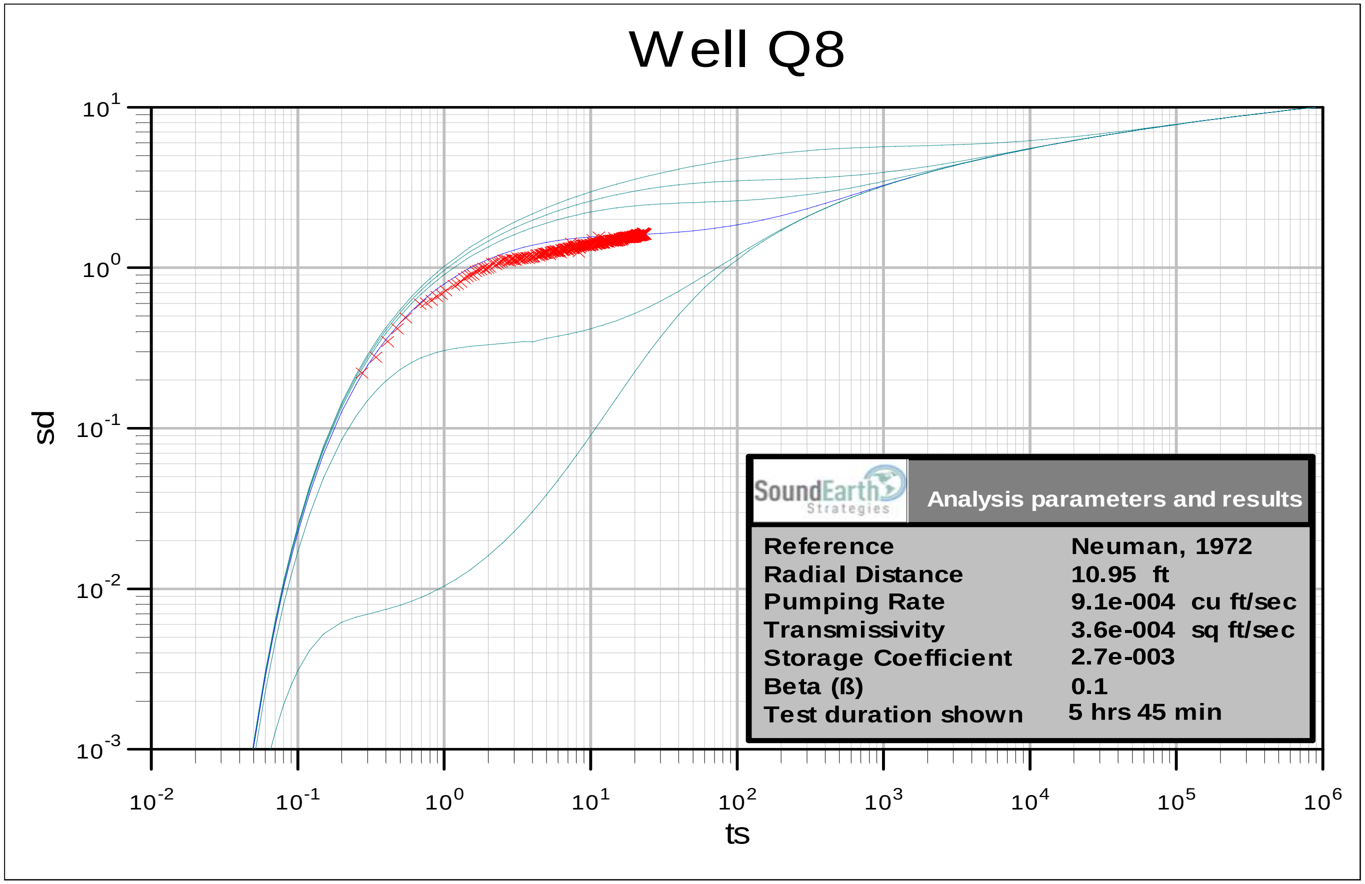


$ts = 1/u_a,\ sd = W(u_a, \beta)$



Well P7
sd
ts
10^1
10^0
10^-1
10^-2
10^-3
10^-2
10^-1
10^0
10^1
10^2
10^3
10^4
10^5
10^6
SoundEarth Strategies
Analysis parameters and results
Reference Neuman, 1972
Radial Distance 10.1 ft
Pumping Rate 9.1e-004 cu ft/sec
Transmissivity 4.4e-004 sq ft/sec
Storage Coefficient 3.0e-003
Beta (ß) 0.03
Test duration shown 6 hrs 11 min


Well P9
sd
ts
10^1
10^0
10^-1
10^-2
10^-3
10^-2
10^-1
10^0
10^1
10^2
10^3
10^4
10^5
10^6
SoundEarth Strategies
Analysis parameters and results
Reference Neuman, 1972
Radial Distance 9.25 ft
Pumping Rate 9.1e-004 cu ft/sec
Transmissivity 3.8e-004 sq ft/sec
Storage Coefficient 4.3e-003
Beta (ß) 0.1
Test duration shown 5 hrs 44 min


Well Q8
sd
ts
10^{1}
10^{0}
10^{-1}
10^{-2}
10^{-3}
10^{-2}
10^{-1}
10^{0}
10^{1}
10^{2}
10^{3}
10^{4}
10^{5}
10^{6}
SoundEarth Strategies
Analysis parameters and results
Reference Neuman, 1972
Radial Distance 10.95 ft
Pumping Rate 9.1e-004 cu ft/sec
Transmissivity 3.6e-004 sq ft/sec
Storage Coefficient 2.7e-003
Beta (ß) 0.1
Test duration shown 5 hrs 45 min

Neuman's (1972) analytical solution was used to analyze the pumping teset data, by visual matching the data to type curves generated by AquiferWin32. The general solution for drawdown produced by pumping in an unconfined aquifer is:

$$s = \frac{Q}{4\pi T} W\left(u_a, u_b, \beta, z_D\right)$$

Where:

s= drawdown (because the solution accounts for vertical flows, actual drawdown in the well is calculated as an average of drawdown along the screened interval).

Q= pumping rate

T= transmissivity ($K_r b$)

K_r= horizontal hydraulic conductivity

b= aquifer thickness

W= is the well function for an unconfined aquifer

$$u_a = \frac{Sr^2}{Tt} \text{ (for the early-time data)}$$

$$u_b = \frac{S_y r^2}{Tt} \text{ (for the late-time data)}$$

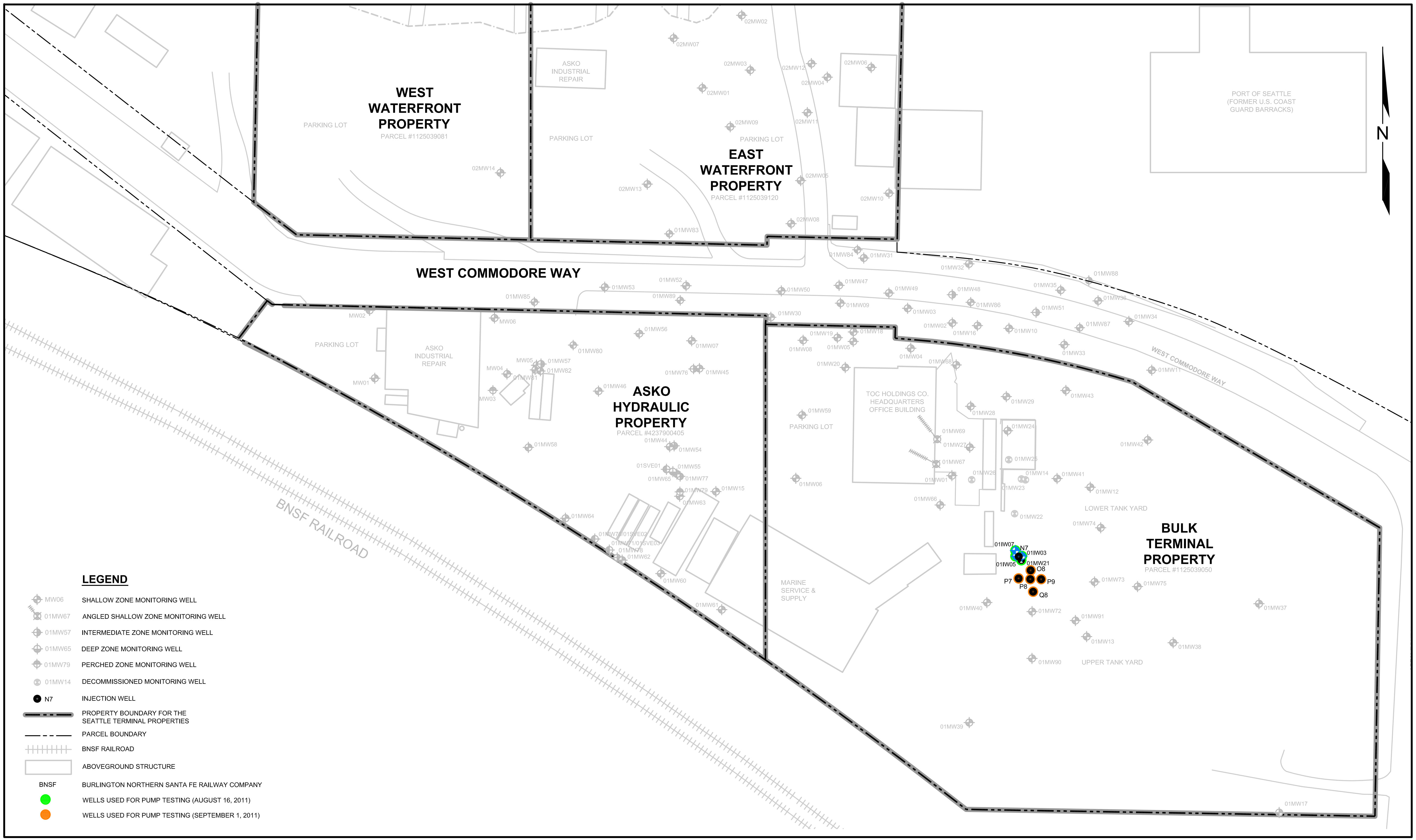
$$\beta = \frac{K_z r^2}{K_r b^2} \text{ (represents the lag between early and late-time data)}$$

K_z= vertical hydraulic conductivity

r= radial distance to the pumping well

z_D= the ratio of the depth (z) at which s is calculated to the aquifer thickness, z/b

Analysis with Neuman's (1972) solution involves matching two type curves- one to early time data, when drawdown represents decrease in elastic (confined) storage, and one to late time data, when drawdown represents the drainage of water from pore space (Sy; specific yield). Due to constraints on test duration, only early time data were available. The dimensionless variables "ts" and "sd" on the analysis plots correspond respectively to 1/ua and W(ua,β).



3/19/2014

P:\0440 TOC HOLDINGS CO\01-600 SEATTLE TERMINAL\DELIVERABLES\2013\BTP\FS\APPENDIX A\01-600_2013FS_PUMP.DWG

SoundEarth Strategies
WWW.SOUNDEARTHINC.COM

DATE: 06/25/13
DRAWN BY: NAC
CHECKED BY: PJK/TSB
CAD FILE: 01-600_2013FS_PUMP

PROJECT NAME: TOC HOLDINGS CO. SEATTLE TERMINAL PROPERTIES
PROJECT NUMBER: 0440-004
STREET ADDRESS: 2737, 2750, 2800, AND 2805 WEST COMMODORE WAY
CITY, STATE: SEATTLE, WASHINGTON

REGION:

0 40 80 160
APPROXIMATE SCALE IN FEET

FIGURE 2 - APPENDIX A
LOCATION OF WELLS USED FOR PUMP TESTING (AUGUST 16 & SEPTEMBER 1, 2011)

Appendix A
Laboratory Measurements of Soil Properties

SoundEarth Strategies

Table A3
Results for Laboratory Analysis of Soil Properties
TOC Holdings Co. Facility No. 01-600
Bulk Terminal Property
2805 West Commodore Way
Seattle, Washington

Well/Boring Identification	Sample ID	Date Sampled	Analysis Depth (feet bgs)	Moisture Content[1][2] (% weight)	Density[1] (g/cm^3): Dry Bulk	Density[1] (g/cm^3): Grain	Porosity[1] (%Vb): Total	Porosity[1] (%Vb): Air Filled	Porosity[1] (%Vb): Water Filled	Porosity[1] (%Vb): Effective[3]	Total Pore Fluid Saturations[1] (% Pv)	Atterberg Limits[4]: Liquid Limit	Atterberg Limits[4]: Plastic Limit	Atterberg Limits[4]: Plasticity Index	USCS/Plasticity Chart Symbol[4] (Fines: <#40 sieve)	USCS Classification[5]	USDA/SCS Soil Texture Scheme[6]
B199			9.25	21.0	1.52	2.70	43.5	11.5	32.1	24.3	73.6	--	--	--	--	--	--
	B199-9-9.5	12/29/11	9.3	--	--	--	--	--	--	--	--	0.9	N/A	Non-Plastic	NP	ML: Sandy Silt	Loam
	B199-19.5-20	12/29/11	19.6	22.1	1.44	2.68	46.3	14.6	--	--	68.6	41.1	22.4	18.7	CL	--	--

Sample ID	Effective Permeability to Air[1] (millidarcy)	Specific Permeability to Air[1] (millidarcy)	Effective Permeability to Water[1][7] (millidarcy)	Specific Permeability to Water[1][7] (millidarcy)	Hydraulic Conductivity[1][7] (cm/s)	Intrinsic Permeability to Water[1][7] (cm^2)	Median Grain Size (mm)	Particle Size Distribution[2] (% by weight): Gravel	Sand Size: Coarse	Sand Size: Medium	Sand Size: Fine	Silt	Clay	Silt and Clay	Fraction Organic Carbon[3] (g/g)	Total Organic Carbon[3] (mg/kg)
	25 psi Confining Stress															
(9.25 ft)	33.0	548	--	189	1.87E-04	1.87E-09	0.058	0.00	0.00	3.41	42.00	39.91	14.69	54.59	--	--
B199-9-9.5	--	--	--	--	--	--	--	--	--	--	--	--	--	--	9.20E-04	920
B199-19.5-20	--	--	1.33	--	1.31E-06	--	0.010	0.00	0.00	0.00	0.00	68.69	31.31	100.00	--	--

NOTES:
Samples collected by SoundEarth Strategies, Inc.
All sample analyses conducted by PTS Laboratories, Inc. of Santa Fe Springs, California.
(1)Analyzed by API RP40.
(2)Analyzed by ASTM D2216.
(3)Analyzed by Modified ASTM D425.
(4)Analyzed by ASTM D4318.
(5)Analyzed by ASTM D2487.
(6)U.S. Department of Agriculture.
(7)Analyzed by EPA 9100.

-- = not detected
% = percent
API = American Petroleum Institute
ASTM = ASTM International
bgs = below ground surface
CL = clay
cm2 = square centimeter(s)
cm/s = centimeters per second
EPA = U.S. Environmental Protection Agency
g/cm^3= grams per cubic centimeter
g/g = gram per gram
mg/kg = milligrams per kilogram
N/A = not applicable
NP = non-plastic
psi = pounds per square inch
Pv = pore volume
USCS = Unified Soil Classification System
USDA/SCS = United States Department of Agriculture Soil Conservation Service
Vb = bulk volume

APPENDIX B
SVE PILOT TEST

Appendix B
Soil Vapor Extraction Pilot Test
Step Test Operational Data for Test Well: 01SVE01
ASKO Hydraulic Property
TOC Holdings Co. Facility No. 01-600
2805 West Commodore Way
Seattle, Washington

							Suction Instrument Train								Bleed Air				Alternate Well Flow	
Date	Time	Barometric Pressure (psi)	Manual Dilution Valve (% open)	VFD Setting (Hz)	Wellhead Vacuum (in. H_2O)	KOT Vacuum (in. H_2O)	Static Pressure (in. H_2O)	Differential Pressure (in. H_2O)	Temp (°F)	VOC (ppmv)	LEL (%)	O_2 (%)	CO_2 (% / ppm)	Flow Rate* (scfm)	Static Pressure (in. H_2O)	Differential Pressure (in. H_2O)	Temp (°F)	Flow Rate (SCFM)	**total Flow (from baseline blower curve) SCFM	Alternate Well Flow Rate Estimate*
	8:55	14.65	60	36	19	25	19.1	0.14	48	0.3	0	20.9	1140	43.9	1.5	6.5	48	130.4	135.2	4.8
	9:20	14.66	60	36	20	25	19.1	0.01	50	8.5	6	17.2	9400	11.7	1.5	6.5	50	130.1	135.2	5.1
	9:35	14.65	60	36	20	25	19.1	1.00	50	7.7	6	16.8	9100	117.1	2.0	6.5	50	130.0	135.2	5.2
	9:50	14.66	35	36	40	44	43.0	0.01	49	10.6	7	17.8	9300	11.4	1.0	5.5	49	119.9	135.2	15.3
02/24/10	10:05	14.66	35	36	40	44	43.0	0.01	54	16	7	14.4	1.26%	11.3	1.0	6.6	50	131.2	135.2	4.0
	10:20	14.64	30	40	58	58	56.0	0.01	54	NM	4	18.7	8740	11.1	1.5	4.0	50	102.0	148.1	46.0
	10:35	14.66	30	40	55	58	56.0	0.01	54	20	6	16.1	1.10%	11.1	1.5	5.0	52	113.9	148.1	34.1
	10:50	14.66	30	40	55	58	56.0	0.01	56	11.5	2	19.5	4120	11.1	1.5	5.0	52	113.9	148.1	34.1
	11:15	Stop Test																		

Comments:
*The suction instrument train flow rates are unreliable due to velocity levels below the recommended range for the averaging flow sensor. Alternatively, flow rates at various steps are estimated to be the difference between the total baseline flow rate and the flow rate calculated for the bleed air.
**The equation for the relationship of baseline flow to VFD setting is: y = 3.2137x + 19.507, where x = VFD setting in Hz.
NM= not measured

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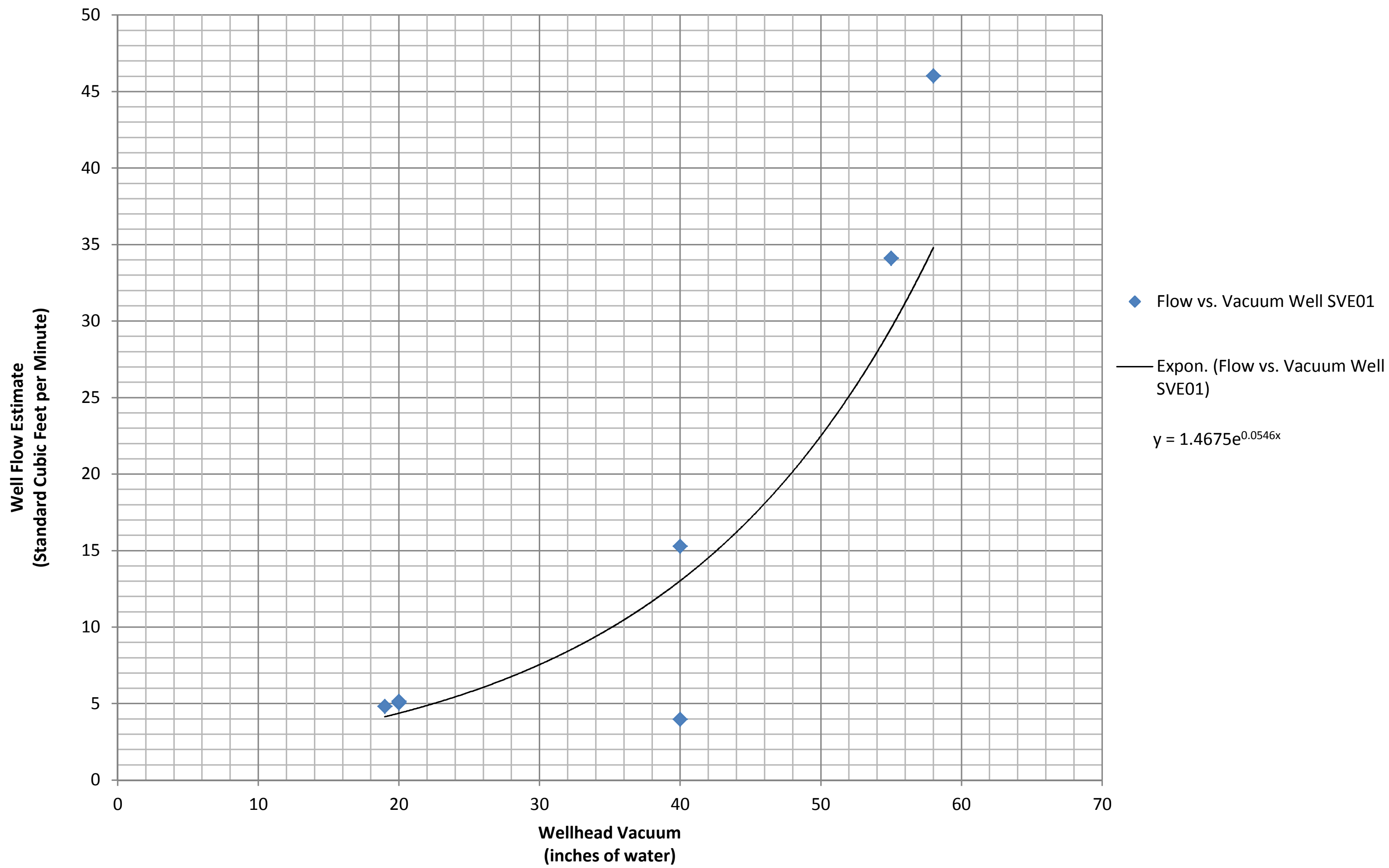
Appendix B
Soil Vapor Extraction Pilot Test
Observation Well Vacuums for Test Well: 01SVE01
ASKO Hydraulic Property
TOC Holdings Co. Facility No. 01-600
2805 West Commodore Way
Seattle, Washington

Date	Time	VFD Setting (Hz)	Manual Dilution Valve (% open)	Observation Well Head Vacuum (in. H_2O)						Notes	
				01MW44	01MW54	01MW65	01MW55	01MW15	01MW63		
Approximate distances from Test Well to Observation Well (ft)				20.6	22.1	6.8	10.8	47.3	25.6	--	--
02/24/10	9:10	36	60	1.2	0.12	0	0.16	2.3	0.3	Start Step 1	
	9:20	36	60	1.25	0.05	0	0.65	2.2	1.3	--	--
	9:35	36		1.21	0.1	0	0.45	2.2	1.3	--	--
	9:50	36	35	1.1	0.01	0.01	0.6	2.4	1.3	Start Step 2	
	10:05	36	35	1.1	0.1	0.05	0.55	2.1	1.2	--	--
	10:20	40	30	0.7	0.15	0.01	0.35	1.45	0.45	Start Step 3	
	10:35	40	30	0.9	0.15	0.05	0	1.95	1	--	--
	10:50	40	30	0.9	0.2	0.01	0.5	2	1.1	--	--

Comments:
(shaded cell) Indicates measurement is a pressure reading in inches of water.

Appendix B
Chart 1
Soil Vapor Extraction Pilot Test
Observation Well Measurements (Flow vs. Vacuum) for Test Well: 01SVE01
TOC Holdings Co. Facility No. 01-600
ASKO Hydraulic Property
2805 West Commodore Way
Seattle, WA



Appendix B
Soil Vapor Extraction Pilot Test
Step Test Operational Data for Test Well: 01MW44
ASKO Hydraulic Property
TOC Holdings Co. Facility No. 01-600
2805 West Commodore Way
Seattle, Washington

Date	Time	Barometric Pressure (psi)	Manual Dilution Valve (% open)	VFD Setting (Hz)	Wellhead Vacuum (in. H_2O)	KOT Vacuum (in. H_2O)	Suction Instrument Train								Bleed Air				Alternate Well Flow	
							Static Pressure (in. H_2O)	Differential Pressure (in. H_2O)	Temp (°F)	VOC (ppmv)	LEL (%)	O_2 (%)	CO_2 (% / ppm)	Flow Rate* (scfm)	Static Pressure (in. H_2O)	Differential Pressure (in. H_2O)	Temp (°F)	Flow Rate (SCFM)	**total Flow (from baseline blower curve) SCFM	Alternate Well Flow Rate Estimate*
02/24/10	Step 1																			
	11:50	14.86	50	42	19	24	26.0	0.05	54	136	13	1	>20,000	26.0	2.0	6.5	54	130.5	154	24.0
	12:05	14.87	50	42	20	27	26.0	0.05	60	9.8	0	20.9	460	25.9	1.5	6.5	54	130.6	154	23.9
	12:20	14.86	50	42	20	27	25.0	0.05	52	179	3	1.1	>20,000	26.1	1.5	6.5	52	130.8	154	23.7
	Step 2																			
	12:30	14.86	25	42	38	44	42.0	0.05	54	186	16	1.2	>20,000	25.5	1.0	5.5	54	120.1	154	34.3
	12:45	14.86	25	42	40	44	43.0	0.02	56	191	3	1.2	>20,000	16.1	1.5	6.0	56	125.2	154	29.3
	13:00	14.86	25	42	40	44	43.0	0.01	54	184	1	1.1	>20,000	11.4	1.0	5.5	54	120.1	154	34.4
	Step 3																			
	13:15	14.86	22	43.5	58	62	60.0	0.01	53	191	4	1.3	>20,000	11.1	1.5	7.0	53	135.6	159	23.7
	13:30	14.86	22	43.5	60	63	61.0	0.01	52	197	5	1.5	>20,000	11.1	1.5	6.5	52	130.8	159	28.5

Comments:
*The suction instrument train flow rates are unreliable due to velocity levels below the recommended range for the averaging flow sensor. Alternatively, flow rates at various steps are estimated to be the difference between the total baseline flow rate and the flow rate calculated for the bleed air.
**The equation for the relationship of baseline flow to VFD setting is: $y = 3.2137x + 19.507$, where x = VFD setting in Hz.

Appendix B
Soil Vapor Extraction Pilot Test
Observation Well Vacuums for Test Well: 01MW44
ASKO Hydraulic Property
TOC Holdings Co. Facility No. 01-600
2805 West Commodore Way
Seattle, Washington

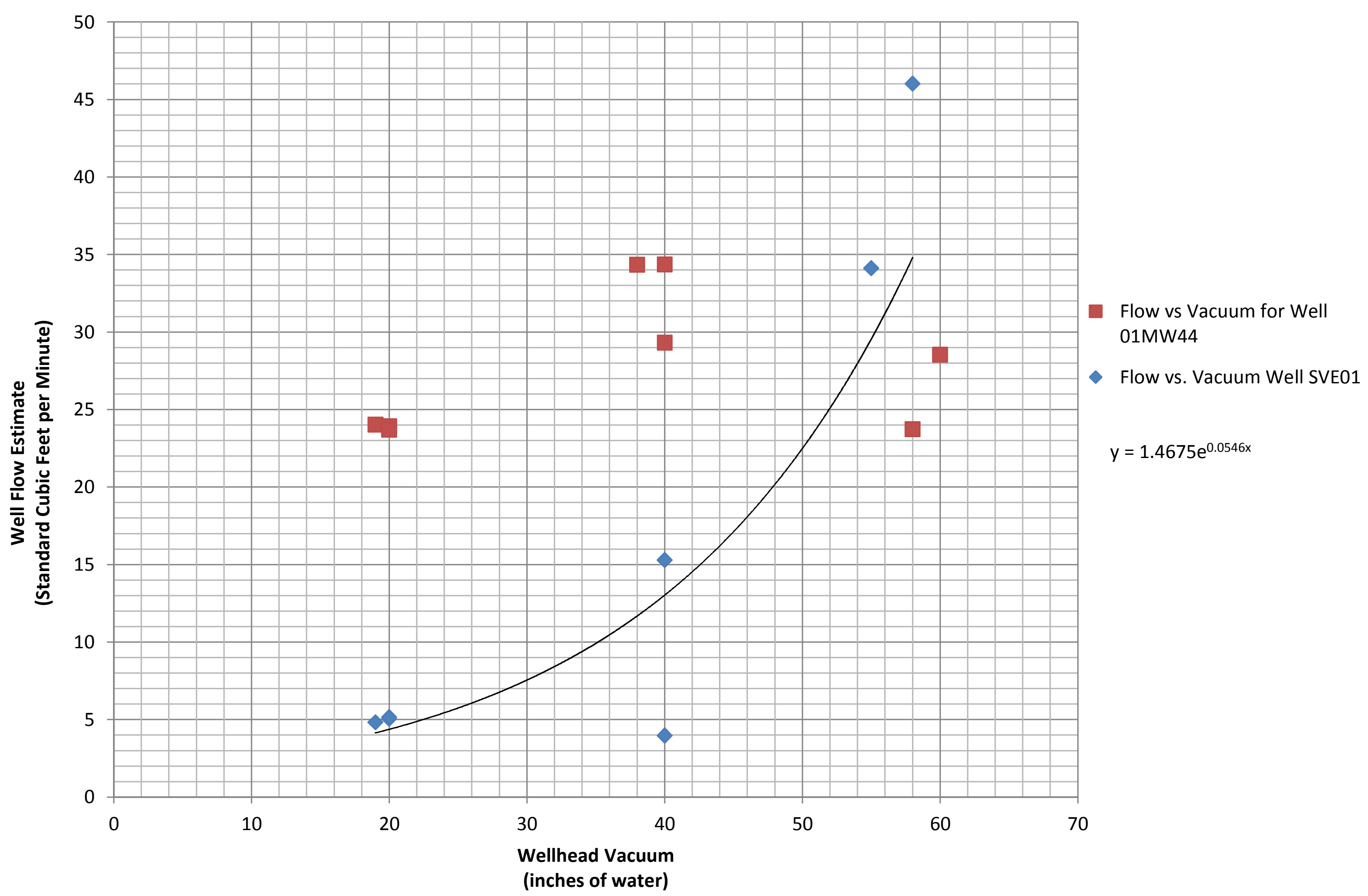
Date	Time	VFD Setting (Hz)	Manual Dilution Valve (% open)	Observation Well Head Vacuum (in. H_2O)						Notes	
				01MW54	01SVE01	01MW65	01MW55	01MW15	01MW63		
Approximate distances from Test Well to Observation Well (ft)				4.1	20.0	21.7	24.6	55.0	43.4	--	--
02/24/10	11:50	42	50	2.5	5.7	0	1.5	2	0.01	Start Step 1	
	12:05	42	50	0.3	5.0	0.01	1.65	1.85	0.2	--	--
	12:20	42	50	0.01	4.0	0	3.4	1.8	0.7	--	--
	12:30	42	25	0.05	3.7	0	4.1	1.7	1.6	Start Step 2	
	12:45	42	25	0.05	3.2	0.05	6.1	1.8	1.8	--	--
	13:00	42	25	0.01	2.6	0	7.4	1.45	1.7	--	--
	13:15	43.5	22	0.01	2.2	0	9.5	1.8	1.85	Start Step 3	
	13:30	43.5	22	0.01	2.0	0.1	13	1.0	2.2	--	--

Comments:
Indicates measurement is a pressure reading in inches of water.

Figure 6
Flow vs. Vacuum Test Well 01SVE01

OBSERVATION WELLHEAD MEASUREMENTS
SVE Test Well: 01MW44

TOC HOLDINGS CO., FACILITY NO. 01-600
2737 WEST COMMODORE WAY
SEATTLE, WA 98199



Appendix B
Soil Vapor Extraction Pilot Test
Step Test Operational Data for Test Well: 01MW63
ASKO Hydraulic Property
TOC Holdings Co. Facility No. 01-600
2805 West Commodore Way
Seattle, Washington

							Suction Instrument Train								Bleed Air				Alternate Well Flow	
Date	Time	Barometric Pressure (psi)	Manual Dilution Valve (% open)	VFD Setting (Hz)	Wellhead Vacuum (in. H_2O)	KOT Vacuum (in. H_2O)	Static Pressure (in. H_2O)	Differential Pressure (in. H_2O)	Temp (°F)	VOC (ppmv)	LEL (%)	O_2 (%)	CO_2 (% / ppm)	Flow Rate (scfm)	Static Pressure (in. H_2O)	Differential Pressure (in. H_2O)	Temp (°F)	Flow Rate (SCFM)	**total Flow (from baseline blower curve) SCFM	Alternate Well Flow Rate Estimate*
02/24/10	Step 1																			
	14:20	14.69	40	30	18	22	21	0.04	53	118	0	20.9	490	23.3	0.5	4.5	53	108.2	116	7.684
	14:35	14.69	40	30	18	22	20	0.04	54	30	0	20.9	360	23.3	0.5	4.5	54	108.1	116	7.789
	Step 2																			
	14:50	14.69	30	36	32	38	36	0.05	60	117	5	18.1	9700	25.4	1.0	5.5	54	119.5	135	15.733
	15:05	14.69	30	36	32	38	36	0.05	68	115	15	11.6	>20,000	25.2	1.5	5.5	55	119.3	135	15.922
	Step 3																			
	15:25	14.69	20	39.5	60	63	60	0.05	68	144	13	11.4	>20,000	24.4	1.5	5.5	55	119.3	146	27.170
	15:40	14.69	20	39.5	60	63	61	0.04	68	146	13	11.4	>20,000	21.8	1.0	5.5	55	119.4	146	27.097
	15:55	14.69	20	39.5	60	64	61	0.04	62	133	5	12.5	>20,000	21.9	1.5	5.5	53	119.5	146	26.938

Comments:

*The suction instrument train flow rates are unreliable due to velocity levels below the recommended range for the averaging flow sensor. Alternatively, flow rates at various steps are estimated to be the difference between the total baseline flow rate and the flow rate calculated for the bleed air.

**The equation for the relationship of baseline flow to VFD setting is: y = 3.2137x + 19.507, where x = VFD setting in Hz.

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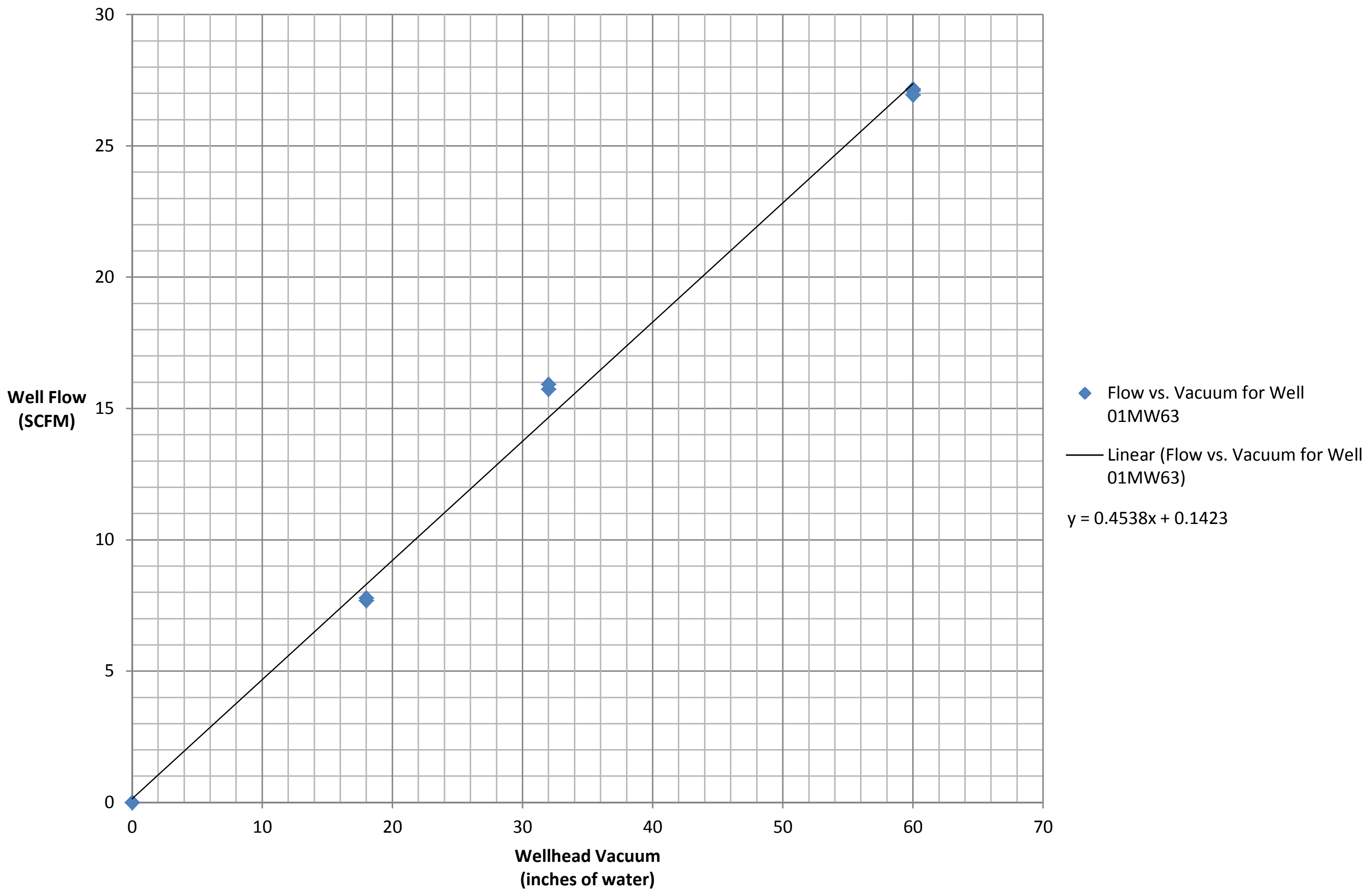
Appendix B
Soil Vapor Extraction Pilot Test
Observation Well Vacuums for Test Well: 01MW63
ASKO Hydraulic Property
TOC Holdings Co. Facility No. 01-600
2805 West Commodore Way
Seattle, Washington

SVE Step Test Well: 01MW63											
Date	Time	VFD Setting (Hz)	Manual Dilution Valve (% open)	Observation Well Head Vacuum (in. H_2O)							
				01MW44	01MW54	01SVE01	01MW65	01MW55	01MW15	Notes	
Approximate distances from Test Well to Observation Well (ft)				43.2	43.4	25.5	21.8	19.1	31.2	--	--
02/24/10	14:20	30	40	12	0.01	0.05	0	4.0	0	Start Step 1	
	14:35	30	40	8.3	0.01	0.08	0	3.2	0	--	--
	14:50	36	30	6.9	0	0.08	0	1.8	0	Start Step 2	
	15:05	36	30	6.0	Flicker	0	0.03	1.4	0.01	--	--
	15:25	39.5	20	5.5	0.05	0	0.05	1.0	0.08	Start Step 3	
	15:40	39.5	20	5.2	0.08	0.04	0	1.0	0.1	--	--
	15:55	39.5	20	5.0	0.1	0.05	0	0.4	0.1	--	--

Comments:

(grey shading) Indicates measurement is a pressure reading in inches of water.

Appendix B
Chart 3
Soil Vapor Extraction Pilot Test
Observation Well Measurements (Flow vs. Vacuum) for Test Well: 01MW63
TOC Holdings Co. Facility No. 01-600
ASKO Hydraulic Property
2805 West Commodore Way
Seattle, WA



Appendix B
Soil Vapor Extraction Pilot Test
Depth to Water Measurements
ASKO Hydraulic Property
TOC Holdings Co. Facility No. 01-600
2805 West Commodore Way
Seattle, Washington

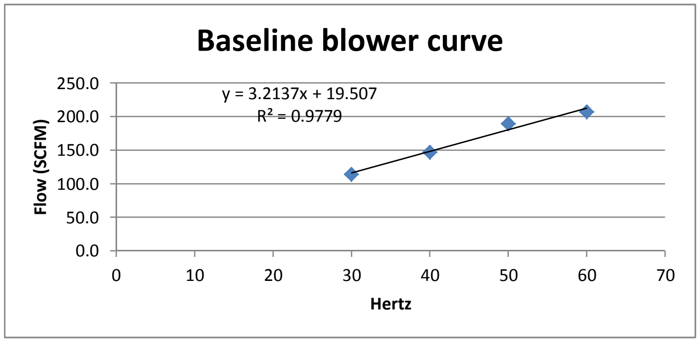
Site: TOC Holdings Co., Seattle Terminal						Field Personnel: JAB/TGO						
Equipment: Krause DTW Meter - Blue												
Pilot Test - Depth to Water Measurements												
		Depth to Water (ft)										
Date	**Time**	**01SVE01**	**01SVE02**	**01SVE03**	**01MW15**	**01MW44**	**01MW54**	**01MW55**	**01MW62**	**01MW63**	**01MW64**	**01MW65**
02/23/10	09:45	--	--	--	22.61	21.42	29.83	22.63	--	26.54	--	33.91
02/24/10	07:36	--	--	--	22.57	22.38	29.75	22.69	--	26.54	--	33.75
	11:15	6.29	--	--	22.64	22.44	29.77	22.80	--	26.68	--	33.80
	13:54	--	--	--	22.86	22.66	29.82	23.15	--	27.23	--	33.80
	16:10	--	--	--	22.81	22.51	29.82	23.20		24.89		33.81

Comments:

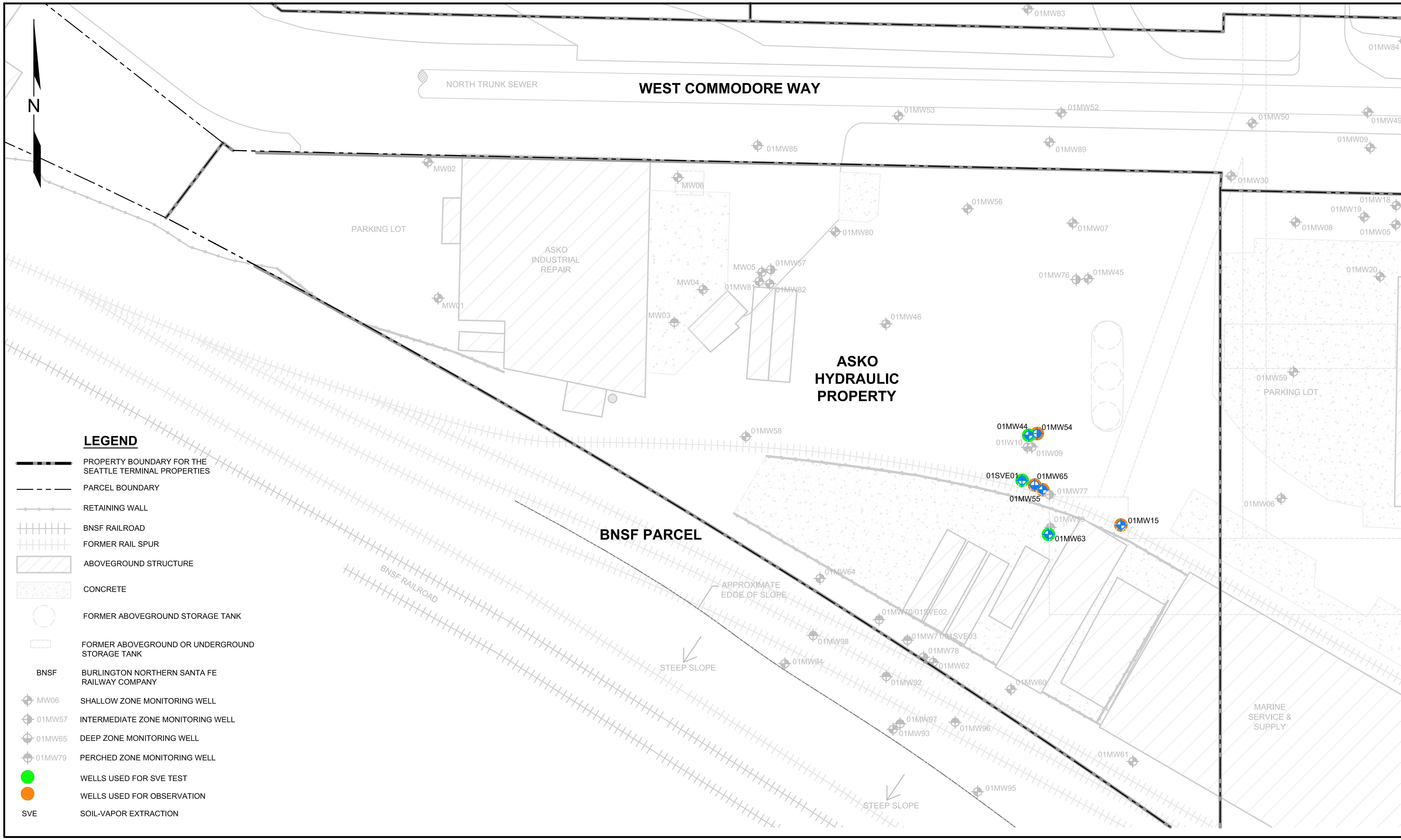
Appendix B
Soil Vapor Extraction Pilot Test
Baseline Blower Curve Data
ASKO Hydraulic Property
TOC Holdings Co. Facility No. 01-600
2805 West Commodore Way
Seattle, Washington

SVE Test Well: BASELINE																			
							Suction Instrument Train (3" schedule 80 pvc)									Bleed Air (2" sch 80 PVC)			
Date	Time	Barometric Pressure (psi)	Manual Dilution Valve (% open)	VFD Setting (Hz)	Wellhead Vacuum (in. H_2O)	KOT Vacuum (in. H_2O)	Static Pressure (in. H_2O)	Differential Pressure (in. H_2O)	Temp (°F)	VOC (ppmv)	LEL (%)	O_2 (%)	CO_2 (% / ppm)	Flow Rate (scfm)	Static Pressure (in. H_2O)	Differential Pressure (in. H_2O)	Temp (°F)	Flow Rate (SCFM)
02/24/10	8:30	14.65	0	60	N/A	16	5.5	3	48	N/A	N/A	N/A	N/A	206.8	N/A	N/A	N/A	N/A
		14.65	0	50	N/A	12	4.0	2.50	48	N/A	N/A	N/A	N/A	189.1	N/A	N/A	N/A	N/A
		14.65	0	40	N/A	8	3.0	1.50	48	N/A	N/A	N/A	N/A	146.7	N/A	N/A	N/A	N/A
		14.65	0	30	N/A	2	1.5	0.90	48	N/A	N/A	N/A	N/A	113.8	N/A	N/A	N/A	N/A

Comments:



3/20/2014



WWW.SOUNDEARTHINC.COM

DATE: 06/25/13
DRAWN BY: NAC
CHECKED BY: PJK/TSB
CAD FILE: 01-600_2013FS_SVE

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

FIGURE 1 - APPENDIX B
LOCATION OF WELLS USED FOR SVE PILOT TEST (FEBRUARY 2010)

P:\0440 TOC HOLDINGS CO\01-600 SEATTLE TERMINAL\DELIVERABLES\2013\BTP\FS\APPENDIX B- SVE PILOT TEST\01-600_2013FS_SVE.DWG