DRAFT
CLEANUP ACTION PLAN
PORT OF SEATTLE TERMINAL 91 SITE
SEATTLE, WASHINGTON

APRIL 2010

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LIST OF ACRONYMS AND ABBREVIATIONS

1998 AO	Agreed Order No. DE 98HW-N108
ACM	Asbestos-Containing Materials
AOC	Area of Concern
API	Asian Pacific Islander
Aspect	Aspect Consulting
BD	Bridge Document
BDR1,2,3	Bridge Document Reports 1, 2, 3
BEI	Burlington Environmental, Inc.
bgs	Below Ground Surface
BTEX	Benzene, Toluene, Ethylbenzene, and Xylenes
CAO	Cleanup Action Objective
CAP	Cleanup Action Plan
Chempro	Chemical Processors, Inc.
Converse	Converse Consultants NW
CPOC	Conditional Point of Compliance
CSM	Conceptual Site Model
CULs	Cleanup Levels
DCA	Dichloroethane
DCE	Dichloroethene
DNAPL	Dense Non-Aqueous Phase Liquid
Ecology	Washington State Department of Ecology
FAMM	Fuel and Marine Marketing
FS	Feasibility Study
Ft	Feet
GWSAP	Groundwater Sampling and Analysis Plan
HQ	Hazard Quotient
IHS	Indicator Hazardous Substance
Lease Parcel	Terminal 91Tank Farm Lease Parcel
LNAPL	Light Non-Aqueous Phase Liquid
MCL	Maximum Contaminant Level
mg/kg	Milligram per Kilogram
µg/kg	Microgram per Kilogram
µg/L	Microgram per Liter
MLLW	Mean Low Low Water
MNA	Monitored Natural Attenuation
MTCA	Model Toxics Control Act
ND	Non-Detect
NPDES	National Pollutant Discharge Elimination System
PAHs	Polycyclic Aromatic Hydrocarbons
PCBs	Polychlorinated Biphenyls
PCE	Perchloroethene
PES	PES Environmental, Inc.

PID	Photoionization Detector
PIONEER	PIONEER Technologies
PLP	Potentially Liable Person
PLRD	Passive LNAPL Recovery Device
PNO	Pacific Northern Oil Corporation
POC	Points of Compliance
PVC	Polyvinyl Chloride
Port	The Port of Seattle
PSC	Philip Services Corporation
RCRA	Resource Conservation and Recovery Act
RCW	Revised Code of Washington
RFA	Terminal 91 RCRA Facility Assessment
RFI	RCRA Facility Investigation
RI	Remedial Investigation
RI/DE	Remedial Investigation/ Data Evaluation
RSSL	Residual Saturation Screening Level
SPOC	Standard Point of Compliance
SVOC	Semi-Volatile Organic Compound
SWMU	Solid Waste Management Unit
TCA	Trichloroethane
TCE	Trichloroethene
TFAA	Tank Farm Affected Area
TPH	Total Petroleum Hydrocarbon
TSCA	Toxic Substances Control Act
USGS	U.S. Geological Survey
VOC	Volatile Organic Compound
WAC	Washington Administrative Code

1.0 INTRODUCTION

1.1 Purpose

This cleanup action plan (CAP) describes the selected cleanup action for the Terminal 91 Tank Farm Site (Site), a portion of the Port of Seattle's (Port's) Terminal 91 Complex in Seattle, Washington (Figure 1). The CAP has been developed in accordance with the Model Toxics Control Act (MTCA) under Chapter 70.105D of the Revised Code of Washington (RCW) and Chapter 173-340 of the Washington Administrative Code (WAC).

The selected cleanup action is based on site-specific data developed pursuant to Agreed Order No. DE 98HW-N108 (1998 AO) between the Port and the Washington Department of Ecology (Ecology). Specifically, the CAP is based on information provided in the Final Draft Feasibility Study Report, Terminal 91 Site, Seattle, Washington (FS Report; PES Environmental, Inc. et al., 2009), the Remedial Investigation Summary Report for the Terminal 91 Tank Farm Site in Seattle, Washington (RI Summary Report; Roth Consulting, 2007), and documents referenced therein. The FS Report and RI Summary Report are on file at the Ecology Northwest Regional Office located at 3190 160th Avenue SE, Bellevue, Washington, 98008-5452.

1.2 Document Organization

The CAP is organized into 10 sections. A brief description of each section is presented below.

- **Section 1 – Introduction.** Section 1 contains an overview of the CAP.

- **Section 2 – Background.** Section 2 provides a summary of the Site description and history, the investigations conducted at the Site, and the cleanup actions previously performed at the Site.

- **Section 3 – Site Conditions.** Section 3 discusses the hydrogeology and groundwater conditions at the Site.

- **Section 4 – Nature and Extent of Contamination.** Section 4 discusses the nature and extent of contamination in Site soil and groundwater.

- **Section 5 – Conceptual Site Model.** Section 5 outlines contaminant sources of, exposure pathways to, and potential receptors of, Site-related contamination.

- **Section 6 – Cleanup Standards.** Section 6 discusses groundwater cleanup levels (CULs), points of compliance (POC), areas exceeding CULs, and also summarizes the regulatory requirements applicable to the cleanup.

- **Section 7 – Approach to Developing Cleanup Action Alternatives.** Section 7 briefly presents the cleanup action objectives (CAOs) for the Site and summarizes the approach used in the FS for developing cleanup action alternatives (CAAs).

- **Section 8 – Description of Selected Cleanup Action Alternatives.** Section 8 provides a description of the selected CAA for the Site, including the presumptive cleanup actions and the selected tank farm CAA, and also summarizes the other five CAAs that were developed and evaluated in the feasibility study for the tank farm portion of the Site.

- **Section 9 – Justification for Selected Cleanup Action Alternative.** Section 9 summarizes how the selected CAA meets the MTCA evaluation criteria and the disproportionate cost analysis.

- **Section 10 – Implementation of the Selected Cleanup Action.** Section 10 outlines the approach for implementing the selected CAA and provides a general implementation schedule.

1.3 Declaration

In accordance with WAC 173-340-360(2)(a), the selected cleanup action meets the threshold requirements, is protective of human health and the environment, complies with applicable state and federal laws, and provides for compliance monitoring. The selected remedy is consistent with the preference of the State of Washington as stated in RCW 70.105D.030(1)(b) for permanent cleanup solutions.

1.4 Applicability

The cleanup standards and the selected cleanup action have been developed as an overall remediation process under Ecology oversight using MTCA authority; they should not be considered as setting precedents for other sites.

1.5 Administrative Record

The documents used to make the decisions discussed in this CAP are part of the administrative record for the Site. The entire administrative record for the Site is available for public review by appointment at Ecology's Northwest Regional Office. To review or obtain copies of the above documents, contact Sally Perkins (Public Disclosure Coordinator) at (425) 649-7190. Information related to the Site, the location of document repositories, and many of the important documents are also available online at the following website: http://www.ecy.wa.gov/programs/tcp/sites/portTerm91/portTerm91_hp.html.

2.0 BACKGROUND

2.1 <u>Site Description</u>

The Site is defined in the 1998 AO as "the Tank Farm Lease Parcel and areas where releases of dangerous constituents originating from the Tank Farm Lease Parcel operations have come to be located." The Tank Farm Lease Parcel (Lease Parcel) is a contiguous parcel, approximately four acres in size, located within the confines of the Port's Terminal 91 Complex. The Terminal 91 Complex is located at 2001 West Garfield Street, Seattle, Washington and encompasses approximately 216 acres, including adjacent submerged and upland areas. The site location map is provided as Figure 1.

Figure 2 is an aerial photograph of the Terminal 91 Facility showing the approximate boundaries of the Site (also known as the Tank Farm Affected Area or TFAA), the Lease Parcel, and other portions of the larger Terminal 91 Complex including the Upland, Short Fill, and Submerged Land portions.

The Lease Parcel is located at the north end of the Site. The primary historical feature of the Lease Parcel is the bulk petroleum storage present from the 1920s through 2005. The aboveground portion of the tank farm, including all of the tanks and containment walls and other aboveground piping and equipment, was demolished and removed in 2005 as part of an interim remedial action. The Lease Parcel consisted of three tank yards and associated buildings and is divided into the following areas (Figure 3):

- **The Black Oil Yard** located at the south end of the Lease Parcel. This yard consisted of three large tanks used to store heavy fuel oils (e.g., Bunker C);
- **The Marine Diesel Oil Yard** located in the center of the tank farm. This yard consisted of 12 main tanks that were used to store a variety of products including diesel, kerosene, and other middle distillates as well as wastewater and waste oil;
- **The Small Yard** was located at the north end of the tank farm and consisted of 10 main tanks and a number of smaller tanks. The small yard was used to store a variety of petroleum products including gasoline and diesel and also wastewater and a variety of other waste materials.
- **The main warehouse** is located just north of the three tank yards. This building still exists at the Site; and
- **Additional areas** including the pipe alley between the Small Yard and the Marine Diesel Oil Yard, the decommissioned oil-water separator west of the Small Yard, and the foam mixing area at the north end of the Lease Parcel.

The Black Oil Yard and the Marine Diesel Oil Yard were surrounded by concrete product-containment walls approximately 15 feet (ft) high. The Small Yard was surrounded by a concrete product-containment wall approximately three ft high. All three tank yards were fully paved with concrete; the Small Yard was paved in 1982 while the paving of the Marine Diesel Oil and Black Oil Yards occurred in 1986. Aboveground and subsurface piping systems were used to transfer product within the tank yards.

2.2 Site History and Development

This section describes the history of the Terminal 91 Complex and its development from the late 1800s through the present day.

2.2.1 History of the Tank Farm Lease Parcel and Related Operations

From the late 1800s through 1920, owners of the Terminal 91 Complex included various railroads, land development companies, and private individuals. The Great Northern Railroad began to develop the area in the early 1900s by filling the area between Magnolia Bluff and Queen Anne Hill. Fill material was added to the area through 1920.

The tank farm at the Lease Parcel was constructed in the 1920s. The Lease Parcel initially may have been used as a gasoline refinery by California Petroleum Company as early as 1925 (Converse Consultants NW [Converse], 1993). The Texas Company appears to have operated the tank farm as a fuel storage facility in the late 1920s and 1930s. The U.S. Navy acquired the entire Terminal 91 Complex in 1942 through condemnation, and operated the tank farm until 1972. During the Navy's possession of the Terminal 91 Complex, the Lease Parcel was used primarily as a fuel and lubricating oil transfer station. The Navy began leasing the Terminal 91 Complex back to the Port in 1972 and deeded it to the Port in 1976.

At about the time the Port leased Terminal 91 back from the Navy, Chemical Processors, Inc. (Chempro), a predecessor of Burlington Environmental, Inc. (BEI) and Philip Services Corporation (PSC), subleased the Lease Parcel from the Port. The main activities conducted by Chempro and its successors were waste oil recovery and wastewater treatment. Beginning in 1980, Chempro applied for and was granted interim status under the Resource Conservation and Recovery Act (RCRA) and began dangerous waste management activities at the Lease Parcel. BEI and the Port (as operator and owner, respectively) were issued a Part B RCRA permit effective August 22, 1992 for the continued operation of a permitted dangerous waste management facility at the Lease Parcel. In September 1995, BEI ceased operations at the Lease Parcel and terminated its lease with the Port; no dangerous waste operations requiring a permit (other than corrective action) have been conducted since then. All regulated waste units at the Lease Parcel have undergone closure.

From approximately 1974 through 1999, Pacific Northern Oil Corporation (PNO) sublet a portion of the Lease Parcel for storage of non-regulated bunker oil and other fuel products. PNO used aboveground and underground piping systems at the Site to transfer bunker oil and fuels within the Lease Parcel and other areas of the Terminal 91 Complex. The Port entered into an agreement with Fuel and Marine Marketing (FAMM), who conducted bunker oil and fuel product storage, blending and marketing operations at the Site until early 2003, when FAMM terminated its lease.

Because the facility would no longer be used as a tank farm, the Port decided to remove the remaining aboveground equipment to reduce risks of hazardous substance releases. In the spring of 2005, the Port initiated product removal, demolition activities, and paving of the Lease Parcel as part of an independent interim remedial action. That interim action was completed in the summer of 2005. An independent cleanup report documenting the interim action was submitted to Ecology on October 20, 2005 (Roth Consulting, 2005).

2.2.2 History of the Vicinity Surrounding the Tank Farm Lease Parcel

Another tank farm was historically located in the area southwest of the Lease Parcel. This former tank farm was identified as the Old Tank Farm and was called out as Area of Concern (AOC) 11 in the Terminal 91 RCRA Facility Assessment (RFA) (EPA, 1994). Figure 2-4 shows the approximate footprint of the Old Tank Farm (AOC 11). The former tank farm in AOC 11 was reportedly active between 1927 and 1942. Operators included Signal Oil & Gas and Richfield Oil Company. This tank farm was demolished subsequent to the United States Department of the Navy taking possession of the site in December 1942.

Other areas of interest at the Site include Solid Waste Management Unit (SMWU 30), which is the location of a pipeline break that occurred in 1989 near the north end of Pier 91 (Figure 4), and former fuel transfer pipelines that ran in and around the Lease Parcel and out towards Piers 90 and 91.

2.3 Previous Investigations

A number of investigations were performed at the Site between 1985 and 2008 that have characterized the types and distribution of contaminants in soil and groundwater and provide the basis for developing and evaluating the cleanup actions for the Site. These investigations, divided into two general time periods (pre- and post-1998 AO), are summarized in this section.

2.3.1 Pre-1998 Agreed Order Site Investigations

Prior to the 1998 AO, a number of investigations were conducted. These pre-1998 AO investigations provided the basis for the more comprehensive Remedial Investigation (RI) investigation conducted pursuant to the Agreed Order. The primary pre-1998 investigations include:

- **Phase I Hydrogeologic Investigation, 1988:** A Phase I Hydrogeologic Investigation of the Site was completed in 1988 (Sweet-Edwards/EMCON, 1988) to provide a preliminary environmental characterization.
- **Phase II Hydrogeologic Investigation, 1989:** A Phase II Hydrogeologic Investigation of the Site was completed in 1989 (Sweet-Edwards/EMCON, 1989) to meet the requirements of BEI's RCRA 3013 Order.
- **RCRA Facility Investigation, 1992/1993:** BEI performed RCRA Facility Investigation (RFI) fieldwork at the Site between 1992 and 1993 in accordance with the final April 1992 RFI Work Plan (BEI, 1992). The results of these activities were reported in the draft RFI for the Site (BEI, 1995).

The results of these investigations were used as the primary basis for development of the Remedial Investigation/Data Evaluation (RI/DE) Report (PSC et al., 1999).

2.3.2 1998 Agreed Order RI/FS Site Investigations and Evaluations

RI/DE Report. The Agreed Order required the Potentially Liable Person (PLP) group, which included the Port, PSC, and PNO, to prepare the RI/DE Report (PSC et al., 1999). The primary objective of the RI/DE Report was to provide a comprehensive report of investigative work completed to date to assist in preparation of a feasibility study and selection of potential cleanup actions.

Bridge Document Investigations. The Draft RI/DE Report identified several data gaps, and the PLP group concluded that additional work would be necessary prior to evaluating cleanup options for the Site in an FS. This additional data was collected between 2000 and 2004 in a series of “Bridge Document” (BD) investigations. The findings of this work were presented in the BD Report 1 (BDR1; Roth Consulting, 2001), BDR2 (Roth Consulting, 2003), and BDR3 (Aspect Consulting [Aspect], 2004a), soil vapor investigation reports (PSC, 2001 and 2002; PIONEER Technologies [PIONEER], 2004), related work plans (Aspect, 2004b), and a groundwater sampling and analysis plan (PSC, 2003).

The primary tasks performed as part of the BD investigations included the following:

- Identification of potential exposure pathways, analysis of the highest beneficial use of groundwater, determination that a terrestrial ecological exclusion was warranted, development of screening levels for groundwater based on site-specific potential exposure pathways and highest beneficial use of groundwater, and assessment of potential points of compliance for groundwater;
- Assessment of monitoring well locations and the then-current sampling program, and preparation of the *Groundwater Sampling and Analysis Plan* (GWSAP) (PSC, 2003).
- Performance of tidal studies in the shallow and deep aquifers;
- Assessment of potential stratification of contaminants in groundwater by depth-specific groundwater sampling;
- Collection of light nonaqueous phase liquids (LNAPL) samples and LNAPL bail-down testing to assess the composition and potential for recovery of LNAPL from the water table;
- Compilation of bulkhead construction data and a review of underground utilities information to assess the potential for contaminant migration along preferred pathways;
- Revision of the conceptual site model (CSM) for the Site; and
- Performance of several soil vapor investigations in the vicinity of Building M-28, located immediately to the southwest of the Lease Parcel to assess the potential for migration of volatile organic compounds (VOCs) from the subsurface into the building;

Groundwater Seepage Investigation. A groundwater seepage evaluation was performed in 2004 to refine the CSM. The work performed included modeling the Shallow Aquifer along the piers and the Deep Confined Aquifer from upland areas to the downgradient offshore limit of the Deep Confined Aquifer using the U. S. Geological Survey (USGS) groundwater flow model

MODFLOW; evaluation of groundwater discharge to Elliott Bay, and recommendation of compliance monitoring wells and an approach for evaluating groundwater compliance.

Monitored Natural Attenuation Evaluation. An evaluation of monitored natural attenuation (MNA) was conducted in 2005 and 2006 to evaluate the effectiveness of MNA as a remedial technology at the Site. The evaluation was completed by considering data collected along three groundwater flow paths from the former tank farm: Pier 90, Pier 91, and AOC 11. Source, plume, and sentinel wells were used along each flow path. The MNA evaluation showed concentrations of site-related constituents below the screening levels at the sentinel wells, a generally stable or shrinking groundwater plume, and strong indications that biodegradation is occurring along each of the three flow paths evaluated.

Data Gaps Investigation. A series of three data gaps investigations was conducted in 2006 and 2007 to provide the data necessary to conduct the soil-to-groundwater pathway evaluation. The primary focus of the first two phases of the data gaps investigation was to characterize the distribution of total petroleum hydrocarbons (TPH) in the source areas of the site (i.e., Lease Parcel, AOC 11, SMWU 30), to evaluate the distribution of LNAPL, and provide the basis for developing site-specific Residual Saturation Screening Levels (RSSLs). The primary focus of the third phase of the data gaps investigation was to evaluate polychlorinated biphenyl (PCB) concentrations in soil west of the pumphouse area, in the Small Yard, and in the Marine Diesel Oil Yard in order to develop disposal costs for use in soil excavation cleanup alternatives.

Development of RSSLs. An evaluation of RSSLs was conducted in an attempt to estimate the maximum residual soil concentrations at which LNAPL will not accumulate on or in groundwater. The evaluation focused on the Lease Parcel and immediately adjacent areas, using reported spills and releases to target specific hazardous substances for evaluation. Based on the comparison of TPH concentrations in data gaps investigation soil samples, shallow monitoring well LNAPL monitoring results, and RSSLs, the evaluation determined that the many complex and competing factors at the Site do not allow clear or precise conclusions regarding the comparison of TPH concentrations in soil, RSSLs, and presence or absence of LNAPL at the Site as a whole (i.e., including Lease Parcel, AOC 11, and SWMU 30). These factors also do not allow for the development of a Site-wide empirical demonstration that measured soil concentrations either will or will not result in the accumulation of LNAPL on or in groundwater.

LNAPL Monitoring Program. The nature and extent of LNAPLs at the Site has been investigated through measurements conducted generally at least monthly since February 1992 LNAPL accumulations (including a sheen to measurable LNAPL) have been detected in 23 current or former wells within the Site.

As part of the FS work described in the FS Work Plan (PES et al., 2005), CP-PR01 and CP-PR02 were installed in August 2005 for use in a pilot study. The purpose of the pilot study was to evaluate the recoverability of LNAPL at the Lease Parcel. CP-PR01 and CP-PR02 were installed at locations where former wells showed the highest LNAPL recovery rate, near CP-117 and CP-118, respectively. From the time of installation until the early November 2005 monthly LNAPL monitoring event, only sheens were detected in the two pilot study wells. Therefore, the two pilot study wells were incorporated into the monthly LNAPL monitoring program. Wells

CP-PR03 through CP-PR12 were installed in October 2007 as part of the data gaps investigation discussed above.

Groundwater Monitoring Program. Groundwater monitoring has been conducted at the site on an ongoing basis since the 1998 Agreed Order has been in place. Over time, the parameters of the monitoring program (e.g., number of wells, chemicals analyzed, and frequency of monitoring) have changed with the approval of Ecology. Groundwater monitoring is currently being performed at the Site on an annual basis using selected wells. The current groundwater monitoring program consists of: (1) annual monitoring of 8 Shallow Aquifer monitoring wells and 5 Deep Confined Aquifer monitoring wells during the dry season (September/October) and (2) samples are analyzed for TPH as gasoline, diesel, and lube-oil-range hydrocarbons; low-level polycyclic aromatic hydrocarbons (PAHs); selected semi-volatile organic compounds (SVOCs) including carbazole, dibenzofuran, and 1-methylnaphthalene; selected VOCs including 1-4 dichlorobenzene and vinyl chloride; and the metals arsenic and zinc.

2.4 Previous Site Closure and Cleanup Activities

This section summarizes the previous closure activities and other interim cleanup actions conducted at the Site. Many of these historical actions have focused on the former tank farm and the Lease Parcel, but other cleanup actions outside the Lease Parcel but within the Site boundaries are also described.

2.4.1 RCRA Closure Activities

In 1997, PSC performed aboveground closure activities of all RCRA Part B permit related facility equipment, secondary containment, and treatment units, pursuant to a closure plan approved by Ecology (PSC, 1996). Specific activities conducted during the closure included decontamination of the various concrete structures using high-pressure water spraying followed by abrasive blasting, cleaning of Tank 164 (portable tank not shown in FS figures but located immediately northwest of Tank 110) and ancillary equipment (associated piping), and collection of concrete chip samples from tank yards in the vicinity of loading pads and sumps to confirm closure standards were met. These closure activities were documented and closure was certified in a letter PSC submitted to Ecology in 1997 (PSC, 1997). The aboveground closure was approved by Ecology in October 2003 (Ecology, 2003). The rest of the Lease Parcel previously used to store dangerous waste was closed under an interim status closure plan (PSC, 1997).

2.4.2 LNAPL Recovery at SWMU 30

This SMWU is the location of a pipeline break that occurred in 1989, near the north end of Pier 91 (Figure 4). In 1989, oil was observed seeping into the Short Fill Impoundment. After a series of investigations in 1989 and 1990, it was confirmed that the oil was the result of a pipeline failure, and the section of pipeline around the area of contamination was abandoned by PNO (Converse GES, 1990). An interim product extraction system for free product recovery began operation in January 1991 (Converse, 1994). The system operated as a skimming system in recovery well EW-1. During 1991 and 1992, the system removed about 53.5 gallons of liquid hydrocarbons.

Product thickness was observed to increase downgradient with time, and in March 1993 a passive skimming system also was installed in downgradient monitoring well MW-102. By April 1994, the system had recovered about 76.4 gallons of liquid hydrocarbons. Because of the poor recovery rates, the pneumatic recovery system was decommissioned in 1994 and passive LNAPL skimming systems were then installed in three monitoring wells (EW-1, MW-102, and MW-3). By early 2002, the total LNAPL recovered from the three skimmers since their installation in April 1994 was about 23.3 gallons (Aspect, 2002). PNO discontinued the quarterly monitoring and LNAPL recovery program in 2002. The Port is currently monitoring the fluid levels in these wells as part of the annual ground water monitoring program for the Site. The Port also has added wells in this area containing LNAPL to its regular monitoring and LNAPL-removal program.

2.4.3 2005 Tank Farm Demolition Interim Remedial Action

In the spring and early summer of 2005, the Port performed an independent interim remedial action known as the Tank Farm Demolition (Tank Farm Demo). The Tank Farm Demo consisted of the demolition and removal of aboveground fuel storage tanks, fuel stations, pump stations, water and waste piping, steam boiler, structures, and all incidental equipment. At the time the Tank Farm Demo was initiated, the tanks contained various fuel products which were removed for recycling or disposal. Other activities included removal and disposal of asbestos-containing materials (ACM), removal and disposal of petroleum-impacted soil from pipe chases, and purging of three underground fuel transmission lines from the tank farm to the fuel riser station on Pier 90. Once the demolition activities were completed, the Lease Parcel and adjacent, previously unpaved areas were paved. The independent interim remedial action report (Roth Consulting, 2005) documenting these activities was submitted to Ecology.

2.4.4 Seeps Remedial Actions

After demolition of the former tank farm and repaving of the area in 2005, three oily seeps (Seeps 1, 2, and 3) appeared on the pavement surface at three locations in the summer of 2006 with a fourth appearing in 2007 (Figure 5). The sources were identified as oily sand within the double-layered tank bases, which had been left in place as part of the demolition activities. The oily sand was removed and disposed of at a permitted facility, and the locations were backfilled with clean soil and repaved. At Seeps 2 and 4, a utility-type vault was installed to allow for ongoing collection of oil which is recovered and disposed of with LNAPL recovered from LNAPL monitoring wells.

2.4.5 Fuel Pipeline Cleaning Remedial Actions

In June 2007, the Port performed an interim remedial action along the west side of the Lease Parcel at the location of a water line break. In order to access the water line for repair, the Port needed to cut and remove some underground fuel lines at this location (Figure 5). Specific remedial activities included removal and recycling of less than 50 gallons of oil from the pipes, removal of several small sections of pipe, and plugging the remaining cut sections of the pipe that remained in place with grout.

In July, 2008, during excavation activities conducted along the southeast corner of the Lease Parcel as part of the Port's Seattle City Light Duct Bank project, PCS discovered an underground fuel pipeline that had not been decommissioned. The interim remedial action that was performed in September 2008 consisted of removing the oil from the pipeline (Figure 5), cleaning the pipeline, and disposing of the oil and piping at appropriate facilities.

2.4.6 Limited Soil Excavation Remedial Action

During excavation activities outside the southeast corner of the Lease Parcel as part of the Seattle City Light Duct Bank project, soil was encountered with concentrations of TPH exceeding MTCA Method A CULs (Figure 5). The contaminated soil was located to the north of the September 2008 pipeline cleaning remedial action location (see Section 2.4.5) and appears to be unrelated. Approximately 252 tons of soil were stockpiled, sampled, and subsequently disposed of as non-dangerous TPH-contaminated soil.

2.4.7 Tanks Farm LNAPL Recovery Program and Pilot Study

In the fall of 1999, passive LNAPL recovery devices (PLRDs) were installed in eight wells that contained or had previously contained LNAPL. At that time, a monthly product monitoring/recovery program was initiated to monitor the occurrence of LNAPL in these wells and to recover LNAPL. Since that time, five of the wells within the Lease Parcel have been decommissioned (prior to initiation of the Tank Farm Demo) and 13 new LNAPL monitoring/pilot study wells have been installed. About 140 gallons of LNAPL/water mixture have been removed from one or more of the 24 LNAPL monitoring/pilot study wells and two seeps since the first PLRDs were installed in October 1999 through the end of 2009.

3.0 SITE CONDITIONS

3.1 Environmental Setting

The Site is located at the Terminal 91 Complex, which encompasses approximately 216 acres, including adjacent submerged and upland areas (Figures 1 and 2). The Site lies at the south end of the Interbay Region, which is approximately 1.5 miles long and 1,000 to 2,000 ft wide and extends from the Lake Washington Ship Canal on the north to Elliott Bay on the south. The Interbay Region lies within a larger physiographic region, known as the Puget Sound Lowland, which is underlain by thousands of feet of unconsolidated glacial and non-glacial sediments.

Both the upland areas and piers at the Site overlie a portion of the Smith Cove inlet that was initially modified by filling in the early 1900s. Adjacent surface water bodies include Elliott Bay and the Short Fill Impoundment, an isolated water body located just south of the Garfield Street Viaduct. Bulkheads of various types bound the seaward portions of the Site and form the perimeter of the fill-cored piers. The east, center and west slips adjacent to the piers have been maintained to dredged depths of about -35 ft mean low low water (MLLW). An exception to this is the landward ends of the east and west slips, where four intertidal habitat sites are located (two on the northeast corner of the east slip and two on the west margin of the west slip).

No drinking water supply wells are present on or downgradient from the Site. Two deep water-supply wells (screened or perforated at depths of greater than about 250 ft below ground surface [bgs]), neither of which is currently in use, have been identified within approximately a one-half-mile radius of the Lease Parcel. Both wells are within the Terminal 91 Complex owned by the Port. The BDR1 (Roth Consulting, 2001) concluded that groundwater at the Site is non-potable.

3.2 Hydrogeology

Analysis of the geologic and hydrogeologic data collected during investigations at the Site indicates the presence of five primary hydrostratigraphic units beneath the Lease Parcel, which roughly correspond to the five primary stratigraphic units present at the Site. The list below summarizes the five hydrostratigraphic units and their corresponding stratigraphic units.

- **Shallow Aquifer (Shallow Sand Unit).** The Shallow Aquifer is unconfined, and contains an unsaturated zone extending from ground surface to approximately 5 ft bgs. The saturated thickness of the Shallow Aquifer is estimated to be about 10 to 15 ft. The Shallow Aquifer is laterally continuous across the Lease Parcel.
- **Upper Confining Unit (Silty Sand Unit).** The Upper Confining Unit is fully saturated and appears to be laterally continuous across the Lease Parcel. The unit is thickest (approximately 29 ft) along the eastern boundary of the Lease Parcel and thins to between 13 and 15 ft along the western boundary of the Lease Parcel.
- **Intermediate Zone (Gravel Layer within Silty Sand Unit).** This unit is a moderately to poorly sorted, silty sandy Gravel Layer was encountered within the Silty Sand Unit at some boring locations and is referred to as the Intermediate Zone in the cross-sections.

- **Deep Confined Aquifer (Deep Sand Unit).** The Deep Confined Aquifer appears to be laterally continuous across the southern and central portions of the Lease Parcel. It is uncertain if the Deep Confined Aquifer exists beneath the northern portion of the Site. The Deep Confined Aquifer is confined above by the Silty Sand Unit (Upper Confining Unit) and below by the Silty Clayey Sand Unit (Lower Confining Unit).
- **Lower Confining Unit (Silty Clayey Sand Unit).** The Silty Clayey Sand Unit is composed of soft to stiff, olive to gray, fine-grained sediments, primarily silty clay and clayey silt, with lesser amounts of silt and silty, clayey sand. The top of the Silty Clayey Sand Unit is shallowest beneath the eastern portion of the Lease Parcel, where it occurs as shallow as 42 ft bgs, in boring CP-106B. Depth to the top of the unit increases to the south and west, with the top of the unit in excess of 100 ft bgs beneath the middle portions of Piers 90 and 91 (Hart Crowser 1999, 2002).

3.3 Groundwater

3.3.1 Flow Direction and Velocity

Shallow Aquifer. Water level data collected in conjunction with a groundwater seepage evaluation (Aspect, 2004b) and during routine monitoring of monitoring wells at the Site show that the dominant unconfined groundwater flow direction is towards the south beneath the Lease Parcel and to the southwest beneath AOC 11 (Figure 7). Water levels in the wells typically range between 3 and 7 ft below ground surface (Aspect, 2004b) and generally correspond to seasonal variations in precipitation rates, with the highest water levels observed during the wetter winter months. The typical Site horizontal gradient beneath the Lease Parcel is approximately 0.001 ft per foot (Aspect, 2004b).

South of the Lease Parcel, water levels and tidal response data indicate that the relatively impermeable east-west trending, shore-parallel bulkheads and fine-grained Short Fill soil exert significant control over Shallow Aquifer groundwater flow, effectively “channeling” groundwater between the bulkheads within the inner portions of Piers 90 and 91. The shore-parallel bulkhead west of Pier 91 appears to direct shallow groundwater flow to the west southwest of AOC 11. Hence, the Short Fill itself does not appear to be within the flow path of shallow groundwater originating from the Site.

Aspect (2004a) reported that downward vertical gradients between the Shallow Aquifer and Deep Confined Aquifers were noted throughout the Site. Vertical gradients ranged from approximately 0.018 to 0.040 ft/foot, with vertical gradients decreasing to the south. Despite the presence of downward vertical gradients, significant downward movement of Shallow Aquifer groundwater under most of the Site is considered unlikely due to the low measured vertical permeabilities in the upper confining unit. From the southeast corner of the Lease Parcel southward where the upper confining unit appears to be absent, some net movement of Shallow Aquifer groundwater into the Deep Confined Aquifer is likely occurring.

Deep Confined Aquifer. Tidally-averaged groundwater elevation data (Aspect, 2004a) confirm that the groundwater flow direction in the Deep Confined Aquifer beneath and shoreward of the Lease Parcel is towards the south. As in the Shallow Aquifer, water levels in the Deep Confined

Aquifer respond to seasonal variations in precipitation rates, with the highest water levels observed during the wetter winter months. The typical Deep Confined Aquifer horizontal gradient is relatively constant at approximately 0.003 ft/foot beneath the Site, with a flattening of the horizontal gradient beneath and southward of the east-west trending, shore-parallel bulkheads. Unlike in the Shallow Aquifer, most of the existing shore-parallel and pier-perimeter bulkheads do not exert an influence on groundwater flow in the Deep Confined Aquifer due to their shallow depth.

3.3.2 Tidal Influence and Seepage

The shore-parallel bulkheads and the fine-grained Short Fill soil at the Site exert significant control over Shallow Aquifer flow, effectively "channeling" groundwater between the bulkheads within the inner portions of Piers 90 and 91. Shallow groundwater enters the fill in the piers and then discharges to Elliott Bay, apparently from the more seaward portions of the piers, where the pier bulkheads appear to exert less control on groundwater flow. In the case of the Deep Confined Aquifer, the existing shore-parallel and pier-perimeter bulkheads generally do not appear to affect groundwater flow or tidal influence, resulting in discharge to Elliott Bay parallel to the shoreline, either where the Deep Confined Aquifer crops out or through sediments.

Groundwater models of Pier 90 and Pier 91 were used to evaluate groundwater seepage along the pier faces. A flow budget analysis was used to compute the percent of inflow that discharges along the pier faces. Areas of relatively high or low seepage are a factor in determining compliance monitoring strategies for each pier.

The model-predicted percent discharge for the two pier models, plotted along the faces of Piers 90 and 91, is shown in Figure 8. The plots show cumulative discharge along the pier. Higher rates of groundwater discharge occur in segments along the pier where the slope of the cumulative discharge line is steep. For each pier, the east and west faces are plotted separately. More groundwater discharges along the face with the higher cumulative discharge (i.e. the east face of both piers). Residual discharge not accounted for on the cumulative plots discharges through the outer end of the piers.

The discharge analysis for the Deep Confined Aquifer indicates that discharge from the Deep Confined Aquifer is nearly uniformly distributed between the vacated Smith Cove Waterway between Piers 90 and 91 and the slip east of Pier 90. Groundwater in the Deep Confined Aquifer flows toward Elliott Bay from the north and discharges to Elliott Bay in areas where the Upper Confining Unit is missing. The Upper Confining Unit is missing throughout the vacated Smith Cove Waterway and much of the waterway on the east side of Pier 90. However, sediments do not allow groundwater to discharge only at the head of the waterways. Consequently, groundwater seeps offshore, and the groundwater discharge is distributed in different parts of the waterways.

4.0 NATURE AND EXTENT OF CONTAMINATION

4.1 LNAPL

NAPL monitoring at the Site has been ongoing since February 1992. LNAPL has been detected only in the Shallow Aquifer. Dense NAPL (DNAPL) has not been detected in any well, and historical and technical data do not indicate potential for a DNAPL source. Apparent LNAPL thicknesses measured in the monitoring wells varies seasonally, with LNAPL thicknesses generally decreasing during periods of rising water levels. LNAPL accumulations (including a sheen to measurable LNAPL) have been detected in the following current or former 23 wells within the Site:

- **Small Yard:** existing wells CP-PR01, CP-PR11, and CP-PR12, and former wells CP-116 and CP-117;
- **Marine Diesel Oil Yard:** existing wells CP-PR02, CP-PR07, and CP-PR08, and former wells CP-118 and CP-119;
- **Black Oil Yard:** existing wells CP-PR03 and CP-PR04, and former well CP-109;
- **Between the Lease Parcel and AOC 11:** existing wells CP-107, CP-110, UT-MW39-2, and UT-MW39-3;
- **AOC 11:** PNO-MW104[1]; and
- **SWMU 30:** existing wells PNO-EW1, PNO-MW03, PNO-MW06A, PNO-MW102, and PNO-MW103.

Table 1 provides a summary of the historical LNAPL monitoring data and the maximum apparent product thickness measured in 2008. Historically, the apparent LNAPL thicknesses measured in the monitoring wells varied seasonally, with LNAPL thicknesses generally decreasing during periods of rising water levels. Currently, the wells with the thickest accumulations of LNAPL are located in and directly to the west of the Lease Parcel. In 2008, LNAPL accumulations have been detected in the following 11 wells within the Site (see Figure 7):

- **Small Yard:** CP-PR01, CP-PR11, and CP-PR12;
- **Marine Diesel Oil Yard:** CP-PR02 and CP-PR07;
- **Black Oil Yard:** CP-PR03 and CP-PR04;
- **Between the Lease Parcel and AOC 11:** CP-110, UT-MW39-2, and UT-MW39-3;
- **AOC 11:** PNO-MW104; and
- **SWMU 30:** none.

[1] Although well PNO1MW104 is located in the extreme eastern edge of AOC 11, LNAPL observed at this location is likely related to releases from operations in the former pipeline corridor located between AOC 11 and the Lease Parcel.

LNAPL characteristics data have been collected from several of the original LNAPL monitoring wells in the Lease Parcel, the adjacent former pipeline area, and from data gap investigation wells. Recent LNAPL density and viscosity testing data supports the historical understanding that the LNAPL may include a mixture of petroleum products (Aspect, 2004a) with a predominance of diesel-range hydrocarbons (PSC et al., 1999). Test results for the LNAPL sample collected from CP-PR04 indicates that the LNAPL in the Black Oil Yard may be distinct from the LNAPL in other areas of the Site. The LNAPL in CP-PR04 has a viscosity that is similar to a heavier fuel oil, typical of the bulk petroleum product historically stored in the Black Oil Yard.

4.2 Soil

Soil sampling at the Site can be divided into two general time periods: (1) the sampling conducted from 1992 through 1995 that is summarized in the RI/DE Report (PSC et al., 1999) which evaluated a broad range of contaminants including VOCs, SVOCs, TPH, PCBs, and metals; and (2) sampling associated with the data gaps investigations conducted in 2007 and 2008 which focused on TPH and PCBs. In the summary below, information for VOCs, SVOCs, and metals is taken exclusively from the RI/DE Report while the TPH and PCB discussions are based primarily on the data collected in the data gaps investigations.

4.2.1 VOCs

Twenty VOCs were detected in soil samples collected at the Site. The VOC detections included low levels of 12 chlorinated VOCs (perchlorethene [PCE], trichloroethene [TCE], cis-1,2-dichloroethene [cis-1,2-DCE], 1,2-DCE (total), 1,1,1-trichloroethane [TCA], 1,1,1-dichloroethane [1,1,1-DCA], chloroethane, chloroform, methylene chloride, chlorobenzene, Freon 113, and 1,1-dicloropropene) and 8 non-chlorinated VOCs (acetone, benzene, 2-butanone, carbon disulfide, ethylbenzene, 2-hexanone, toluene, and total xylenes). The detections were in samples collected from borings in or near the former Lease Parcel tank yards.

Benzene, toluene, ethylbenzene, and xylenes (BTEX) compounds represent the most widely distributed group of VOCs in Site soil, detected in all but three borings (PSC et al., 1999). The highest concentration of total BTEX (5,000 milligram/kilogram [mg/kg]) was found in a soil boring in the eastern portion of the Small Yard, with concentrations above 10 mg/kg in other borings drilled in the Lease Parcel tank yards. PSC et al. (1999) reported that the distribution of BTEX compounds in soil was consistent with the distribution of LNAPL observed in Site wells. The highest concentrations of benzene were found in a boring just outside the northeast corner of the Small Yard, and the highest concentrations of toluene were found in borings in the Small Yard.

4.2.2 SVOCs

SVOCs were detected in most borings drilled at the Site. The detected SVOCs consisted of:

- PAHs: Naphthalene, 2-methylnaphthalene, acenaphthalene, acenaphthene, fluorene, phenanthrene, anthracene, fluoranthene, pyrene, benzo(a)anthracene, chrysene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(a)pyrene, indeno(1,2,3-c,d)pyrene, dibenzo(a,h)anthracene, and benzo(g,h,i)perylene;

- Phthalates: di-n-butyl phthalate, butylbenzylphthalate, bis(2-ethylhexyl) phthalate, and di-n-octylphthalate; and

- Other SVOCs: 1,2,4-trichlorobenzene, 4-chloro-3-methylphenol, benzyl alcohol, dibenzofuran, and N-nitrosodiphenylamine.

Total PAH compounds in concentrations greater than 10,000 micrograms/kilogram (μg/kg) and total phthalate concentrations in excess of 40,000 μg/kg were detected in soil samples from each of the three Lease Parcel tank yards.

1,2,4-trichlorobenzene, n-nitrosodiphenylamine, benzyl alcohol, and dibenzofuran were only detected in single borings located in or east of the Small Yard.

4.2.3 TPH

Soil sampling has shown the widespread occurrence of TPH in shallow soil at the Site. Most of the samples have been collected in and near the Lease Parcel, although, samples have also been collected in AOC 11 and SMWU 30.

The highest concentrations of gasoline range TPH (up to 22,000 mg/kg) are contained in smear zone samples from soil borings in the Small Yard, the northern end of the Lease Parcel, and the southern end of AOC 11. The highest concentrations of diesel range TPH (up to 130,000 mg/kg) and motor oil range TPH (up to 41,000 mg/kg) are contained in vadose and smear zone samples from soil borings in the Marine Diesel Oil Yard and the Black Oil Yard. The nature of the TPH impacts in the Black Oil Yard appears to be distinct from the rest of the Site due to the heavier oil bulk products that were stored in this tank farm; total TPH concentrations in this area are entirely from the diesel and motor oil TPH fractions. Total TPH concentrations in the SWMU 30 area also are entirely from the diesel and motor oil TPH fractions. Other areas contain a mixture of gasoline-range and heavier fractions, but all are predominantly diesel and motor oil TPH fractions.

4.2.4 PCBs

PCBs have been detected in shallow soil and in LNAPL within and directly west of the Lease Parcel. Soil sampling results indicate only one soil result above the 50 mg/kg level regulated under the Toxic Substances Control Act (TSCA). That sample was collected prior to 1999 from soil boring HA-03 at 6 ft bgs. The sample contained 85 mg/kg PCBs. The remaining soil PCB concentrations were low compared to the elevated PCB result (85 mg/kg) in historical boring

HA-03. The next highest total PCB concentration was 9.3 mg/kg (DG-104). The remaining total PCB concentrations ranged between non-detect (ND) and 4.2 mg/kg. Locations and results of total PCBs in soil samples are shown on Figure 9, Figure 10, and Table 2.

LNAPL samples were collected from wells with sufficient volumes of LNAPL (PR-07, PR-12, and UT-MW39-3) and analyzed for PCBs. Two of these LNAPL samples (222 mg/kg in PR-12 and 125 mg/kg in UT-MW39-3) were above the 50 mg/kg level regulated under TSCA. Locations and results of total PCBs in LNAPL samples are shown on Figure 9.

4.2.5 Metals

Soil samples were analyzed for 12 metals: arsenic, barium, beryllium, cadmium, chromium, copper, mercury, nickel, lead, selenium, silver, and zinc. Except for selenium, each of these metals was detected in at least one soil sample. The results for all metals but lead were consistent with background concentrations for metals concentrations in the Puget Sound Basin (Ecology, 1994). Arsenic, barium, chromium, copper, nickel, and zinc were detected in every soil sample analyzed. Lead was detected in the majority of the samples analyzed, and beryllium and cadmium were detected in the majority of shallow soil samples analyzed, but not in the deeper soil samples analyzed. Mercury was detected in a minority of the samples analyzed, and silver was only detected in two soil samples. Lead, the only metal detected above the Puget Sound Basin background concentrations, was detected in concentrations ranging from 0.91 to 326 mg/kg. The highest lead concentrations were found in and near the Small Yard.

4.3 <u>Groundwater</u>

The results of the 2007 and 2008 groundwater sampling at the Site are summarized in this section[2]. Groundwater samples were collected from 28 monitoring wells in March 2007, September 2007, and March 2008, and from 29 monitoring wells in September 2008. The results of the 2007 and 2008 groundwater monitoring are summarized in the *Annual Ground Water Report for 2007* (Roth Consulting, 2008) and the *Annual Ground Water Report for 2008* (Roth Consulting, 2009).

4.3.1 Metals

Groundwater samples were analyzed for eight metals (total arsenic, barium, chromium, lead, mercury, selenium, silver, and zinc) in 2007 and 2008. Arsenic was detected in most samples, with the highest concentration (19 micrograms/liter [µg/L]) detected in CP-GP12. Barium was analyzed only in 2008 and was detected in all samples, with the highest concentration (328 µg/L) in CP-GP13. Chromium was detected in 10 to 16 wells in each sampling event, with the highest concentration (13.6 µg/L) in CP-115B. Lead was detected in one well (CP-114) during two events with a maximum concentration of 9.4 µg/L. Mercury was detected (0.0235 µg/L) in only one sample, which was collected from CP-111. Selenium was analyzed only in 2008 and was detected in 7 to 12 wells per sampling event, with the highest concentration (20 µg/L) in

[2] Note that a more extensive data set is used to develop and evaluate CULs in Section 7 of the FS report. The data summarized here are intended to describe the current nature and extent of contamination.

CP-GP03AR. Silver was analyzed only in 2008 and was not detected in any of the wells. Zinc was detected in 3 to 12 wells per event, with the highest concentration (200 µg/L) in CP-103A.

4.3.2 Organic Constituents

TPH Compounds. TPH as gasoline and diesel have been detected in groundwater at the Site, with the highest concentrations and most of the detections in the vicinity of the former Lease Parcel and AOC-11 tank farms and SWMU 30. TPH was not detected in the wells farthest downgradient. Figure 11 shows the concentrations of gasoline-range hydrocarbons in the shallow monitoring wells in 2008, while Figure 12 shows the concentrations of gasoline-range hydrocarbons in the deep monitoring wells in 2007.

Diesel-range hydrocarbons were less widely distributed than gasoline-range hydrocarbons in shallow groundwater and were not detected in 2007 or 2008 in any Deep Confined Aquifer wells[3]. Figure 13 show concentrations of diesel-range hydrocarbons in shallow monitoring wells for 2008.

VOCs. Seventeen VOCs were detected in groundwater samples collected in 2007 and 2008. The VOC detections included three chlorinated VOCs (chlorobenzene, chloroethane, and dichlorodifluoromethane) and 14 non-chlorinated VOCs (acetone, benzene, n-butylbenzene, carbon disulfide, ethylbenzene, hexane, isopropyl benzene, n-propylbenzene, o-xylene, p-isopropyl toluene, sec-butylbenzene, tert-butylbenzene, toluene, and total xylenes). The detections were all relatively low (i.e., less than 20 µg/L) and were distributed in wells located around the former tank farms in the Lease Parcel and AOC-11.

SVOCs. Twenty-two SVOCs were detected in one or more groundwater samples from all wells monitored in 2007 and 2008. The SVOC detections included 15 PAHs (acenaphthene, acenaphthylene, anthracene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i)perylene, benzo(k)fluoranthene, chrysene, fluoranthene, fluorene, indeno(1,2,3-c,d)pyrene, naphthalene, phenanthrene, and pyrene) and 7 other SVOCs (2,4-dimethylphenol, 2-methyl naphthalene, 2-methylphenol, bis(2-ethylhexyl) phthalate, dibenzofuran, diethyl phthalate, and phenol). Low-level PAH detections were widespread but intermittent in groundwater at the Site. One or more of the PAH compounds have been detected in all the wells monitored with the exception of CP-115B. Some of the PAHs such as naphthalene are distributed across the Site; Figure 14 shows naphthalene concentrations in shallow groundwater in 2008. Other PAHs occur at limited and scattered locations. Figures 15 and 16 depict examples of a typical PAH occurrences (chrysene) in shallow and deep Site groundwater. The other seven SVOCs detections were infrequent and localized.

PCBs. Aroclor 1260 was detected in one Shallow Aquifer monitoring well (PNO-MW06A) at a concentration of 0.016 µg/L in March 2008. PCBs were not detected in any other groundwater samples collected at the Site in 2007 or 2008.

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[3] Although diesel-range hydrocarbons were not detected in the monitoring wells sampled during the 2007 and 2008 monitoring events, not all wells were monitored. The removal of certain wells from the monitoring program was approved by Ecology. Diesel was detected prior to 2007 in several deep monitoring wells, including wells CP_106B and CP_203B.

5.0 CONCEPTUAL SITE MODEL

This section provides a summary of the CSM for the Site, including identifying and describing the potentially completed and complete exposure pathways.

Figure 17 presents the CSM for the Site that summarizes the sources of contamination, potential routes of exposure, and potential receptors. The CSM is based on the current and future industrial land use, the soil and groundwater sampling results, and the active and potentially active fate and transport mechanisms.

5.1 Contaminant Sources

Tank Farm Lease Parcel. The primary source of contamination at the Site is the Tank Farm and associated operations. A number of documented releases have occurred, including two large releases of petroleum hydrocarbons in 1978 (420,000 gallons of Bunker C) and 1980 (up to 113,000 gallons of oil). In both of these cases, the oil was contained within the tank farm by the concrete dikes and the oil and impacted soil removed to the extent practicable. A number of smaller releases of petroleum products and/or oily water have been documented, ranging in size from several hundred gallons to 20,000 gallons. In all cases, these documented releases were reported to be cleaned up.

No releases were documented at the Lease Parcel prior to 1971, although historical unreported releases are suspected. Periodic releases of oily liquids have reportedly occurred at the Lease Parcel since the 1930s and there are historical photographs and documents indicating that the tank yards were contaminated when Chempro began operations in 1971.

Other Source Areas. There are three other potential sources of contamination located within the Site, but outside the Lease Parcel, which are addressed in the FS:

- **SWMU 30 –** This SMWU is the location of a pipeline break that occurred in 1989 near the north end of Pier 91 (Figure 4). An estimated 340 to 1,370 gallons of product were released before the pipeline was repaired. A product recovery system was installed and operated between 1991 and 1994 and recovered a total of 76 gallons. Passive product recovery (i.e., bailing) continued after 1994 with limited amounts of product recovered.
- **AOC 11 –** AOC 11 was a former tank farm located west of the Lease Parcel (Figure 4). The former tank farm in AOC 11 was reportedly active between 1927 and 1942 and used to store a variety of petroleum products, including gasoline and oil. The AOC 11 tank farm was reportedly demolished after the United States Department of the Navy took over the site in December, 1942. There are no documented releases from the AOC 11 tank farm.
- **Former Fuel Transfer Pipelines –** Over the history of the site, petroleum and other materials were transferred between ships at Piers 90 and 91, the tank farms, and waste management areas located within the Site, typically via above and belowground pipelines. Figure 6 shows the portions of the site where above or belowground pipeline corridors were (and in some cases still are) located.

5.2 Exposure Pathways and Receptors

The CSM shown in Figure 17 identifies the potentially complete exposure pathways and the potential receptors for the Site for both soil and groundwater.

Soil. Three potentially complete exposure pathways related to soil were identified: (1) direct contact with soil by utility or construction workers; (2) soil to indoor air; and (3) soil to groundwater (which ultimately may impact aquatic receptors). The approach to addressing each of these three pathways is summarized below.

- **Direct Soil Contact.** Direct soil contact by workers (or trespassers) was not retained as a pathway of concern for the Site because soils are currently covered by pavement or buildings. If any future excavation or underground utility work takes place, workers could potentially be exposed to soil, and direct contact with soil would become a pathway of concern. However, institutional controls and standard worker health and safety procedures will be implemented and would provide adequate protection in such instances.

- **Soil to Indoor Air.** This pathway is only potentially applicable at the tank farm, and possibly in areas immediately adjacent to the tank farm. Previous studies (PSC, 2002; PIONEER, 2004) have documented that there are no unacceptable current risks. The only potential future exposures via this pathway would result from future Site development activities. The approach for addressing these potential future exposures will be to implement institutional controls, such as notices on parcel deeds of the potentially impacted properties that require either: (1) use of engineering controls (e.g., vapor barriers, sub-slab venting systems) in Site development plans to mitigate the potential exposure; or (2) conducting a development-specific evaluation of the soil to indoor air pathway (i.e., developing risk-based CULs for the specific-potential exposures related to the proposed development) and implementing remedial actions and/or engineering controls if development specific CULs are exceeded).

- **Soil to Groundwater.** As with the soil to indoor air pathway, the soil to groundwater pathway is only potentially applicable to the tank farm and immediately adjacent areas, generally coinciding with areas where LNAPLs have been observed. The soil to groundwater pathway was evaluated consistent with WAC 173-340-747, which states that concentrations of hazardous substances in soil shall not cause contamination of groundwater at levels that exceed groundwater CULs. This demonstration requires that two criteria be met at the Site:

    - **Soil concentrations shall not cause an exceedance of groundwater CULs.** The potential for soil causing an exceedance of groundwater CULs was evaluated empirically by comparing groundwater concentrations to CULs at the standard point of compliance (SPOC) or conditional POC (CPOC). If groundwater concentrations are below the CULs, then by definition, the concentrations of IHSs in soil are not causing exceedances of groundwater CULs. Conversely, if groundwater concentrations at the POC exceed CULs, then soil to groundwater CULs will be developed for those constituents at that time.

- **Soil concentrations shall not result in the accumulation of LNAPL on or in the groundwater.** The potential for accumulation of LNAPL was evaluated through development of site-specific RSSLs. RSSLs are an estimate of the maximum residual soil concentrations at which LNAPL will not accumulate on or in groundwater and are based on site specific factors such as soil type and contaminant characteristics.

Groundwater. Two potentially complete exposure pathways related to groundwater were identified: (1) groundwater to indoor air; and (2) groundwater to surface water/sediment.

- **Groundwater to Indoor Air.** As noted above, inhalation of indoor air impacted by vapor intrusion from groundwater does not represent an unacceptable risk to workers at the Site under current conditions (PSC 2001, 2002; PIONEER, 2004). However, this remains a potentially-complete exposure pathway for the Site and could be of concern for future commercial land-use scenarios.

- **Groundwater to Surface Water/Sediment.** These pathways are the primary pathways of concern for the Site. Impacted groundwater from the Site could be released to Elliott Bay via the groundwater to surface water pathway and/or groundwater to sediment pathway, potentially resulting in exposure to aquatic receptors (i.e., fish or invertebrates), or to people consuming seafood collected from Elliott Bay.

5.3 Terrestrial Ecological Exclusion

An assessment of Site conditions was performed in order to determine the need for a terrestrial ecological evaluation under WAC 173-340-7490. The Site qualifies for an exclusion from the terrestrial ecological evaluation process, as documented in BDR1 (Roth Consulting, 2001), which was approved by Ecology in a letter dated May 30, 2002 (Ecology, 2002).

6.0 CLEANUP STANDARDS

This section summarizes the development of cleanup standards for the Site per MTCA requirements. Cleanup standards, as explained in WAC 173-340-700 (3), consist of the following:

a) CULs for hazardous substances present at the Site;

b) The location where these CULs must be met (i.e., the POC); and

c) Other regulatory requirements that apply to the Site because of the type of action and/or location of the Site (i.e., applicable state, local, and federal laws).

The approach to developing CULs for the Site consisted of the following steps:

- Selection of IHSs;
- Development of CULs; and
- Selection of the point(s) of compliance.

As described above, most of the potentially applicable soil exposure pathways (e.g., direct contact, soil to indoor air) are either not currently complete or do not currently present a risk. As a result, IHSs were not identified for soil and no risk-based CULs were developed for soil related exposure pathways. Potential future risks associated with these soil-related pathways are addressed through implementation of engineering and institutional controls. The portion of the soil to groundwater pathway related to preventing accumulation of LNAPL in the groundwater is a potentially complete pathway, and the RSSLs developed for the Site were evaluated for use as remediation levels.

6.1 Selection of Indicator Hazardous Substances

Cleanup levels were developed for constituents in groundwater that could potentially contribute significantly to human health or ecological risks. Under MTCA, these constituents are considered IHSs. IHSs were identified for the Site according to the guidelines provided in WAC 173-340-703, which allows those constituents that do not contribute significantly to the risk associated with a Site to be eliminated from further consideration. Constituents that contributed only a small percentage to the risk were identified and screened from further evaluation based on the following criteria:

- The frequency that a specific constituent occurred in groundwater;
- The geographic distribution of detections for that constituent;
- The magnitude of the concentration for that constituent; and
- The constituent's chemical/physical properties (e.g., persistence in the environment, toxicity to humans or aquatic organisms, and the potential to bioaccumulate).

Initially, the frequency of detection for each constituent was calculated for the entire groundwater data set, which was comprised of sampling rounds from 2000 to 2007. In general, constituents that were never detected, or detected in less than five percent of the samples, were eliminated from further consideration. In some cases, if the detections of infrequently detected constituents were geographically clustered (i.e., adjacent to one another), or were detected at an especially high concentration, they were retained for further evaluation. If the maximum detected value was greater than the 75th percentile plus three times the IQR, then the constituent was retained for further consideration. Constituents that were detected in more than five percent of the samples were automatically retained as IHSs. See *Terminal 91 Tanks Farm Site Feasibility Study Cleanup Levels* (FS CUL Memorandum; PIONEER, 2008) for detailed discussion of this IHS screening process. See Table 7-1 of the FS Report for a complete list of IHSs and the rationale for excluding certain constituents.

Area background groundwater concentrations were based on analytical results from five on-site wells and five upland wells (Figure 18). The analytical results were combined to calculate the area background concentrations for inorganics, based on the decision rule presented in WAC 173-340-709. See *Background Groundwater Evaluation* (PIONEER, 2007) for a detailed discussion. Based on this evaluation, arsenic concentrations found on the Site were determined as area background. Ecology concurred with this conclusion, and arsenic was not considered in the development of CULs.

6.2 Determination of Cleanup Levels

Human health and ecological CULs were developed for the following complete exposure pathways, identified in the CSM: (1) groundwater to indoor air; (2) groundwater to surface water; and (3) groundwater to sediment. CULs were based on the protection of indoor air, surface water, and sediment quality according to MTCA requirements (WAC 173-340-750, WAC 173-340-730, and WAC 173-204, respectively). A detailed description of the derivation of human health and ecological CULs is presented in the FS CUL Memorandum (PIONEER, 2008). Table 3 presents final CULs for shallow groundwater and Table 4 presents final CULs for deep groundwater.

The RSSLs developed for the Site are included as potential remediation levels.

6.2.1 Human Health Cleanup Levels

Groundwater Cleanup Levels Based on Protection of Indoor Air. Groundwater CULs protective of indoor air quality were calculated to address the groundwater to indoor air pathway. MTCA Method C (WAC 173-340-750 (4)) CULs for indoor air were derived and the groundwater CULs were then calculated by dividing the indoor air CULs by groundwater to indoor air attenuation factors developed based on the EPA's Johnson and Ettinger Model. A hazard quotient (HQ) of one was used for calculating noncarcinogenic CULs. The target risk used for calculating carcinogenic CULs was 1×10^{-5}.

Groundwater Cleanup Levels Based on Protection of Surface Water and Sediment. Human health CULs were developed to protect people who may consume seafood from Elliott Bay (including Asian Pacific Islander [API] Fisher) in the vicinity of the Site, in accordance with WAC 173-340-730. Human health CULs were based on surface water CULs, assuming no dilution from groundwater to surface water. MTCA Method B CULs were derived for surface water based on protection of human health. In addition, modified exposure parameters were used for the API Fisher population, consistent with the MTCA Science Advisory Board recommendations. An HQ of one was used for calculating the noncarcinogenic CULs. The target risk used for calculating carcinogenic CULs was $1x\ 10^{-6}$. Groundwater CULs based on protection of surface water were considered applicable to both Shallow Aquifer and Deep Confined Aquifer groundwater.

6.2.2 Ecological Cleanup Levels

Ecological CULs were based on surface water CULs, assuming no dilution from groundwater to surface water and were developed to protect aquatic organisms that may be exposed to surface water and sediment in Elliott Bay, which may be potentially impacted by groundwater from the Site. These CULs were identified based on:

- Washington State Water Quality Standards (WAC 173-201A);
- Federal Ambient Water Quality Criteria (Section 304 CWA);
- National Toxics Rule (40 CFR 131); and
- Environmental Effects. Where there were no existing standards or criteria for IHSs, groundwater CULs were derived from concentrations that would likely result in no or minimal adverse effects to aquatic organisms (including benthic invertebrates).

6.3 RSSLs

Final RSSLs were developed using Site-specific soil physical property data and LNAPL characteristic data collected in the first data gaps investigation. RSSLs were developed for toluene, gasoline, middle distillate petroleum products (diesel range), and fuel oil. The MTCA four-phase partitioning model spreadsheets were used to develop the revised toluene RSSL, and Ecology and other published industry references were used to develop the revised RSSLs for gasoline, middle distillate petroleum products, and fuel oil. The final RSSL ranges are as follows:

- For fuel oils, the calculated RSSL range was 8,727 to 30,000 mg/kg;
- For middle distillate petroleum products, the calculated RSSL range was 3,879 to 13,333 mg/kg;
- For gasoline, the calculated RSSL range was 1,636 to 5,625 mg/kg; and
- For toluene, the calculated RSSL was 832 mg/kg.

The lower end of the ranges represents product in coarse sand and gravel, while the upper end of the ranges represents product in fine to medium sand.

6.4 Groundwater Point of Compliance

As defined in the MTCA regulations, a POC is the point or points at which CULs must be attained. MTCA defines both an SPOC and a CPOC. The groundwater SPOC, as described in

WAC 173-340-720(8)(b), includes all groundwater within the saturated zone beneath the Site and in any area affected by releases from the Site. A CPOC is used at the Site when it can be demonstrated under WAC 173-340-350 through 173-340-390 that it is not practicable to meet the CULs at the SPOC throughout the Site within a reasonable restoration timeframe.

As discussed below, IHSs are present at concentrations above CULs at a number of SPOC wells, primarily in and adjacent to the source areas in the interior portions of the Site. As a result of these exceedances, CPOC wells are proposed and evaluated. The demonstration of the practicability of achieving CULs at the SPOC (i.e., throughout the Site), and the appropriateness of using a CPOC, were made during the development and evaluation of cleanup alternatives discussed below. The SPOC and CPOC wells for the Site are shown in Figure 18.

6.5 Areas Exceeding Groundwater Cleanup Levels

Groundwater data collected from monitoring wells at the Site were compared to the final FS CULs to determine whether the Site detected groundwater concentrations exceeded final FS CULs at the POC.

6.5.1 Standard Points of Compliance

The SPOC includes all wells located within the Site boundaries. To determine whether groundwater data exceeded the final FS CULs at the Site, the IHS groundwater concentrations in each well were compared to final FS CULs. Locations of SPOC wells are shown in Figure 18. For shallow groundwater, maximum detected IHS concentrations in shallow groundwater exceeded final FS CULs in 15 wells. The locations of these wells are presented in Figure 19. Wells with PAH, diesel, or gasoline concentrations exceeding the final FS CULs were concentrated around the former tank farm, SWMU-30, and AOC-11.

Maximum detected IHS concentrations in deep groundwater exceeded final FS CULs in seven wells. The locations of these wells are presented in Figure 20. The main IHSs exceeding final FS CULs were PAHs, diesel, and gasoline. As with the shallow aquifer, wells with PAH, diesel, or gasoline concentrations exceeding the final FS CULs were clustered around the Lease Parcel.

6.5.2 Conditional Points of Compliance

Because there were exceedances of the final FS CULs at the SPOCs within the Site, compliance at CPOCs was evaluated. Under WAC 173-340-720(8)(c), Ecology may approve use of a CPOC if it can be demonstrated that it is impracticable to meet CULS at the SPOC in a reasonable timeframe; this demonstration is made in Sections 10 and 11 of the FS report. Groundwater final FS CULs must be met at the CPOC, and in areas downgradient of the CPOC.

Four shallow groundwater wells and two deep groundwater wells are proposed CPOC wells (Figure 18). These CPOC wells are the wells closest to potential discharge points on Elliott Bay. There were no IHSs detected in CPOC wells exceeding final FS CULs in shallow or deep wells.

6.6 Areas Exceeding RSSLs

The final RSSLs listed above were compared to the results from the 250 soil samples analyzed during the three phases of the data gaps investigation. For the purposes of this comparison, the fuel oil RSSL is compared to motor oil range TPH concentrations at the Site, and the middle distillate petroleum product RSSL is compared to diesel range TPH concentrations. Figures 21 through 23 highlight soil borings with samples that exceeded the RSSLs for both the individual TPH fractions and for total TPH (i.e., the sum of the gasoline, diesel, and motor oil ranges). The greatest number of samples with TPH concentrations greater than RSSLs is located in and around the Lease Parcel. These samples are largely distributed across the vadose zone and smear zone sample depths, although there are also some exceedances in the saturated zone. The toluene RSSL is exceeded in only two smear zone samples in the Small Yard.

The other areas of the Site (AOC 11 and SMWU-30) have only a few smear zone soil samples with TPH concentrations greater than RSSLs. The data gaps investigation in AOC 11 identified only a single sample in one soil boring that exceeded an individual TPH-range RSSL, in this case the RSSL for gasoline. None of the monitoring wells in AOC 11 had measurable LNAPL in 2008. With respect to SMWU-30, there were two borings each with one sample that exceeded the diesel-range TPH RSSL in the smear zone and one well that had measurable LNAPL in 2008.

6.7 Regulatory Requirements

Cleanup actions must comply with applicable local, state, and federal laws as required by WAC 360(2)(a)(iii); WAC 173-340-710; RCW 70.105D.090. In certain cases, obtaining a permit is required. In other cases, the cleanup action must comply with the substantive requirements of the law but is exempt from the procedural requirements of the law (RCW 70.105D.090; WAC 173-340-710(9)).

6.7.1 Model Toxics Control Act

Ecology's MTCA regulations were the primary regulations used to guide the performance of the FS. Specifically, the FS was conducted following the procedures outlined in WAC 173-340-350. The 1998 AO was issued pursuant to MTCA and the Port's corrective action obligations under the 1998 AO are enforceable conditions of the dangerous waste management permit issued pursuant to Washington Dangerous Waste Regulations.

6.7.2 Washington Dangerous Waste Regulations

Corrective Action Requirements. Activities associated with the former tank farm included the treatment and storage or dangerous wastes, which are regulated under Chapter 70.105 RCW, the Hazardous Waste Management Act of 1976, as amended, and regulations codified in WAC 173-303. Pursuant to these regulations, Ecology issued Permit No. WAD000812917 on August 26, 1992 to the Port, requiring corrective action at the Terminal 91 Complex.

Ecology is requiring that the Port fulfill corrective action responsibilities for the facility, as defined by WAC 173-303-040, using the MTCA regulations as well as the Dangerous Waste Regulations (WAC 173-303 and specifically WAC 173-303-646). The corrective actions taken must meet or exceed all substantive corrective action requirements of the state Hazardous Waste Management Act, and Dangerous Waste Regulations as well as RCRA.

Dangerous Waste Management Requirements. The Dangerous Waste Regulations provide the framework for how to manage the various wastes, debris, and environmental media generated during cleanup actions at the Site. The approach to managing impacted environmental media (e.g., soil, groundwater) and debris (e.g., concrete and steel associated with the former tank farm) that may be generated during cleanup actions is complicated by the range of both dangerous and non-dangerous wastes managed throughout the Lease Parcel, and by the status of the Lease Parcel as a permitted facility. Discussions between the Port and Ecology have lead to the development of two memoranda that provide guidance on this subject:

- *Guidance for Waste Designation Procedures at Terminal 91* (See Appendix B); and
- *Management of the Port of Seattle's T-91 Facility's Tank Farm Site Subsurface Debris* (Appendix B).

6.7.3 Applicable Local, State, and Federal Laws

As noted above, MTCA's threshold requirements listed in WAC 173-340-360(2) include the requirement to "comply with applicable state and federal laws," which are further defined in WAC 173-340-710. The following Federal and Washington State laws and their associated regulations may be applicable to the CAAs developed for the Site:

- **Federal Clean Water Act; (33 U.S.C. §1251 et seq)** contains standards protective of human health and aquatic life. Specific portions of the Clean Water Act applicable to the Site include:
    - Ambient Water Quality Standards (Section 304); and
    - Standards issued under the National Toxics Rule (40 CFR 131).
- **Washington Water Well Construction Regulations (WAC 173-160)** establish state standards for installing, maintaining, and decommissioning groundwater monitoring and recovery wells.
- **Washington Ground Water Quality Standards (WAC 173-201)** establish standards to protect groundwater quality (e.g., maximum contaminant levels [MCLs]) and beneficial uses.
- **Washington State Sediment Management Standards (WAC 1732-204)** establish sediment quality standards protective of aquatic life.

- **Washington Surface Water Quality Standards (WAC 173-201A)** are applicable to surface waters of the state, are protective of aquatic life and other beneficial uses, and could be applicable if an alternative includes discharge of treated water.

- **Washington State NPDES Program Regulations (WAC 173-220)** could be applicable for discharge to surface waters under a National Pollutant Discharge Elimination System (NPDES) permit.

- **Washington Dangerous Waste Regulations (WAC 173-303)** establish procedures and standards related to the definition, management, and disposal of dangerous wastes. The Dangerous Waste Management Permit and related corrective requirements are summarized in Section 8.2.2 above.

- **Washington Clean Air Act Regulations (WAC 173-400)** provide standards and procedures for managing the discharge of contaminants to the atmosphere.

- **Washington Industrial Safety and Health Act Regulations (WAC 296-62)** contain health and safety training requirements for on-site workers. They also contain permissible exposure limits for conducting work at the Site.

7.0 APPROACH TO DEVELOPING CLEANUP ACTION ALTERNATIVES

7.1 Cleanup Action Objectives

Cleanup action objectives form the basis for evaluating potential cleanup technologies and actions for the Site. CAOs are based on an evaluation of the data collected during previous investigations and on the CULs established for the Site. The focus of the CAOs is protection of human health and the environment. The CAOs for soil and groundwater focus on four primary exposure or migration pathways:

- Exposure of future subsurface construction workers to IHSs in soil, particulates, and soil vapors;
- Exposure of future workers and trespassers to IHSs in vapors originating from soil and/or groundwater via indoor air;
- Groundwater discharge to surface water and/or sediment and the subsequent potential for impacts on aquatic life or humans consuming fish; and
- The presence of LNAPL on the groundwater and/or the migration of contaminants from soil that results in the accumulation of LNAPL on groundwater.

The CULs developed for the Site and the CAOs, combined with the current concentrations of IHSs in the soil and groundwater, indicate that there are no current exposures above risk-based criteria on the Site. The first two of the above future exposure pathways (direct contact with soil and vapor migration to indoor air) will be addressed through implementation of engineering and institutional controls.

Because long-term groundwater monitoring has documented that concentrations of IHSs at the CPOC are below risk-based CULs, the third exposure pathway (groundwater discharge to surface water and sediment) does not appear to present a current risk to human health and the environment. Furthermore, the *Monitored Natural Attenuation Evaluation, Final Technical Memorandum* (PES et al., 2006c) documented that naturally occurring attenuation mechanisms have resulted in stable plumes of petroleum-related compounds originating in the tank farm, SMWU 30, and other potential sources; and CULs are likely to continue to be met in the future at the CPOC. As a result, the groundwater to surface water/sediment pathway will be addressed by implementation of an MNA program at the Site.

With the first three pathways being addressed by the presumptive actions described above, the final pathway (LNAPL accumulation on groundwater or the potential migration of LNAPL from soil to groundwater) was the primary focus for the development of the CAA and evaluation process.

7.2 Approach to Developing Cleanup Action Alternatives

As described in Section 7.1, the majority of the potential exposure pathways are addressed using presumptive response actions (i.e., engineering controls, institutional controls, and MNA). The cleanup actions associated with the presumptive response actions, including the rationale for selecting these actions, are described in Section 8.1.

The remaining parts of the Site not addressed by these presumptive cleanup actions are the Lease Parcel and other contaminant source areas. Section 5.1.1 identified the contaminant sources at the Site, with the Lease Parcel and immediately adjacent areas being by far the most significant source areas. Secondary sources identified within the Site boundaries included SWMU 30, AOC 11, and the former fuel transfer pipelines. Compared to the Lease Parcel, these secondary sources are much smaller in size, contain fewer types of contaminants, and have much less contaminant mass associated with them. Given the relative simplicity of these secondary sources, evaluating a range of alternatives for each was not warranted, and specified cleanup actions were developed for each to effectively eliminate these as potential long-term contaminant sources. These secondary source cleanup actions were included in the presumptive actions described below.

For the Lease Parcel and adjacent areas, addressing the CAOs associated with preventing LNAPL accumulation on groundwater and/or the potential migration of LNAPL from soil to groundwater (i.e., source control) was the primary focus of the CAA development process described in the FS. The combination of the presumptive cleanup actions and one of the CAAs developed for the Lease Parcel constituted the overall cleanup action for the Site.

8.0 DESCRIPTION OF SELECTED CLEANUP ACTION ALTERNATIVE

As noted above, the final CAA for the Site consists of two major components: (1) the presumptive cleanup actions that address areas outside the Lease Parcel and adjacent areas and (2) the CAA for the Lease Parcel.

8.1 Presumptive Cleanup Actions

A series of presumptive cleanup actions were identified to address the following aspects of the Site:

- Preventing exposure via direct contact with contaminated soil and inhalation of vapors by future subsurface workers;
- Preventing exposure of future workers and trespassers via inhalation of indoor air impacted by migration of vapors originating from contaminated soil and groundwater;
- Secondary sources; and
- Groundwater downgradient of the Lease Parcel.

8.1.1 Subsurface Worker Direct Contact and Vapor Inhalation

This pathway addresses potential future exposure of subsurface workers to IHSs in soil and groundwater via the direct contact, vapor inhalation, and particulate inhalation pathways. The cleanup action to address this potential exposure consists of the following institutional controls:

- Notice on the property deed and in operating procedures implemented by the Port notifying personnel of the potential exposure and requirements to implement standard worker health and safety procedures; and
- Requirement that qualified personnel evaluate soil and/or groundwater that may be removed as part of construction activities and manage the material consistent with applicable regulations.

These institutional controls will be included in an environmental covenant developed consistent with Ecology's Model Restrictive (Environmental) Covenant[4].

8.1.2 Indoor Air Pathway

There are no current exposures via the indoor air pathway and potential exposures via this pathway would occur only if future development activities at the Site include construction of a building or other enclosed structure over contaminated soil or groundwater. The approach for

[4] Ecology's Model Restrictive (Environmental) Covenant can be found at: www.ecy.wa.gov/programs/TCP/vcp/vcp_boilerplates/Model%20Covenant%20(Quick%20Fix)%20(2).doc

addressing the potential future exposure of workers or trespassers via the indoor air pathway is to implement land use restrictions that include the following institutional controls:

- Placing a notice in the public land records identifying the potential presence of contaminated soil and/or groundwater;

- Requiring that one of the following approaches be taken to address the potential exposure:

  (1) Include engineering controls (e.g., vapor barriers, sub-slab venting systems) in Site development plans to prevent the potential exposure; or

  (2) Conduct a development-specific evaluation of the soil/groundwater to indoor air pathway (i.e., developing risk-based CULs for the specific potential exposures related to the proposed development).

If concentrations of IHSs exceed the CULs developed under the second option, appropriate supplemental remedial actions will be evaluated and implemented or engineering controls implemented, as appropriate.

8.1.3 Secondary Source Area Actions

The three secondary source areas within the Site are SWMU 30, AOC 11, and the former fuel transfer pipelines. The approach for addressing each of these is described below.

SWMU 30. The presumptive remedy for SMWU 30 includes excavating two areas with evidence of LNAPL to a depth of 9 to 12 ft (see Figure 24), totaling approximately 4,300 square feet (sq ft) and approximately 1,000 cubic yards. The LNAPL and TPH-impacted soil will be stockpiled and profiled for off-site disposal at an approved facility. As part of the excavation, three monitoring wells (PNO-MW-03, PNO-MW-102, and PNO-EW-1) will be decommissioned. Removal of the observed LNAPL source and soil exceeding the RSSLs will greatly reduce the potential for SWMU 30 to cause future exceedances of CULs at the CPOC. The capital costs associated with the proposed SWMU 30 actions are summarized in Table 5 and total $260,000.

AOC 11. Given that none of the monitoring wells in AOC 11 had measurable LNAPL in 2008, that downgradient CPOC well CP_GP14 is below CULs, and the lack of any LNAPL or extensive areas of significant soil contamination that may lead to future LNAPL accumulation, aggressive source removal actions similar to those proposed for SWMU 30 do not appear warranted for AOC 11. The absence of a current LNAPL source is not unexpected given that the AOC 11 tank farm was only operational for 15 years and was demolished over 75 years ago. As a result, the approach for addressing the residual contamination present in AOC 11 will be incorporated into the MNA approach described below.

Former Fuel Transfer Pipelines. A number of subsurface fuel and wastewater transfer pipelines running between the Lease Parcel and Piers 90 and 91 remain in place (Figure 6). Although some of these remaining pipelines have been recently cleaned or otherwise decommissioned in place and in some cases removed, there may be pipelines that remain in place that have not been cleaned and could contain residual petroleum products. To prevent residual product in the remaining pipelines from becoming a future LNAPL source, the following actions are proposed:

- Prepare an inventory of pipelines known to be remaining in place that have not been properly cleaned and abandoned; and
- Develop and implement a plan to clean and abandon in place the identified pipelines. This plan will include specific procedures for characterizing and managing residual materials in the pipelines, cleaning and decommissioning techniques, and reporting and documentation requirements. Unless a pipeline needs to be physically removed for development reasons, it is assumed that all pipelines will be cleaned and decommissioned in place. This plan also will identify procedures for handling currently unidentified pipelines that may be discovered in the future during maintenance or site development activities.

Although the exact lineal footage of pipelines remaining is unknown, available information suggests that there could be as much as 22,000 ft of pipelines in and around the Lease Parcel and extending to the piers.

8.1.4 Groundwater Downgradient of Lease Parcel

As described in detail in the FS, achieving CULs at the groundwater SPOC is not practicable or technically feasible at the Site. Therefore, consistent with WAC 173-340-720(8)(c), CPOC wells were established for the Site, and monitoring has documented that IHS concentrations in groundwater downgradient of the Lease Parcel are below CULs at the CPOC. The effectiveness of MNA at achieving and maintaining compliance with the CULs was evaluated and documented consistent with Ecology protocols (PES, 2006a). Therefore, groundwater downgradient of the Lease Parcel will be addressed using MNA.

The Port proposes to implement an MNA program consistent with Ecology's MNA guidance document (Ecology, 2005a and 2005b). To monitor both the primary and secondary sources at the Site, wells along the three flowpaths monitored during the MNA evaluation (PES, 2006a) would be included in the program (Figure 25). A well (or wells) upgradient of the Lease Parcel tank farms will be included to confirm the background water quality over time, a well or wells representative of the tank farm source water quality will be included to determine changes in the source area water quality, and wells along the Pier 90, Pier 91, and AOC 11 flowpaths will be included to determine plume water quality and sentinel well water quality. If additional wells are needed to monitor the source area post remediation, or if wells at the site are damaged, the Port will notify Ecology.

8.2 Selected Lease Parcel CAA: Alternative 4 – Containment, Subsurface Structure Removal, and Enhanced LNAPL Recovery

Based on the development and evaluation of the CAAs developed for the Lease Parcel presented in the FS report, Alternative 4 was selected for implementation at the Site. Alternative 4's primary objective is to prevent migration of LNAPL from the Lease Parcel source area and to prevent future surface product seeps from occurring. This alternative includes: constructing a subsurface slurry wall around the perimeter of the former tank farm; removal of the remaining subsurface structures and tank bases that appear to be the source of the current seeps; removal of highly contaminated soil encountered during the tank bottom removal process; installing an enhanced passive LNAPL recovery system; replacing the existing asphalt paving with new asphalt paving; site drainage improvements; annual asphalt paving inspections and repair; LNAPL monitoring and passive recovery; compliance monitoring; and reporting.

The purpose of the slurry wall will be to prevent migration of LNAPL from the Lease Parcel and to prevent groundwater from flowing through the source area. Removing the existing subsurface structures and highly contaminated soil, along with replacing the asphalt paving, will prevent direct contact with impacted soils, minimize infiltration of precipitation, and effectively eliminate the potential for surface LNAPL seeps to occur. Improvements will be made to existing site drainage infrastructure to prevent stormwater from ponding on the asphalt paving. Figure 26 shows the major features of Alternative 4.

Prior to commencing the slurry wall construction activities described below, all 16 monitoring wells within the footprint of the former tank farm will be decommissioned and the existing asphalt paving will be removed and hauled off site for disposal. In addition to the pavement, all of the remaining subsurface structures, including concrete containment wall footings, steel tank bases, concrete tank bottom "floors," and other structures will be removed (Figure 26). This will require removal of all of the subgrade and fill between the existing asphalt paving and the former tank bottom floor and tank bases (approximately 6,250 cubic yards, or 9,400 tons). The steel tank bases will be decontaminated as necessary and transported off site for recycling as scrap metal.

The slurry wall will be approximately 2 ft wide and 1,550 ft long and will extend to an average depth of approximately 20 ft bgs (Figure 26). The wall will be constructed with a slurry mix based on site soil types and compatibility with site groundwater and LNAPL. The depth of the wall was established to be approximately 10 ft below the low water table to prevent migration of LNAPL and minimize contact of groundwater from outside the wall with the most impacted source material.

It is anticipated that once the existing paving and subsurface structures (including tank bases) are removed and the underlying soil exposed, there will likely be one or more areas of surface soil that are visibly and highly contaminated with petroleum (i.e., product-saturated soil). In order to minimize the potential for these soils to act as a source of future seeps, these areas of highly contaminated surface soil will be removed. It was assumed for purposes of the FS that approximately 240 tons of soil (10 areas each measuring 12 ft square and 3 ft deep) will be removed, characterized, and the soil disposed of off site.

The enhanced LNAPL recovery system will be designed to remove the recoverable LNAPL to the extent practicable using passive recovery techniques. Based on the recent LNAPL monitoring data (PES, 2008d), portions of the Lease Parcel most likely to contain recoverable LNAPL are located in the western portion of the former tank farm area and center around wells PR-07, PR-12, and UT-MW39-3. For purposes of the FS, the enhanced LNAPL recovery system involved a series of 5 trenches located in the target areas listed above (see Figure 26). These trenches would be approximately 50 to 75 ft long, 2 ft wide, and completed approximately 10 ft below the surrounding grade. Each trench would be backfilled with pea gravel, with a section of 6-inch slotted pipe running the length of the trench installed at average low water table elevation. At both ends of the trench, a cleanout well will be installed. These wells would be completed to the bottom of the trench and also connected to the slotted pipe within the trench. As LNAPL collects within the gravel backfill and the slotted piping and cleanout wells, it would be removed either by bailing or pumping depending on the quantity of LNAPL present.

Once the slurry wall and asphalt paving have been installed, ongoing O&M activities associated with Alternative 4 include annual asphalt paving inspections and maintenance, LNAPL recovery and monitoring, compliance groundwater monitoring, and reporting. The enhanced LNAPL recovery system is assumed to be operated and maintained on a monthly basis for three years, bimonthly for an additional two years, and quarterly for five years (10 years total operation period). Recovered LNAPL and water will be disposed of as required. In addition to the operation of the enhanced LNAPL recovery system, O&M activities will include annual asphalt paving inspections and maintenance, LNAPL monitoring and passive recovery outside the area of influence of the enhanced LNAPL recovery system, compliance groundwater monitoring, and reporting.

8.3 Summary of Costs for Selected Cleanup Actions

The total capital costs for implementing the presumptive actions are $930,000 and includes developing and implementing institutional controls; excavating LNAPL source areas at SWMU 30; inventorying, cleaning, and abandoning remaining subsurface pipelines; and developing the MNA plan and installing the required additional monitoring wells. The only estimable long-term O&M cost associated with these actions is the monitoring and reporting that make up the MNA program. The NPV of these monitoring and reporting costs over a 30-year timeframe is $450,000. The total estimated cost for implementing these presumptive cleanup actions is approximately $1,380,000.

The estimated capital costs for Alternative 4 are approximately $2,690,000. Annual O&M costs are estimated to range from approximately $60,000 to $70,000 per year depending on the frequency of LNAPL recovery efforts, and the NPV of the O&M activities for a 30-year time period is approximately $1,190,000. The total estimated present worth costs for Alternative 4 are $3,880,000 (Table 6).

The total estimated cost for implementing the selected cleanup action is $5,260,000.

8.4 Other Lease Parcel CAAs Considered

In addition to the selected CAA described above, five other CAAs were evaluated for the Lease Parcel. These other alternatives are described in detail in the FS Report and summarized briefly below.

8.4.1 Alternative 1 – Existing Asphalt Paving Maintenance and Monitoring

Alternative 1 was the baseline option against which the other alternatives were compared and consists of maintaining the existing asphalt paving in place over the former tank farm, LNAPL monitoring in select wells, and long-term compliance monitoring of groundwater.

8.4.2 Alternative 2 – Containment and Passive LNAPL Recovery

Alternative 2 included constructing a subsurface slurry wall around the perimeter of the former tank farm, replacing the existing asphalt paving with a composite cap (cap) consisting of new asphalt paving and underlying geomembrane, site drainage improvements, annual cap inspections and repair, LNAPL monitoring and passive recovery, compliance monitoring, and reporting. The purpose of the slurry wall was to prevent migration of LNAPL from the Lease Parcel and to prevent groundwater from flowing through the source area. The new composite cap would have prevented direct contact with impacted soils, minimize infiltration of precipitation, and effectively eliminate the potential for surface LNAPL seeps to occur. A majority of the existing subsurface structures/soil would have been left in place. Improvements would have been made to existing site drainage infrastructure to prevent stormwater from ponding on the cap.

8.4.3 Alternative 3 – Active LNAPL Recovery and Subsurface Structure Removal

Alternative 3 is similar to Alternative 2 in that its primary objective was to prevent migration of LNAPL from the Lease Parcel source area and prevent future product seeps from occurring on the asphalt paving, but it achieved those objectives using different approaches. To address LNAPL, Alternative 3 included a vacuum-enhanced LNAPL recovery system while surface seeps were addressed by removing all of the remaining subsurface structures and tank bases that appear to be the source of the current seeps. Alternative 3 also included new asphalt paving to prevent direct contact with impacted soils and prevent infiltration of precipitation.

8.4.4 Alternative 5 - Limited Excavation of LNAPL Areas

The primary component of Alternative 5 was the removal of the LNAPL source areas in and near the Lease Parcel through excavation and disposal of impacted soil in areas where LNAPL has been observed. The excavation would have extended to approximately 3 ft below the low water table, about 10.5 ft bgs after removing the paving, subgrade material, and remaining tank farm concrete. By excavating soils to this depth, the entire “smear zone” and the top of the saturated zone, where most if not all of the LNAPL is expected to be present, would have been removed. The lateral extent of the excavations was based on currently available information regarding the presence of LNAPL in the Lease Parcel and immediately surrounding areas. This approach would have resulted in approximately 12,700 cubic yards, or 19,000 tons, of soil being excavated. Soil would either be direct-loaded into trucks for transportation off site if sufficient data existed to characterize the soil, or stockpiled on site for characterization prior to disposal.

Other components of this alternative included removal of the existing asphalt paving and all remaining above ground and subsurface structures in the former tank farm, backfilling the excavation area with clean soil, constructing new asphalt paving, and installing new monitoring wells.

8.4.5 Alternative 6 – Excavation of Soils Exceeding RSSLs

Alternative 6 was very similar to Alternative 5 (i.e., source area excavation), except that the boundaries of the excavation were defined by two factors: (1) the areas where LNAPL has been observed as in Alternative 5; and (2) areas where soil contains petroleum hydrocarbons at concentrations exceeding RSSLs. In most cases, the areas exceeding the RSSLs includes all of the areas included in Alternative 5 plus additional soil where LNAPL has not been observed but soil sampling results show TPH concentrations above the RSSLs. For Alternative 6, the excavation of soil to a depth of 10.5 ft would remove approximately 21,500 cubic yards, or 32,300 tons, of soil.

9.0 JUSTIFICATION FOR SELECTED CLEANUP ACTION ALTERNATIVE

Because the final cleanup action for the Site consists of two components – the presumptive cleanup actions and the Lease Parcel Cleanup Action – the analysis of the cleanup actions was performed in two steps. First, the extent to which the presumptive cleanup actions addressed (in part or in full) the MTCA requirements listed above was evaluated. Second, the six cleanup actions for the Lease Parcel were evaluated against those requirements applicable to the Lease Parcel. Finally, the comparative evaluation of the retained remedial alternatives for each evaluation criteria was summarized and a final cleanup action selected for implementation. This detailed evaluation of the CAAs for the Site is provided in Sections 11 and 12 of the FS Report and summarized for the selected CAA below.

9.1 Evaluation of Presumptive Cleanup Actions

The majority of the objectives for the Site are addressed through presumptive actions including engineering and institutional controls, implementation of an MNA program, and controlling LNAPL at the secondary source areas. These actions are described in Section 8.1. The combined presumptive actions address the majority of the MTCA requirements for the Site, as discussed below.

9.1.1 Threshold Requirements

Protectiveness. The presumptive cleanup actions specifically address the primary exposure and migration pathways at the Site and are protective of human health and the environment. Potential future worker exposures via subsurface soil and soil vapors are controlled through engineering and institutional controls. Discharges of groundwater to surface water, which currently meet cleanup levels, will be addressed in the future through implementation of the MNA program. The presumptive cleanup actions for the secondary sources, along with the Lease Parcel Cleanup Actions, only enhance the likelihood that the protectiveness will be maintained and improved in the future.

Compliance with Cleanup Standards. The primary numeric cleanup standards for the Site are the groundwater cleanup levels described in Section 6.2, which address protection of human and aquatic receptors. The other cleanup standard applicable to the Site relates to the prevention of LNAPL from accumulating on the groundwater. Compliance with each of the two standards is discussed below.

The concentration of IHSs in groundwater are currently below cleanup levels at all CPOC wells. Implementation of the MNA program included in the presumptive cleanup actions will document that cleanup levels are met at these wells in the future.

With the exception of the LNAPL observed at SWMU 30, LNAPL (and soils with the potential to result in LNAPL accumulation) is observed primarily in and adjacent to the Lease Parcel. Therefore, the evaluation of whether this cleanup objective is met is addressed mainly by the Lease Parcel CAA. With respect to SWMU 30, the presumptive cleanup action removes the observed LNAPL around well PNO-MW102 and the soil impacted with TPH above RSSLs (Figure 24). By removing the observed LNAPL source and soil exceeding the RSSLs, the potential for SWMU 30 to cause future exceedances of the LNAPL cleanup standard is eliminated.

Compliance with Regulatory Requirements. All of the presumptive cleanup actions will comply with the applicable legal requirements, including MTCA. Off-site management and disposal of wastes will comply with the applicable solid and dangerous waste regulations.

Compliance Monitoring. The presumptive actions include a comprehensive MNA program that will be developed consistent with Ecology guidelines. Additional compliance monitoring to assess the ongoing performance of the cleanup actions and to monitor compliance with cleanup goals is included in the CAA selected for the Lease Parcel.

9.1.2 Other Requirements

Use of Permanent Solutions. As described in FS, the development of a "permanent" cleanup action for the Site is not feasible because of the severe technical challenges and associated extraordinary costs in attempting such a cleanup. Furthermore, the evaluation process for determining whether a cleanup action uses permanent solutions to maximum extent practicable defined in WAC 173-340-360(3), utilizes a disproportionate cost analysis that is not readily applicable to the use of presumptive actions. That being said, the actions for SWMU 30 and the former fuel transfer pipelines effectively and permanently remove the contaminant sources from these areas and add to the permanence of the overall cleanup action for the Site.

Restoration Time Frame. "Restoration time frame" is defined by MTCA to be the period of time needed to achieve the required cleanup levels at the POC established for the site. For the Site, the POC for groundwater was established at the CPOC wells shown in Figure 18. Groundwater monitoring results indicate that CULs are currently being met at the CPOC. The actions necessary to maintain compliance include implementation of the MNA program included in the presumptive cleanup actions. In addition, implementation of the source control actions included in the presumptive cleanup actions, as well as the Lease Parcel CAA, will help assure that IHS concentrations remain below CULs.

The FS assumes that MNA monitoring would continue for 30 years, although establishing that cleanup standards have been met may take less time, at which point monitoring can be discontinued (i.e., restoration is achieved). A restoration time frame of 20 to 30 years for the Site is considered reasonable based on an evaluation of the factors listed in WAC 173-340-360(4)(b) for determining what is considered a reasonable restoration time frame. Specifically, the Site:

- Poses a low risk to human health and the environment and what risk is present can be readily and effectively controlled through implementation of engineering and institutional controls;
- The current and potential future uses of the Site (i.e., industrial, commercial) are not significantly impacted by the Site contamination and are appropriate uses for the property;

- Existing or potential future water supplies are not affected;
- Monitoring can be effectively implemented throughout the entire site; and
- Natural processes which reduce contaminant concentrations have been documented to occur at the Site.

For these reasons, the presumptive cleanup actions (in conjunction with the Lease Parcel CAA) are considered to provide a reasonable restoration time frame for the Site.

Consider Public Concerns. Ecology has developed a Public Participation Plan (PPP; Ecology, 2010) to promote public understanding and participation in the cleanup process for this Site. As part of the activities outlined in the PPP, Ecology has solicited public comment on the RI, FS, and the 2010 AO by providing for a 45-day public comment period from February 12 through March 29, 2010. Comments received on these documents during the public comment period were considered by Ecology and ***Summarize response to comments and any changes these comments had on final CAA selection***. Ecology will continue to involve the public throughout the cleanup process, consistent with the approach presented in the PPP.

9.2 Evaluation of Selected Lease Parcel Cleanup Action Alternative

Alternative 4 was the selected alternative for the Lease Parcel and includes constructing a slurry wall around the perimeter of the former tank farm, removal of all of the remaining subsurface structures and tank bases, removal of highly contaminated surface soil, installation of an enhanced LNAPL recovery system, new asphalt paving, annual paving inspections and repair, LNAPL monitoring and passive recovery outside the enhanced LNAPL recovery system, compliance monitoring, and reporting.

The only CAOs that are not addressed by the presumptive actions relate to the Lease Parcel and include:

- Controlling, to the extent practicable, the migration of IHSs from soil to groundwater in quantities that would result in the accumulation of LNAPL on the groundwater; and
- Controlling, to the extent practicable, the accumulation of LNAPL on the groundwater.

Section 11 and 12 of the FS Report provide a detailed analysis of how Alternative 4 complies with the applicable MTCA evaluation criteria by addressing these two CAOs. This evaluation is summarized below.

9.2.1 Threshold Requirements

Protect human health and the environment. The evaluation of protection of human health and the environment for the Lease Parcel CAAs addressed the control, prevention, or elimination of product seeps through the asphalt paving placed over the former tank farm. All of the other aspects of complying with this requirement are addressed by the presumptive cleanup actions. Alternative 4 effectively eliminates the potential for product seeps through the asphalt paving by removing all of the remaining subsurface structures, including all of the remaining tank bases, as well as removing highly contaminated surface soil from the former tank farm area and constructing new asphalt paving. The enhanced LNAPL recovery system would further reduce the potential for surface seeps.

Comply with cleanup standards (WAC 173-340-700 through –760). The evaluation of compliance with cleanup standards for the Lease Parcel considered how the CAA prevents LNAPL accumulation on groundwater or migration from soil to groundwater. This evaluation criterion also evaluated the MTCA requirement that nonpermanent cleanup actions treat or remove the LNAPL sources using accepted engineering practices.

Alternative 4 addresses the cleanup standards related to LNAPL by using a combination of the enhanced LNAPL recovery system to remove recoverable LNAPL from the Lease Parcel and adjacent areas and construction of a slurry wall around the former tank farm. Outside the area affected by the enhanced LNAPL recovery system, monitoring and passive recovery activities will be used. By removing the recoverable LNAPL and surrounding the former tank farm area with a slurry wall, Alternative 4 will greatly reduce the potential for migration of LNAPL from the source area.

Alternative 4 relies in part on maintenance of the asphalt paving to minimize infiltration of precipitation and prevent or minimize the migration of LNAPL from soil to groundwater. Because all of the subsurface structures and the highly contaminated surface soil are removed in this alternative, many of the potential soil sources for LNAPL migration to groundwater are removed.

Comply with applicable state and federal laws (WAC 173-340-710). Alternative 4 complies with the applicable legal requirements, including MTCA. Off-site management and disposal of wastes will comply with the applicable solid and dangerous waste regulations.

Provide for compliance monitoring. In addition to the MNA program included in the presumptive cleanup actions, Alternative 4 includes compliance monitoring to assess the ongoing performance of the alternative and to monitor compliance with cleanup goals.

9.2.2 Other Requirements

Use permanent solutions to the maximum extent practicable. The process for determining whether a cleanup action uses permanent solutions to maximum extent practicable is defined in WAC 173-340-360(3). Since none of the alternatives, including the selected alternative, meet the definition of a permanent cleanup action contained in WAC 173-340-200 (a cleanup action where cleanup standards are met without any further cleanup actions being required), the evaluation of this criteria utilized a disproportionate cost analysis that focuses on determining which CAA provides the greatest degree of permanence [WAC 173-340-360(3)(e)(ii)(B)]. The approach for conducting the disproportionate cost analysis is described in Section 9.2.3 below.

Provide for a reasonable restoration time frame. The evaluation of this criterion focused on the time required for Alternative 4 to prevent LNAPL accumulation on groundwater or migration of LNAPL from soil to groundwater in the Lease Parcel. The use of the enhanced LNAPL recovery system in Alternative 4 will remove much of the recoverable LNAPL from the subsurface, and remove it more quickly than the passive techniques of Alternatives 1 and 2 (although potentially not as much or as quickly as the vacuum-enhanced system in Alternative 3). The slurry wall will control migration from the source immediately upon construction. For cost estimating purposes, it was assumed that active LNAPL recovery would continue for 10 years (Table 6), although it is important to note that the majority of the LNAPL recovered in this time would occur in the first several years of operation. At the end of the 10 years, there should be very little residual LNAPL remaining in the area affected by the LNAPL recovery system. Outside the area where active recovery is feasible, monitoring and passive recovery activities will be used and will continue for 30 years.

Preventing or minimizing the migration of LNAPL from soil to groundwater would happen immediately upon implementation of Alternative 4 (e.g., removal of all of the subsurface structures and the highly contaminated surface soil, new asphalt paving) and continue by maintaining the asphalt paving.

Consider public concerns. As noted above, Ecology has developed a PPP for the Site (Ecology, 2010) and solicited public comment on the RI, FS, and the 2010 AO by providing for a 45-day public comment period. Comments received on these documents during the public comment period were considered by Ecology and ***Summarize response to comments and any changes these comments had on final CAA selection.*** Ecology will continue to involve the public throughout the cleanup process consistent with the approach presented in the PPP.

9.2.3 Disproportionate Cost Analysis

The disproportionate cost evaluation used the criteria described in WAC 173-340-360(3)(f) to determine which Lease Parcel CAA is a permanent solution to the maximum extent practicable. These criteria, and how they were applied to the Lease Parcel CAAs, are:

- **Protectiveness**. This is essentially the same as the primary MTCA requirement described above.

- **Permanence**. This criterion focuses on the degree to which the alternative permanently reduces the toxicity, mobility or volume of hazardous substances. For the evaluation of the Lease Parcel CAAs, this criterion focused on the permanence of addressing the LNAPL on the groundwater and potential sources of LNAPL in soil.

- **Cost**. The overall cost to implement the alternative, including the cost of construction and the NPV of any long-term costs, was used to compare alternatives to each in the cost-benefit analysis.

- **Effectiveness over the long term**. This criterion addresses the degree of certainty that the selected alternative will be successful, the reliability of the alternative during the period of time hazardous substances are expected to remain on-site, the magnitude of residual risk with the alternative in place, and the effectiveness of controls required to manage treatment residues or remaining wastes. For the evaluation of the Lease Parcel

CAAs, the differentiating aspect of this criterion was the effectiveness and reliability of the LNAPL control and prevention actions.

- **Management of short-term risks**. This criterion addresses the risk to human health and the environment associated with the alternative during construction and implementation, and the effectiveness of measures taken to manage such risks.

- **Technical and administrative implementability**. The ability of an alternative to be implemented including the technical feasibility, availability of necessary off site facilities, administrative and regulatory requirements, access for construction operations and monitoring, and integration with existing facility operations was addressed by this criterion.

- **Consideration of public concerns**. For this evaluation, the potential for a CAA to raise public concerns was addressed.

Alternative 4 provides protection through the construction and maintenance of new asphalt paving and removing all of the remaining subsurface structures and highly contaminated surface soil. It is implementable from both a technical and an administrative standpoint and, although there are some short-term risks associated with its implementation (e.g., heavy construction activities, volatilization of VOCs); these risks can be controlled using standard worker health and safety procedures and engineering controls.

The enhanced LNAPL recovery system will permanently reduce the volume of the recoverable LNAPL at the Lease Parcel. The slurry wall constructed around the former tank farm will significantly and permanently reduce the potential migration of LNAPL from this area. Monitoring and maintenance is required to assure the long-term effectiveness of the paving and LNAPL recovery activities in these areas.

The disproportionate cost analysis was based on comparative evaluation of the Lease Parcel CAAs against the criteria listed above and is summarized in Table 7. The alternatives were ranked from the most to the least permanent solution and then compared based on cost to determine if the benefits provided by a higher cost alternative (as defined by the permanence of the alternative and its ability to meet the CAOs for the Lease Parcel) outweighed the incremental increase in cost of the alternative. The alternative providing the best balance of permanence and cost was selected for implementation along with the presumptive cleanup actions. Based on the analysis detailed in the FS and summarized in Table 7, Alternative 4 provided the best balance of permanence, the ability to meet the CAOs, and cost, and was therefore recommended for implementation.

9.3 Ecology Expectations

WAC 173-340-370 outlines a series of eight expectations that Ecology has regarding selection and implementation of cleanup actions. Selection of the overall cleanup action summarized above for the Site is consistent with these expectations in that it:

- Uses engineering controls (containment) to contain large volumes of materials where treatment is impracticable;

- Minimizes migration of hazardous substances by preventing precipitation and runoff from contacting contaminated soils and waste materials;

- Takes active measures (source control actions) to prevent releases of hazardous substances to surface waters via groundwater discharges; and

- Utilizes natural attenuation appropriately in that:

  - Source control will be conducted to the extent practicable;

  - The contaminants left in place after implementation of the cleanup action do not pose an unacceptable risk to human health and the environment;

  - There is evidence that natural biodegradation is occurring and will continue to occur at a reasonable rate; and

  - Appropriate monitoring requirements are conducted to ensure that natural attenuation processes are taking place and human health and the environment are protected.

  - Does not result in a greater overall threat to human health and the environment compared to other alternatives.

10.0 IMPLEMENTATION OF THE SELECTED CLEANUP ACTION

10.1 Implementation Approach

The final CAA for the Site consists of the presumptive actions described in Section 8.1 and Lease Parcel Alternative 4 as described in Section 8.2. This overall cleanup action will include the general steps outlined below.

- Preparation of this CAP.
- Following final approval of the CAP, initiating cleanup action design.
- Implementation of the presumptive cleanup actions including:
  - Developing and implementing institutional controls;
  - Excavating LNAPL source areas at SWMU 30;
  - Inventorying, cleaning, and abandoning remaining subsurface pipelines; and
  - Developing the MNA monitoring plan, including installing the required additional monitoring wells.
- Implementation of the Lease Parcel cleanup actions including:
  - Removing the existing asphalt paving;
  - Removing and stockpiling existing subgrade and fill, and demolishing the remaining above ground and subsurface structures;
  - Removing highly contaminated surface soil from within the Lease Parcel;
  - Constructing a slurry wall around the former tank farm area;
  - Hauling all demolished and excavated material and decontamination water off site;
  - Designing and installing the enhanced LNAPL recovery trenches;
  - Constructing new asphalt paving with associated stormwater system improvements;
  - Installing new LNAPL monitoring wells; and
  - Initiating the long-term O&M activities including operation of the enhanced LNAPL recovery system, monitoring, asphalt paving inspection and maintenance, passive LNAPL recovery, and reporting.

Following implementation of the preferred cleanup alternative, site development and facility maintenance activities that include subsurface work (e.g., excavation, boring) have the potential to discover additional contamination at the Site. This potential is recognized in the engineering and institutional controls included in the presumptive cleanup actions; these controls will ensure that future subsurface work (e.g., excavation, boring) will utilize appropriate worker health and safety procedures during the subsurface work, and that the appropriate long-term engineering controls (e.g., vapor barriers) are implemented for new developments. Potentially contaminated soil and groundwater removed during these development and maintenance activities will be managed consistent with the specific procedures contained in the Contamination Contingency Plan, which is expected to be part of the new Agreed Order for the entire Terminal 91 Complex.

10.2 Schedule

The remedy design and construction of the cleanup action will be completed in accordance with the schedule below. This schedule anticipates installation of the cleanup action during the 2012 construction season.

Cleanup Action Task	Estimated Completion Date
Finalize 2010 Agreed Order and Permit	July 2010
Public Review of Draft Cleanup Action Plan	July 2010
Finalize Cleanup Action Plan	September 2010
Negotiate Cleanup Order	October 2010
Cleanup Action Design	October 2011
Construction Bidding and Contracting	February 2012
Cleanup Action Construction	November 2012

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TABLES

Table 1

LNAPL Monitoring Data Summary
Port of SeattleTerminal 91 Cleanup Action Plan
Seattle, Washington

Location	Well	Historical Apparent Thickness Range (feet)	Maximum 2008 Apparent Thickness (feet)	Comments
Lease Parcel, Small Yard	CP-116	0.1 to 0.9	—	No LNAPL recovery since 2001. Well decommissioned in 2004.
	CP-117	0.2 to 1.1	—	Consistent/seasonal recovery until well decommissioned in 2004.
	CP-PR01	0.01 to 0.4	0.09	Pilot test well installed in 2005.
	CP-PR11	Trace to 0.01	0.01	Data gap investigation well installed in 2007.
	CP-PR12	Trace to 1.59	1.59	Data gap investigation well installed in 2007.
Lease Parcel, Marine Diesel Oil Yard	CP-118	0.1 to 1.9	—	Consistent/seasonal recovery until well decommissioned in 2004.
	CP-119	0.1 to 1.6	—	Consistent/seasonal recovery until well decommissioned in 2004.
	CP-PR02	0.01 to 0.3	0.06	Pilot test well installed in 2005.
	CP-PR07	Trace to 0.49	0.49	Data gap investigation well installed in 2007.
	CP-PR08	Trace	Not detected	Data gap investigation well installed in 2007.
Lease Parcel, Black Oil Yard	CP-109	0.2 to 1.2	—	LNAPL thickness decreased to 0.0 to 0.02 ft by 2004. Well decommissioned in 2004.
	CP-PR03	Trace to 0.01	0.01	Data gap investigation well installed in 2007.
	CP-PR04	0.01 to 0.68	0.68	Data gap investigation well installed in 2007.
Between Lease Parcel and AOC 11	CP-107	0.1 to 0.3	Not detected	
	CP-110	0.2 to 0.8	Trace	Periodically contains a PLRD.
	UT-MW39-2	Not detected	0.25 to 0.71	Well monitored between August and December 2008.
	UT-MW39-3	0.1 to 1.6	Trace to 0.99	Periodically contains a PLRD.
AOC 11	PNO-MW104	0.06 to 0.19	0.12	Typical 2008 apparent thickness was 0.01 ft.
SWMU 30	PNO-EW01	0.0 to 1.02	Not monitored	Well under concrete barriers.
	PNO-MW03	0.0 to 1.43	Not detected	Periodically contains a PLRD.
	PNO-MW06A	0.0 to 0.01	Not detected	
	PNO-MW102	0.0 to 0.80	Not detected	
	PNO-MW103	0.0 to 0.08	Not detected	

Notes:

1. Historical LNAPL thickness range is approximate and rounded to the neared 0.1 ft from historical LNAPL monitoring data.
2. PLRD = passive LNAPL recovery device.
3. — = not applicable.

Table 2
Concentrations of PCBs in Soil Samples
Port of Seattle Terminal 91 Cleanup Action Plan
Seattle, Washington

Soil Boring Number	Date Drilled	Sample Depth	Soil Saturation Status	PCBs (mg/kg) Total PCBs
DG-99	9/16/08	2.5	V	ND
		6	Sm	ND
		12	Sat	ND
DG-100	9/16/08	3	V	ND
		6	Sm	**0.42**
		10	Sat	ND
DG-101	9/17/08	3	V	**0.095**
		5.5	Sm	**0.71**
		11	Sat	ND
DG-102	9/16/08	3	V	**0.22**
		6	Sm	**0.63**
		10	Sm/Sat	ND
DG-103	9/16/08	2.5	V	ND
		5	Sm	ND
		13	Sat	ND
DG-104	9/17/08	5.5	Sm	**9.3**
		9	Sat	**0.21**
		13	Sat	**0.14**
DG-105	9/17/08	4	V/Sm	**2.04**
		7	Sm	**0.47**
		11	Sat	ND
DG-106	9/17/08	4	V/Sm	**0.76**
		8	Sm/Sat	ND
		10	Sat	ND
DG-107	9/17/08	3	V	**1.83**
		6	Sm	**0.91**
		11	Sat	ND
DG-108	9/17/08	3	V	**0.54**
		8	Sm/Sat	**0.70**
		10	Sat	ND
DG-109	9/17/08	4	V/Sm	ND
		5	Sm	ND
		10	Sat	ND
DG-110	9/17/08	4	V/Sm	**0.23**
		8	Sm/Sat	**0.345**
		9.5	Sat	ND
		11	Sat	ND
DG-111	9/18/08	3	V	**0.43**
		3 (dup)	V	**1.10**
		7	Sm	**0.557**
DG-112	9/18/08	4	V/Sm	ND
		7	Sm	ND
		7 (dup)	Sm	ND
		10	Sat	ND

Table 2
Concentrations of PCBs in Soil Samples
Port of Seattle Terminal 91 Cleanup Action Plan
Seattle, Washington

Soil Boring Number	Date Drilled	Sample Depth	Soil Saturation Status	PCBs (mg/kg)
				Total PCBs
DG-113	9/17/08	3	V	ND
		6.5	Sm	**1.58**
		10	Sat	ND
DG-114	9/17/08	5	Sm	**1.6**
		10	Sat	**0.11**
		13	Sat	ND
DG-115	9/18/08	6	Sm	**2.07**
		10	Sat	ND
		12	Sat	ND
		12 (dup)	Sat	ND

Notes:

1. ft bgs = feet below ground surface.
2. Soil saturation status (based on historical water levels):
   - v = vadose zone (always above the water table);
   - sm = smear zone (seasonally below the water table); and
   - sat = saturated zone (always below the water table).
3. PCB analyses performed using EPA Method 8082.

Table 3
Final Cleanup Levels for Shallow[1] Groundwater
Port of Seattle Terminal 91 Cleanup Action Plan
Seattle, WA

CAS Number	Indicator Hazardous Substance	Class	Final Recommended Ecological Cleanup Level for Surface Water (ug/L)	Basis of Final Ecological Cleanup Level	Rationale for Selecting this CUL for Final CUL (if not most protective)	Most Protective Human Health Cleanup Level for Groundwater (ug/L)[2]	Basis of Final Human Health Cleanup Level for Shallow Groundwater	Groundwater PQL[3] (ug/L)	Area Background Concentration for Groundwater[4] (ug/L)	Final FS Shallow Groundwater CUL[5] (ug/L)	Basis for Final FS CUL
7440-38-2	Arsenic	Inorganic	36	State WQS		0.042	API Fisher MTCA Method B - 730-2 Modified Ingestion of Fish	0.2	4.71	**4.7**	Background
7440-39-3	Barium	Inorganic	5,700	ECOTOX		55,300	API Fisher MTCA Method B - 730-1 Modified Ingestion of Fish	0.5		**5,700**	Ecological
7440-47-3	Chromium	Inorganic	74	AWQC		104,000	API Fisher MTCA Method B - 730-1 Modified Ingestion of Fish	0.5	7.31	**74**	Ecological
7439-92-1	Lead	Inorganic	8.10	State WQS	Marine chronic; regulatory threshold	--		1	2.47	**8.1**	Ecological
7439-97-6	Mercury	Inorganic	0.030	State WQS	Marine chronic; regulatory threshold	0.300	AWQC Federal Human Health Consumption of Organisms Only	0.02	0.01	**0.03**	Ecological
7782-49-2	Selenium	Inorganic	71	State WQS	Marine chronic; regulatory threshold	27.6	API Fisher MTCA Method B - 730-1 Modified Ingestion of Fish	0.5		**27.6**	Human Health
7440-22-4	Silver	Inorganic	1.90	State WQS		1,100	API Fisher MTCA Method B - 730-1 Modified Ingestion of Fish	0.2		**1.9**	Ecological
7440-66-6	Zinc	Inorganic	81	State WQS		5,000	AWQC Federal Organoleptic Effect Criteria	4	38.3	**81**	Ecological
68334-30-5	Diesel	Petroleum				500	Petroleum Related MTCA Method A Table 720-1 Values	250		**500**	Human Health
86290-81-5	Gasoline	Petroleum				800	Petroleum Related MTCA Method A Table 720-1 Values	250		**800**	Human Health
541-73-1	1,3-dichlorobenzene	Semi-Volatile	206	ECOTOX		33.2	API Fisher MTCA Method B - 730-1 Modified Ingestion of Fish	1		**33.2**	Human Health
90-12-0	1-methylnaphthalene	Semi-Volatile	1,190	ECOTOX		31.6	API Fisher MTCA Method B - 730-1 Modified Ingestion of Fish	0.01		**31.6**	Human Health
105-67-9	2,4-dimethylphenol	Semi-Volatile	397	ECOTOX		236	API Fisher MTCA Method B - 730-1 Modified Ingestion of Fish	1		**236**	Human Health
121-14-2	2,4-dinitrotoluene	Semi-Volatile	307	ECOTOX		3.40	AWQC Federal Human Health Consumption of Organisms Only	1		**3.4**	Human Health
91-57-6	2-methylnaphthalene	Semi-Volatile	373	ECOTOX		421	API Fisher MTCA Method B - 730-1 Modified Ingestion of Fish	0.01		**373**	Ecological
95-48-7	2-methylphenol	Semi-Volatile	4,020	ECOTOX		8,770	API Fisher MTCA Method B - 730-1 Modified Ingestion of Fish	1		**4,020**	Ecological
106-44-5	4-methylphenol	Semi-Volatile	1,830	ECOTOX		891	API Fisher MTCA Method B - 730-1 Modified Ingestion of Fish	1		**891**	Human Health
83-32-9	Acenaphthene	Semi-Volatile	34	ECOTOX		20	AWQC Federal Organoleptic Effect Criteria	0.01		**20**	Human Health
208-96-8	Acenaphthylene	Semi-Volatile	10.7	SMS		--		0.01		**10.7**	Ecological
120-12-7	Anthracene	Semi-Volatile	2.68	ECOTOX		11,000	API Fisher MTCA Method B - 730-1 Modified Ingestion of Fish	0.01		**2.7**	Ecological
56-55-3	Benzo(a)anthracene	Semi-Volatile	0.276	SMS		0.018	AWQC Federal Human Health Consumption of Organisms Only	0.01		**0.02**	Human Health
50-32-8	Benzo(a)pyrene	Semi-Volatile	0.110	ECOTOX		0.013	API Fisher MTCA Method B - 730-2 Modified Ingestion of Fish	0.01		**0.01**	Human Health
205-99-2	Benzo(b)fluoranthene	Semi-Volatile	0.187	SMS		0.018	AWQC Federal Human Health Consumption of Organisms Only	0.01		**0.02**	Human Health
UNK-009	Benzo(b,k)fluoranthene	Semi-Volatile	0.187	SMS		0.126	API Fisher MTCA Method B - 730-2 Modified Ingestion of Fish	0.01		**0.13**	Human Health
191-24-2	Benzo(g,h,i)perylene	Semi-Volatile	0.012	SMS		--		0.01		**0.01**	Ecological
207-08-9	Benzo(k)fluoranthene	Semi-Volatile	0.187	SMS		0.018	AWQC Federal Human Health Consumption of Organisms Only	0.01		**0.02**	Human Health
65-85-0	Benzoic Acid	Semi-Volatile	2,950	ECOTOX		280,000	API Fisher MTCA Method B - 730-1 Modified Ingestion of Fish	1		**2,950**	Ecological
86-74-8	Carbazole	Semi-Volatile	299	ECOTOX		0.921	API Fisher MTCA Method B - 730-2 Modified Ingestion of Fish	1		**0.9**	Human Health
218-01-9	Chrysene	Semi-Volatile	1,560	ECOTOX		0.018	AWQC Federal Human Health Consumption of Organisms Only	0.01		**0.02**	Human Health
53-70-3	Dibenz(a,h)anthracene	Semi-Volatile	0.003	SMS		0.018	AWQC Federal Human Health Consumption of Organisms Only	0.01		**0.01**	PQL
132-64-9	Dibenzofuran	Semi-Volatile	268	ECOTOX		14.70	API Fisher MTCA Method B - 730-1 Modified Ingestion of Fish	0.01		**14.7**	Human Health
206-44-0	Fluoranthene	Semi-Volatile	4.10	ECOTOX		38.40	API Fisher MTCA Method B - 730-1 Modified Ingestion of Fish	0.01		**4.1**	Ecological
86-73-7	Fluorene	Semi-Volatile	78	ECOTOX		1,470	API Fisher MTCA Method B - 730-1 Modified Ingestion of Fish	0.01		**78**	Ecological
67-72-1	Hexachloroethane	Semi-Volatile	NR			2.27	API Fisher MTCA Method B - 730-2 Modified Ingestion of Fish	1		**2.3**	Human Health
193-39-5	Indeno(1,2,3-cd)pyrene	Semi-Volatile	0.01	SMS		0.018	AWQC Federal Human Health Consumption of Organisms Only	0.01		**0.01**	Ecological
CRESOLS34	Methylphenol, P-, M-	Semi-Volatile	1,250	ECOTOX		--		1		**1,250**	Ecological
91-20-3	Naphthalene	Semi-Volatile	97	ECOTOX		2,110	API Fisher MTCA Method B - 730-1 Modified Ingestion of Fish	0.01		**97**	Ecological
85-01-8	Phenanthrene	Semi-Volatile	22	ECOTOX		--		0.01		**22**	Ecological
129-00-0	Pyrene	Semi-Volatile	35	ECOTOX		1,110	API Fisher MTCA Method B - 730-1 Modified Ingestion of Fish	0.01		**35**	Ecological
75-34-3	1,1-dichloroethane	Volatile	2,800	ORNL		17,500	Commercial MTCA Method C - 750-1 Inhalation of Indoor Air	0.2		**2,800**	Ecological
95-63-6	1,2,4-trimethylbenzene	Volatile	NR			320	Commercial MTCA Method C - 750-1 Inhalation of Indoor Air	0.2		**320**	Human Health
106-46-7	1,4-dichlorobenzene	Volatile	NR			2.07	API Fisher MTCA Method B - 730-2 Modified Ingestion of Fish	0.2		**2.1**	Human Health

Table 3
Final Cleanup Levels for Shallow[1] Groundwater
Port of Seattle Terminal 91 Cleanup Action Plan
Seattle, WA

CAS Number	Indicator Hazardous Substance	Class	Final Recommended Ecological Cleanup Level for Surface Water (ug/L)	Basis of Final Ecological Cleanup Level	Rationale for Selecting this CUL for Final CUL (if not most protective)	Most Protective Human Health Cleanup Level for Groundwater (ug/L)[2]	Basis of Final Human Health Cleanup Level for Shallow Groundwater	Groundwater PQL[3] (ug/L)	Area Background Concentration for Groundwater[4] (ug/L)	Final FS Shallow Groundwater CUL[5] (ug/L)	Basis for Final FS CUL
67-64-1	Acetone	Volatile	NR			311,000	API Fisher MTCA Method B - 730-1 Modified Ingestion of Fish	1		**311,000**	Human Health
71-43-2	Benzene	Volatile	NR			9.66	API Fisher MTCA Method B - 730-2 Modified Ingestion of Fish	0.2		**9.7**	Human Health
104-51-8	Butylbenzene,n-	Volatile	NR			--		0.2			
108-90-7	Chlorobenzene	Volatile	NR			20	AWQC Federal Organoleptic Effect Criteria	0.2		**20**	Human Health
75-00-3	Chloroethane	Volatile	230,000	USGS		381	API Fisher MTCA Method B - 730-2 Modified Ingestion of Fish	0.2		**381**	Human Health
156-59-2	Cis-1,2-dichloroethene	Volatile	11,600	USGS		1,360	API Fisher MTCA Method B - 730-1 Modified Ingestion of Fish	0.2		**1,360**	Human Health
100-41-4	Ethylbenzene	Volatile	NR			2,100	AWQC Federal Human Health Consumption of Organisms Only	0.2		**2,100**	Human Health
98-82-8	Cumene	Volatile	NR			850	API Fisher MTCA Method B - 730-1 Modified Ingestion of Fish	0.2		**850**	Human Health
103-65-1	n-Propylbenzene	Volatile	NR			1,160	API Fisher MTCA Method B - 730-1 Modified Ingestion of Fish	0.2		**1,160**	Human Health
135-98-8	Sec-butylbenzene	Volatile	NR			152	API Fisher MTCA Method B - 730-1 Modified Ingestion of Fish	0.2		**152**	Human Health
98-06-6	Tert-butylbenzene	Volatile	NR			152	API Fisher MTCA Method B - 730-1 Modified Ingestion of Fish	0.2		**152**	Human Health
108-88-3	Toluene	Volatile	NR			8,260	API Fisher MTCA Method B - 730-1 Modified Ingestion of Fish	0.2		**8,260**	Human Health
75-01-4	Vinyl Chloride	Volatile	930	RAIS		1.69	API Fisher MTCA Method B - 730-2 Modified Ingestion of Fish	0.2		**1.7**	Human Health
1330-20-7	Xylene (total)	Volatile	NR			1,160	API Fisher MTCA Method B - 730-1 Modified Ingestion of Fish	0.4		**1,160**	Human Health

Notes:

Final FS CULs = These are the most stringent applicable CULs and are the initial CULs that will be considered in the Feasibility Study (FS). As such, they may be adjusted upward or downward based on area background concentrations, practical quantitation limits, or other information, as appropriate, in the FS.

-- = Toxicity value not available to calculate CUL

API Fisher = Asian Pacific Islander Fisherman

AWQC = Federal Ambient Water Quality Criteria (Section 304 of the Clean Water Act)

CR = Cancer Risk

CUL = Cleanup Level

ECOTOX = U.S. EPA Ecotoxicity Database - available on-line at http://www.epa.gov/ecotox/

HQ = Hazard Quotient

MTCA = Model Toxics Control Act (WAC 173-340)

No BCF = No bioconcentration factor was available to calculate the cleanup level

No Alpha = No groundwater to indoor air volatilization factor was available to calculate the cleanup level

No RfD = No Reference Dose was available to calculate the cleanup level

No SF = No Slope Factor was available to calculate the cleanup level

PQL = Practical Quantitation Limit

NR = No value recommended. Difficulties in the exposure methods of the tests used to derive values resulted in values being highly uncertain.

ORNL = Oak Ridge Nation Laboratory Toxicological Benchmarks for Screening Potential Contaminants of Concern for Effects

RAIS = Risk Assessment Information System - available online at http://risk.lsd.ornl.gov/index.shtml

SMS = Sediment Management Standards

USGS 1999 = United States Geological Survey - Selection Procedure and Salient Information for Volatile

WQS = Water Quality Standards

[1] Shallow groundwater wells were screened at a maximum depth of 21 feet below ground surface (bgs)

[2] Based on protection of surface water and protection from vapor intrusion

[3] PQLs were acquired from ARI Laboratories, Inc. *Personal Communication with Susan Dunnihoo, July 22, 2008* .

[4] Based on Terminal 91 Tank Farm Site Background Groundwater Evaluation (PIONEER, 2007)

[5] Based on Terminal 91 Tank Farm Site Feasibility Study Cleanup Levels (PIONEER, 2008)

Table 4
Final Cleanup Levels for Deep[1] Groundwater
Port of Seattle Terminal 91 Cleanup Action Plan
Seattle, WA

CAS Number	Indicator Hazardous Substance	Class	Final Recommended Ecological Cleanup Level for Surface Water (ug/L)	Basis of Final Ecological Cleanup Level for Surface Water	Rationale for Selecting this CUL for Final CUL (if not most protective)	Most Protective Human Health Cleanup Level for Groundwater (ug/L)[2]	Basis of Final Human Health Cleanup Level for Deep Groundwater	Groundwater PQL[3] (ug/L)	Area Background Concentration for Groundwater[4] (ug/L)	Final FS Deep Groundwater CUL[4] (ug/L)	Basis for Final FS CUL
7440-38-2	Arsenic	Inorganic	36	State WQS		0.042	API Fisher MTCA Method B - 730-2 Modified Ingestion of Fish	0.2	4.71	**4.7**	Background
7440-39-3	Barium	Inorganic	5,700	ECOTOX		55,300	API Fisher MTCA Method B - 730-1 Modified Ingestion of Fish	0.5		**5,700**	Ecological
7440-47-3	Chromium	Inorganic	74	AWQC		104,000	API Fisher MTCA Method B - 730-1 Modified Ingestion of Fish	0.5	7.31	**74**	Ecological
7439-92-1	Lead	Inorganic	8.10	State WQS	Marine chronic; regulatory threshold	--		1	2.47	**8.1**	Ecological
7439-97-6	Mercury	Inorganic	0.030	State WQS	Marine chronic; regulatory threshold	0.300	AWQC Federal Human Health Consumption of Organisms Only	0.02	0.01	**0.03**	Ecological
7782-49-2	Selenium	Inorganic	71	State WQS	Marine chronic; regulatory threshold	27.6	API Fisher MTCA Method B - 730-1 Modified Ingestion of Fish	0.5		**27.6**	Human Health
7440-22-4	Silver	Inorganic	1.90	State WQS		1,100	API Fisher MTCA Method B - 730-1 Modified Ingestion of Fish	0.2		**1.9**	Ecological
7440-66-6	Zinc	Inorganic	81	State WQS		5,000	AWQC Federal Organoleptic Effect Criteria	4	38.3	**81**	Ecological
68334-30-5	Diesel	Petroleum				500	Petroleum Related MTCA Method A Table 720-1 Values	250		**500**	Human Health
86290-81-5	Gasoline	Petroleum				800	Petroleum Related MTCA Method A Table 720-1 Values	250		**800**	Human Health
541-73-1	1,3-dichlorobenzene	Semi-Volatile	206	ECOTOX		33.2	API Fisher MTCA Method B - 730-1 Modified Ingestion of Fish	1		**33.2**	Human Health
90-12-0	1-methylnaphthalene	Semi-Volatile	1,190	ECOTOX		31.6	API Fisher MTCA Method B - 730-1 Modified Ingestion of Fish	0.01		**31.6**	Human Health
105-67-9	2,4-dimethylphenol	Semi-Volatile	397	ECOTOX		236	API Fisher MTCA Method B - 730-1 Modified Ingestion of Fish	1		**236**	Human Health
121-14-2	2,4-dinitrotoluene	Semi-Volatile	307	ECOTOX		3.40	AWQC Federal Human Health Consumption of Organisms Only	1		**3.4**	Human Health
91-57-6	2-methylnaphthalene	Semi-Volatile	373	ECOTOX		421	API Fisher MTCA Method B - 730-1 Modified Ingestion of Fish	0.01		**373**	Ecological
95-48-7	2-methylphenol	Semi-Volatile	4,020	ECOTOX		8,770	API Fisher MTCA Method B - 730-1 Modified Ingestion of Fish	1		**4,020**	Ecological
106-44-5	4-methylphenol	Semi-Volatile	1,830	ECOTOX		891	API Fisher MTCA Method B - 730-1 Modified Ingestion of Fish	1		**891**	Human Health
83-32-9	Acenaphthene	Semi-Volatile	34	ECOTOX		20	AWQC Federal Organoleptic Effect Criteria	0.01		**20**	Human Health
208-96-8	Acenaphthylene	Semi-Volatile	10.7	SMS		--		0.01		**10.7**	Ecological
120-12-7	Anthracene	Semi-Volatile	2.68	ECOTOX		11,000	API Fisher MTCA Method B - 730-1 Modified Ingestion of Fish	0.01		**2.7**	Ecological
56-55-3	Benzo(a)anthracene	Semi-Volatile	0.276	SMS		0.018	AWQC Federal Human Health Consumption of Organisms Only	0.01		**0.02**	Human Health
50-32-8	Benzo(a)pyrene	Semi-Volatile	0.110	ECOTOX		0.013	API Fisher MTCA Method B - 730-2 Modified Ingestion of Fish	0.01		**0.01**	Human Health
205-99-2	Benzo(b)fluoranthene	Semi-Volatile	0.187	SMS		0.018	AWQC Federal Human Health Consumption of Organisms Only	0.01		**0.02**	Human Health
UNK-009	Benzo(b,k)fluoranthene	Semi-Volatile	0.187	SMS		0.126	API Fisher MTCA Method B - 730-2 Modified Ingestion of Fish	0.01		**0.13**	Human Health
191-24-2	Benzo(g,h,i)perylene	Semi-Volatile	0.012	SMS		--		0.01		**0.01**	Ecological
207-08-9	Benzo(k)fluoranthene	Semi-Volatile	0.187	SMS		0.018	AWQC Federal Human Health Consumption of Organisms Only	0.01		**0.02**	Human Health
65-85-0	Benzoic Acid	Semi-Volatile	2,950	ECOTOX		280,000	API Fisher MTCA Method B - 730-1 Modified Ingestion of Fish	1		**2,950**	Ecological
86-74-8	Carbazole	Semi-Volatile	299	ECOTOX		0.921	API Fisher MTCA Method B - 730-2 Modified Ingestion of Fish	1		**0.9**	Human Health
218-01-9	Chrysene	Semi-Volatile	1,560	ECOTOX		0.018	AWQC Federal Human Health Consumption of Organisms Only	0.01		**0.02**	Human Health
53-70-3	Dibenz(a,h)anthracene	Semi-Volatile	0.003	SMS		0.018	AWQC Federal Human Health Consumption of Organisms Only	0.01		**0.01**	PQL
132-64-9	Dibenzofuran	Semi-Volatile	268	ECOTOX		14.70	API Fisher MTCA Method B - 730-1 Modified Ingestion of Fish	0.01		**14.7**	Human Health
206-44-0	Fluoranthene	Semi-Volatile	4.10	ECOTOX		38.40	API Fisher MTCA Method B - 730-1 Modified Ingestion of Fish	0.01		**4.1**	Ecological
86-73-7	Fluorene	Semi-Volatile	78	ECOTOX		1,470	API Fisher MTCA Method B - 730-1 Modified Ingestion of Fish	0.01		**78**	Ecological
67-72-1	Hexachloroethane	Semi-Volatile	NR			2.27	API Fisher MTCA Method B - 730-2 Modified Ingestion of Fish	1		**2.3**	Human Health
193-39-5	Indeno(1,2,3-cd)pyrene	Semi-Volatile	0.01	SMS		0.018	AWQC Federal Human Health Consumption of Organisms Only	0.01		**0.01**	Ecological
CRESOLS34	Methylphenol, P-, M-	Semi-Volatile	1,250	ECOTOX		--		1		**1,250**	Ecological
91-20-3	Naphthalene	Semi-Volatile	97	ECOTOX		2,110	API Fisher MTCA Method B - 730-1 Modified Ingestion of Fish	0.01		**97**	Ecological
85-01-8	Phenanthrene	Semi-Volatile	22	ECOTOX		--		0.01		**22**	Ecological
129-00-0	Pyrene	Semi-Volatile	35	ECOTOX		1,110	API Fisher MTCA Method B - 730-1 Modified Ingestion of Fish	0.01		**35**	Ecological
75-34-3	1,1-dichloroethane	Volatile	2,800	ORNL		23,000	API Fisher MTCA Method B - 730-1 Modified Ingestion of Fish	0.2		**2,800**	Ecological
95-63-6	1,2,4-trimethylbenzene	Volatile	NR			643	API Fisher MTCA Method B - 730-1 Modified Ingestion of Fish	0.2		**643**	Human Health

Table 4
Final Cleanup Levels for Deep[1] Groundwater
Port of Seattle Terminal 91 Cleanup Action Plan
Seattle, WA

CAS Number	Indicator Hazardous Substance	Class	Final Recommended Ecological Cleanup Level for Surface Water (ug/L)	Basis of Final Ecological Cleanup Level for Surface Water	Rationale for Selecting this CUL for Final CUL (if not most protective)	Most Protective Human Health Cleanup Level for Groundwater (ug/L)[2]	Basis of Final Human Health Cleanup Level for Deep Groundwater	Groundwater PQL[3] (ug/L)	Area Background Concentration for Groundwater[4] (ug/L)	Final FS Deep Groundwater CUL[4] (ug/L)	Basis for Final FS CUL
106-46-7	1,4-dichlorobenzene	Volatile	NR			2.07	API Fisher MTCA Method B - 730-2 Modified Ingestion of Fish	0.2		**2.1**	Human Health
67-64-1	Acetone	Volatile	NR			311,000	API Fisher MTCA Method B - 730-1 Modified Ingestion of Fish	1		**311,000**	Human Health
71-43-2	Benzene	Volatile	NR			9.66	API Fisher MTCA Method B - 730-2 Modified Ingestion of Fish	0.2		**9.7**	Human Health
104-51-8	Butylbenzene,n-	Volatile	NR			--		0.2			
108-90-7	Chlorobenzene	Volatile	NR			20	AWQC Federal Organoleptic Effect Criteria	0.2		**20**	Human Health
75-00-3	Chloroethane	Volatile	230,000	USGS		381	API Fisher MTCA Method B - 730-2 Modified Ingestion of Fish	0.2		**381**	Human Health
156-59-2	Cis-1,2-dichloroethene	Volatile	11,600	USGS		1,360	API Fisher MTCA Method B - 730-1 Modified Ingestion of Fish	0.2		**1,360**	Human Health
100-41-4	Ethylbenzene	Volatile	NR			2,100	AWQC Federal Human Health Consumption of Organisms Only	0.2		**2,100**	Human Health
98-82-8	Cumene	Volatile	NR			850	API Fisher MTCA Method B - 730-1 Modified Ingestion of Fish	0.2		**850**	Human Health
103-65-1	n-Propylbenzene	Volatile	NR			1,160	API Fisher MTCA Method B - 730-1 Modified Ingestion of Fish	0.2		**1,160**	Human Health
135-98-8	Sec-butylbenzene	Volatile	NR			152	API Fisher MTCA Method B - 730-1 Modified Ingestion of Fish	0.2		**152**	Human Health
98-06-6	Tert-butylbenzene	Volatile	NR			152	API Fisher MTCA Method B - 730-1 Modified Ingestion of Fish	0.2		**152**	Human Health
108-88-3	Toluene	Volatile	NR			8,260	API Fisher MTCA Method B - 730-1 Modified Ingestion of Fish	0.2		**8,260**	Human Health
75-01-4	Vinyl Chloride	Volatile	930	RAIS		1.69	API Fisher MTCA Method B - 730-2 Modified Ingestion of Fish	0.2		**1.7**	Human Health
1330-20-7	Xylene (total)	Volatile	NR			1,160	API Fisher MTCA Method B - 730-1 Modified Ingestion of Fish	0.4		**1,160**	Human Health

Notes:

Final FS CULs = These are the most stringent applicable CULs and are the initial CULs that will be considered in the Feasibility Study (FS). As such, they may be adjusted upward or downward based on area background concentrations, practical quantitation limits, or other information, as appropriate, in the FS.
-- = Toxicity value not available to calculate CUL
API Fisher = Asian Pacific Islander Fisherman
AWQC = Federal Ambient Water Quality Criteria (Section 304 of the Clean Water Act)
CR = Cancer Risk
CUL = Cleanup Level
ECOTOX = U.S. EPA Ecotoxicity Database - available on-line at http://www.epa.gov/ecotox/
HQ = Hazard Quotient
MTCA = Model Toxics Control Act (WAC 173-340)
No BCF = No bioconcentration factor was available to calculate the cleanup level
No Alpha = No groundwater to indoor air volatilization factor was available to calculate the cleanup level
No RfD = No Reference Dose was available to calculate the cleanup level
No SF = No Slope Factor was available to calculate the cleanup level
PQL = Practical Quantitation Limit
NR = No value recommended. Difficulties in the exposure methods of the tests used to derive values resulted in values being highly uncertain.
ORNL = Oak Ridge Nation Laboratory Toxicological Benchmarks for Screening Potential Contaminants of Concern for Effects
RAIS = Risk Assessment Information System - available online at http://risk.lsd.ornl.gov/index.shtml
SMS = Sediment Management Standards
USGS 1999 = United States Geological Survey - Selection Procedure and Salient Information for Volatile
WQS = Water Quality Standards
[1]Deep groundwater wells were screened at a maximum depth of 60 feet below ground surface (bgs)
[2] Based on protection of surface water and protection from vapor intrusion
[3] PQLs were acquired from ARI Laboratories, Inc. *Personal Communication with Susan Dunnihoo, July 22, 2008*.
[4]Based on Terminal 91 Tank Farm Site Background Groundwater Evaluation (PIONEER, 2007)
[5]Based on Terminal 91 Tank Farm Site Feasibility Study Cleanup Levels (PIONEER, 2008)

Table 5
Construction Costs
SMWU-30 - Limited Excavation of LNAPL Source Areas
Port of Seattle Terminal 91 Cleanup Action Plan
Seattle, Washington

Construction Costs							
ITEM	UNIT COST		UNITS	QUANTITY		COST	
	low	high		low	high	low	high
Construction Costs							
1. Mobilization/demobilization	$ 10,000	$ 15,000	LS	1	1	$ 10,000	$ 15,000
2. Excavate clean overburden	$ 5	$ 7	ton	1,000	1,300	$ 5,000	$ 9,100
3. Excavate TPH-impacted soil	$ 5	$ 7	ton	1,500	1,900	$ 7,500	$ 13,300
4. Water management	$ 15,000	$ 20,000	LS	1	1	$ 15,000	$ 20,000
5. Offsite soil disposal							
a) Disposal as solid waste (TPH only)	$ 35	$ 40	ton	1,500	1,900	$ 52,500	$ 76,000
6. Backfill excavated area with clean soil							
a) With excavated "clean soil"	$ 10	$ 12	ton	1,000	1,300	$ 10,000	$ 15,600
a) With imported clean soil	$ 26	$ 30	ton	1,650	2,100	$ 42,900	$ 63,000
7 Replace cap							
a) Remove existing asphalt	$ 0.65	$ 0.75	SF	4,350	5,400	$ 2,828	$ 4,050
b) New asphalt paving	$ 2.00	$ 2.25	SF	4,350	5,400	$ 8,700	$ 12,150
8. Well decommissioning	$ 400	$ 500	EA	3	3	$ 1,200	$ 1,500
Subtotal						$ 155,600	$ 229,700
Sales Tax on Materials (9%)						$ 9,300	$ 13,800
Engineering and Permitting (10%)						$ 15,600	$ 23,000
Construction Cost Contingency (20%)						$ 31,100	$ 45,900
Total Estimated Capital Costs						**$ 210,000**	**$ 310,000**
Average Capital Cost						**$ 260,000**	

Table 6
Construction and Operation and Maintenance Costs
Alternative 4 - Containment, Subsurface Structure Removal, and Enhanced LNAPL Recovery
Port of Seattle Terminal 91 Cleanup Action Plan, Seattle, Washington

Construction Costs							
ITEM	UNIT COST low	UNIT COST high	UNITS	QUANTITY low	QUANTITY high	COST low	COST high
Construction Costs							
1. Mobilization/demobilization	$ 70,000	$ 80,000	LS	1	1	$ 70,000	$ 80,000
2. Remove existing asphalt paving	$ 0.65	$ 0.75	SF	135,000	135,000	$ 88,000	$ 101,000
3. Excavate existing sub base	$ 3.00	$ 5.00	ton	9,400	11,750	$ 28,000	$ 59,000
4. Demolish, decontaminate and haul out all existing subsurface structures	$ 520,000	$ 1,100,000	LS	1	1	$ 520,000	$ 1,100,000
5. Excavate highly contaminated soils, incl backfill	$ 31	$ 40	ton	250	500	$ 7,750	$ 20,000
6. Dispose highly contaminated soils							
a) Disposal as solid waste (TPH-only, low level PCB	$ 38	$ 43	ton	150	300	$ 5,700	$ 12,900
b) Disposal as TSCA Waste (PCB >50 ppm)	$ 215	$ 240	ton	50	100	$ 10,750	$ 24,000
c) Contained-out waste (e.g., F001-F005)	$ 58	$ 64	ton	50	100	$ 2,900	$ 6,400
7. Excavate working trench for wall installation	$ 3	$ 5	ton	3,900	4,900	$ 12,000	$ 25,000
8. Slurry wall installation	$ 5	$ 10	SF	31,000	31,000	$ 155,000	$ 310,000
9. Stockpile, replace, and compact trench spoils	$ 5	$ 7	ton	3,900	4,900	$ 20,000	$ 34,000
10. Install enhanced LNAPL recovery trenches	$ 65,000	$ 120,000	LS	1	1	$ 65,000	$ 120,000
11. Install new asphalt paving							
a) Stockpile, replace, and compact clean sub base	$ 5	$ 7	ton	9,400	11,800	$ 47,000	$ 83,000
b) Install new asphalt paving	$ 2.00	$ 2.25	SF	135,000	135,000	$ 270,000	$ 304,000
12. Site drainage improvements	$ 25,000	$ 50,000	LS	1	1	$ 25,000	$ 50,000
13. Decommission and replace select monitoring wells	$ 5,000	$ 8,000	EA	16	16	$ 80,000	$ 128,000
14. Oversight during construction/construction report	$ 50,000	$ 75,000	LS	1	1	$ 50,000	$ 75,000
					Subtotal	$ 1,407,100	$ 2,457,300
					Sales Tax on Materials (9%)	$ 127,000	$ 221,000
					Engineering and Permitting (10%)	$ 141,000	$ 246,000
					Construction Cost Contingency (20%)	$ 281,000	$ 491,000
					Total Estimated Capital Costs	**$ 1,960,000**	**$ 3,420,000**
					Average Capital Cost	**$ 2,690,000**	

Operation and Maintenance Costs			**Baseline O&M Case**
Activity	**Estimated Annual Cost low**	**Estimated Annual Cost high**	**PW[1] (30 Years)**
1. Annual asphalt paving inspection and maintenance	$ 7,000	$ 13,000	$ 154,000
2. Monthly LNAPL recovery (years 1-2)	$ 25,000	$ 35,000	$ 56,000
3. Bimonthly LNAPL recovery (years 3-5)	$ 15,000	$ 20,000	$ 43,000
4. Quarterly LNAPL recovery (years 5-10)	$ 10,000	$ 15,000	$ 42,000
5. LNAPL monitoring and passive recovery outside expanded recovery system	$ 6,000	$ 12,000	$ 138,000
6. Compliance groundwater monitoring	$ 15,000	$ 25,000	$ 307,000
7. Annual reporting (inspections, LNAPL recovery and monitoring, groundwater monitoring	$ 20,000	$ 25,000	$ 346,000
	$ 98,000	$ 145,000	
		Subtotal	$ 1,086,000
		O&M Cost Contingency (10 %)	$ 108,600
		Total Estimated O&M Costs	**$ 1,190,000**
TOTAL ESTIMATED PRESENT WORTH COST			**$ 3,880,000**

[1] PW = present worth, calculated assuming a 5% discount rate using the average annual cost and years of operation indicated in the following formula

where A = average annual cost
i = discount rate
n = number of years of operation

All total costs are in 2009 dollars and rounded to nearest $10,000.

Table 7

Evaluation of Use of Permanent Solutions to Maximum Extent Practicable
Lease Parcel Cleanup Action Alternatives
Port of Seattle Terminal 91 Cleanup Action Plan
Seattle, Washington

Evaluation Criteria	Alternative 1 – Existing Asphalt Paving Maintenance and Monitoring	Alternative 2 – Containment and Passive LNAPL Recovery	Alternative 3 – Active LNAPL Recovery and Subsurface Structure Removal	Alternative 4 – Containment, Subsurface Structure Removal, and Expanded LNAPL Recovery	Alternative 5 – Limited Excavation of LNAPL Areas	Alternative 6 – Excavation of Soils Exceeding RSSLs
Protectiveness	Potential future receptors (potential site workers and/or trespassers) will be protected through inspection and maintenance of the existing asphalt paving, including corrective action to address product seeps that may occur.	Alternative 2 protects potential future receptors (potential site workers and/or trespassers) through construction, inspection, and maintenance of a new composite cap. In addition, removing approximately 30 percent of the remaining subsurface structures from the former tank farm will further reduce the potential for surface seeps.	Alternative 3 effectively eliminates potential exposure by eliminating the source of the product seeps through removal of all remaining subsurface structures and constructing new asphalt paving. The active LNAPL recovery system would further reduce the potential for surface seeps.	Similar to Alternative 3 with additional protection provided by removing highly contaminated surface soil from the former tank farm area.	Potential future receptors are protected by Alternative 5 by eliminating the source of product seeps through removal of all remaining subsurface structures and constructing new asphalt paving. In addition, this alternative removes approximately a quarter of the unsaturated zone soil in the Lease Parcel as well as excavating the areas with observed LNAPL, further reducing the potential for surface seeps.	Very similar to Alternative 5, except more soil (including soil exceeding the RSSLs) is removed.
Permanence	With the exception of the relatively minor amount of LNAPL removed through the passive recovery activities, this alternative does not significantly reduce the toxicity or volume of hazardous substances present at the Lease Parcel. Although the mobility of contaminants, including LNAPL, from the Lease Parcel appears limited, Alternative 1 does not take any actions to further reduce the mobility or contain the contamination at the source.	Through construction of a slurry wall around the perimeter of the Lease Parcel, Alternative 2 significantly reduces the mobility of hazardous substances inside the wall. As with Alternative 1, this alternative removes only a minor amount of LNAPL through passive recovery activities.	Alternative 3 significantly reduces the volume of LNAPL in the Lease Parcel through the construction and operation of an active LNAPL recovery system, and removal of all remaining subsurface structures that are a significant source of the seeps.	Alternative 4 significantly reduces the volume of LNAPL in the Lease Parcel with the expanded LNAPL recovery system and removal of the subsurface structures and highly contaminated soil. By including a slurry wall, Alternative 4 also permanently reduces the mobility of residual hazardous substances inside the wall.	Alternative 5 significantly reduces the volume of LNAPL and hazardous substances present in the in the Lease Parcel by excavating approximately 19,000 tons of impacted soil in areas where LNAPL has been recently observed.	Similar to Alternative 5, except Alternative 6 removes over 32,000 tons of soil that exceeds the RSSLs and/or is situated at locations where LNAPL has been observed.
Cost	**Capital:** $90,000 **O&M (30-yr NPV):** $1,070,000 **Overall Cost:** $1,160,000	**Capital:** $1,840,000 **O&M (30-yr NPV):** $1,070,000 **Overall Cost:** $2,910,000	**Capital:** $2,600,000 **O&M (30-yr NPV):** $1,780,000 **Overall Cost:** $4,380,000	**Capital:** $2,690,000 **O&M (30-yr NPV):** $1,190,000 **Overall Cost:** $3,880,000	**Capital:** $4,310,000 **O&M (30-yr NPV):** $1,070,000 **Overall Cost:** $5,380,000	**Capital:** $5,920,000 **O&M (30-yr NPV):** $1,070,000 **Overall Cost:** $6,990,000
Long-Term Effectiveness	This alternative will require long-term inspection and maintenance of the asphalt paving, groundwater and LNAPL monitoring, and passive recovery of LNAPL. These are all straightforward and effective actions that are reliable as long as they continue to be implemented.	The slurry wall around the Lease Parcel will effectively and reliably control potential migration of LNAPL from the Lease Parcel with little or no maintenance. Also, by isolating the major source of dissolved phase contamination in groundwater, Alternative 2 will reduce downgradient concentrations over time. This Alternative also requires long-term inspection and maintenance of the cap, groundwater and LNAPL monitoring, and passive recovery of LNAPL.	Although the active LNAPL recovery system included in Alternative 3 requires ongoing O&M, the technologies utilized are well established and can be effectively and reliably operated. Also, by reducing a major source of dissolved phase contamination in groundwater, Alternative 3 may reduce downgradient concentrations over time. As with the other alternatives, Alternative 3 requires long-term inspection and maintenance of the asphalt paving, groundwater and LNAPL monitoring, and passive recovery of LNAPL outside the area where the active LNAPL recovery system is operational.	Similar to Alternative 3, the LNAPL recovery system will require O&M (albeit less than the Alternative 3 system) but will reduce a major source of groundwater contamination. The slurry wall around the Lease Parcel will effectively and reliably control potential migration of LNAPL from the Lease Parcel with little or no maintenance. The combination of these actions in reducing and isolating the major source of dissolved phase contamination in groundwater will reduce downgradient concentrations over time.	Excavation of the impacted soil (19,000 tons) in areas where LNAPL has been observed is an effective and reliable approach to removing LNAPL and requires no O&M after implementation. Also, by reducing a major source of dissolved phase contamination in groundwater, Alternative 5 could reduce downgradient concentrations over time. As with the other alternatives, Alternative 5 requires long-term inspection and maintenance of the asphalt paving, groundwater and LNAPL monitoring, and passive recovery of LNAPL as needed outside the excavation area.	The long-term effectiveness of Alternative 6 is expected to be similar to or slightly better than Alternative 5. Given that significant additional impacted soil removal, (70%) it is likely that downgradient dissolved concentrations will decrease over time.

Table 7

Evaluation of Use of Permanent Solutions to Maximum Extent Practicable
Lease Parcel Cleanup Action Alternatives
Port of Seattle Terminal 91 Cleanup Action Plan
Seattle, Washington

Evaluation Criteria	Alternative 1 – Existing Asphalt Paving Maintenance and Monitoring	Alternative 2 – Containment and Passive LNAPL Recovery	Alternative 3 – Active LNAPL Recovery and Subsurface Structure Removal	Alternative 4 – Containment, Subsurface Structure Removal, and Expanded LNAPL Recovery	Alternative 5 – Limited Excavation of LNAPL Areas	Alternative 6 – Excavation of Soils Exceeding RSSLs
Management of Short-Term Risks	With respect to the Lease Parcel, there are no current or short-term risks to human health or the environment that need to be addressed. Given the limited actions associated with Alternative 1, there are minimal short-term risks associated with its implementation, and what minor risks are present (associated with monitoring, LNAPL recovery, etc.) can be easily mitigated through development and implementation of a site-specific health and safety plan, including appropriate use of engineering controls and personal protective equipment.	As with Alternative 1, there are no current or short-term risks to human health that need to be addressed. Implementation risks associated with Alternative 2 are related to the heavy construction activities involved with placement of the slurry wall and composite surface cap. Potential volatilization of subsurface VOCs should be minimized by the nature of one-pass trencher operations. With appropriate engineering design and careful implementation of health and safety procedures typical for this type of activity, these risks can be adequately controlled.	As with Alternative 1, there are no current or short-term risks to human health that need to be addressed. Implementation risks associated with Alternative 3 include the heavy construction activities associated with removal of the existing asphalt paving, removal of the remaining subsurface structures, and construction of the asphalt paving. Potential volatilization of subsurface VOCs can be minimized by sequencing of excavation and backfilling to minimize the amount of exposed soil. There are also construction-related risks associated with installation of the active LNAPL recovery system (e.g., well installation, trenching, piping and equipment installation). With appropriate engineering design and careful implementation of health and safety procedures typical for this type of activity, these risks can be adequately controlled.	As with Alternative 1, there are no current or short-term risks to human health that need to be addressed. Implementation risks associated with Alternative 4 are similar to those described for Alternative 3, with a slight increase in the construction-related risks associated with construction of the slurry wall. As with Alternative 3, careful engineering design and appropriate use of health and safety procedures can control these risks.	As with Alternative 1, there are no current or short-term risks to human health that need to be addressed. Implementation risks associated with Alternative 5 are related to the heavy construction activities associated with removal of the existing asphalt paving, removal of the remaining subsurface structures, excavation of 19,000 tons of soil, and construction of the asphalt paving. Potential volatilization of subsurface VOCs can be minimized by sequencing of excavation and backfilling to minimize the amount of exposed soil. There are also traffic-related risks associated with the off-site transport of the excavated soil and import of clean backfill material (approximately 900 to 1,000 truck and trailer trips). With appropriate engineering design and careful implementation of health and safety procedures typical for this type of activity, these risks can be adequately controlled.	The short-term risks for Alternative 6 are very similar to those of Alternative 5, except the amount of soil excavation and related truck traffic for off site disposal are approximately 70 percent higher.
Technical and Administrative Implementability	Technical – All of the components are in common use and readily available, and there are no significant technical implementability issues for this alternative. Administrative – There are no significant permits required for implementation of this alternative. Recovered LNAPL would need to be characterized and disposed of consistent with state and federal solid and dangerous/hazardous waste regulations.	Technical – All of the components used in the slurry wall have been demonstrated at full scale at dozens of other sites, and the materials are readily available. The one-pass trencher technology used to place the slurry wall has been demonstrated at the anticipated depths and used many times in similar applications. There are no significant technical implementability issues for this alternative. Administrative – There are no major permits required to implement this alternative as it is constructed entirely onsite. Minor permits that may be required include an Ecology NPDES Construction Stormwater General Permit and a city grading permit. Excavated soils and other waste (LNAPL) would need to be characterized and disposed of consistent with state and federal solid and dangerous/hazardous waste regulations.	Technical – All of the components used in the construction of the active LNAPL recovery system have been well demonstrated at other sites. There are no significant technical implementability issues for this alternative. Administrative – There are no major permits required to implement this alternative as it is constructed entirely onsite. Minor permits that may be required include an Ecology NPDES Construction Stormwater General Permit and a city grading permit. Excavated soils and other waste (LNAPL) would need to be characterized and disposed of consistent with state and federal solid and dangerous/hazardous waste regulations.	Technical – All of the components used in the construction of the expanded LNAPL recovery system and slurry wall have been well demonstrated at other sites. There are no significant technical implementability issues for this alternative. Administrative – There are no major permits required to implement this alternative as it is constructed entirely onsite. Minor permits that may be required include an Ecology NPDES Construction Stormwater General Permit and a city grading permit. Excavated soils and other waste (LNAPL) would need to be characterized and disposed of consistent with state and federal solid and dangerous/hazardous waste regulations.	Technical – All of the components of this alternative are standard construction technologies that have been well demonstrated at other sites. There are no significant technical implementability issues for this alternative. Administrative – There are no major permits required to implement this alternative as it is constructed entirely onsite. Minor permits that may be required include an Ecology NPDES Construction Stormwater General Permit and a city grading permit. Excavated soils and other waste would need to be characterized and disposed of consistent with state and federal solid and dangerous/hazardous waste regulations.	Same as Alternative 5.

Table 7

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Consideration of Public Concerns	Public concerns associated with the possible implementation of this alternative will be addressed during the public review and comment process for this FS.	Public concerns associated with the possible implementation of this alternative will be addressed during the public review and comment process for this FS.	Public concerns associated with the possible implementation of this alternative will be addressed during the public review and comment process for this FS.	Public concerns associated with the possible implementation of this alternative will be addressed during the public review and comment process for this FS.	Public concerns associated with the possible implementation of this alternative will be addressed during the public review and comment process for this FS.	Public concerns associated with the possible implementation of this alternative will be addressed during the public review and comment process for this FS.

U.S.G.S. Topo Map - Seattle North W, WA, 7.5-minute quadrangle.1983

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Site Location Map
Port of Seattle Terminal 91
Seattle, Washington

FIGURE
1

JOB NUMBER	DRAWING NUMBER	REVIEWED BY	DATE
948.002.16.001	948-00216001_DCAP_1		2/10

948-00216001_DCAP_2

For areas shown as Tank Farm Affected Area ("TFAA") that are outside the Tank Farm Lease Parcel, the TFAA includes only soil and ground water below the water table. Soil above the water table (and outside the Tank Farm Lease Parcel) is outside the TFAA.

Note:

N

0 700 feet

The locations of all features are approximate.

Explanation

- Port of Seattle Property Limits
- Tank Farm Lease Parcel
- Tank Farm Affected Area
- Submerged Land

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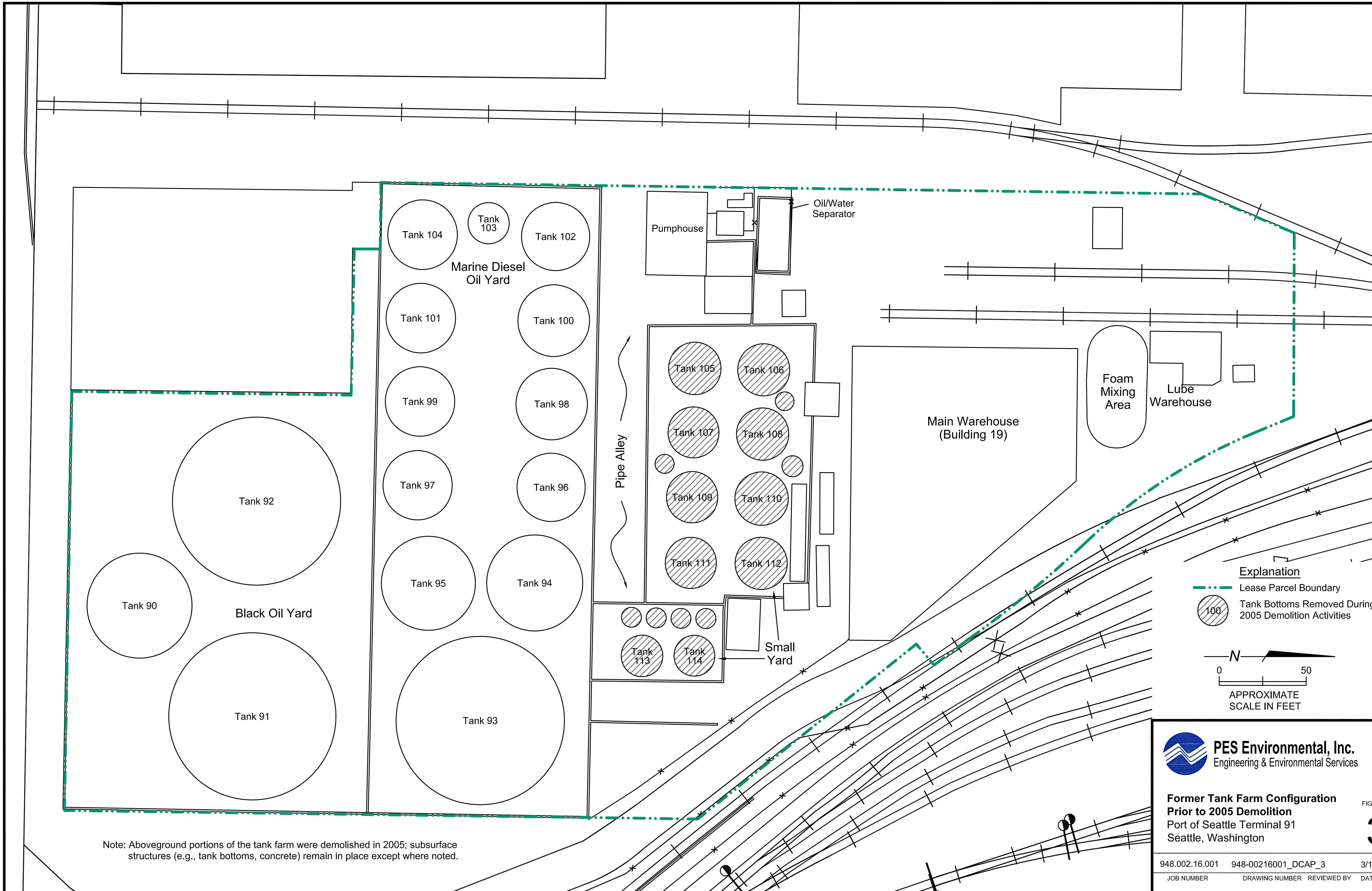
FIGURE 2

Port of Seattle Terminal 91 Facility and Tank Farm Lease Parcel

Port of Seattle Terminal 91
Seattle, Washington

JOB NUMBER	DRAWING NUMBER	REVIEWED BY	DATE
948.002.16.001	948-00216001_DCAP_2		2/10



Note: Aboveground portions of the tank farm were demolished in 2005; subsurface structures (e.g., tank bottoms, concrete) remain in place except where noted.

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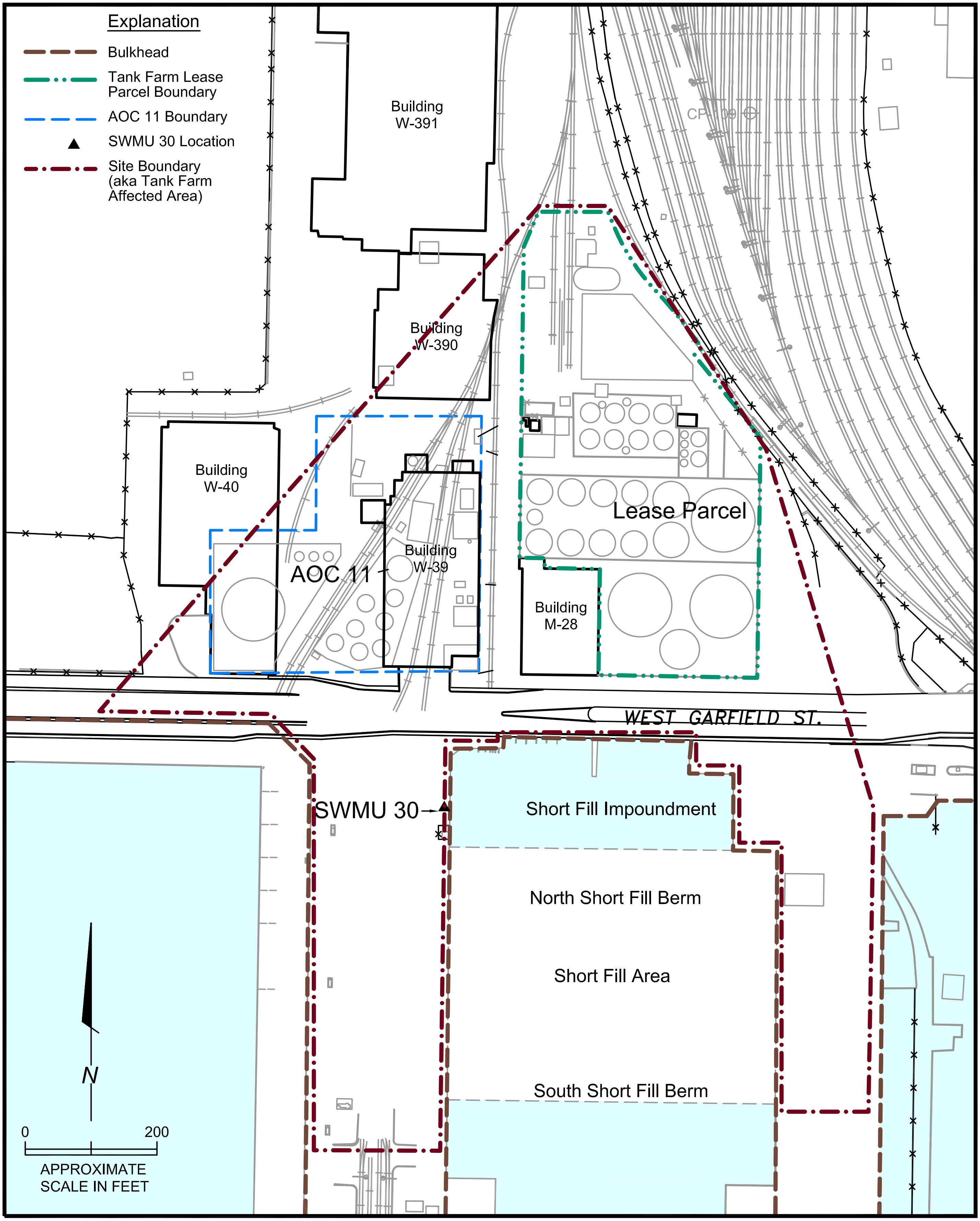
Former Tank Farm Configuration Prior to 2005 Demolition
Port of Seattle Terminal 91
Seattle, Washington

FIGURE 3

JOB NUMBER	DRAWING NUMBER	REVIEWED BY	DATE
948.002.16.001	948-00216001_DCAP_3		3/10



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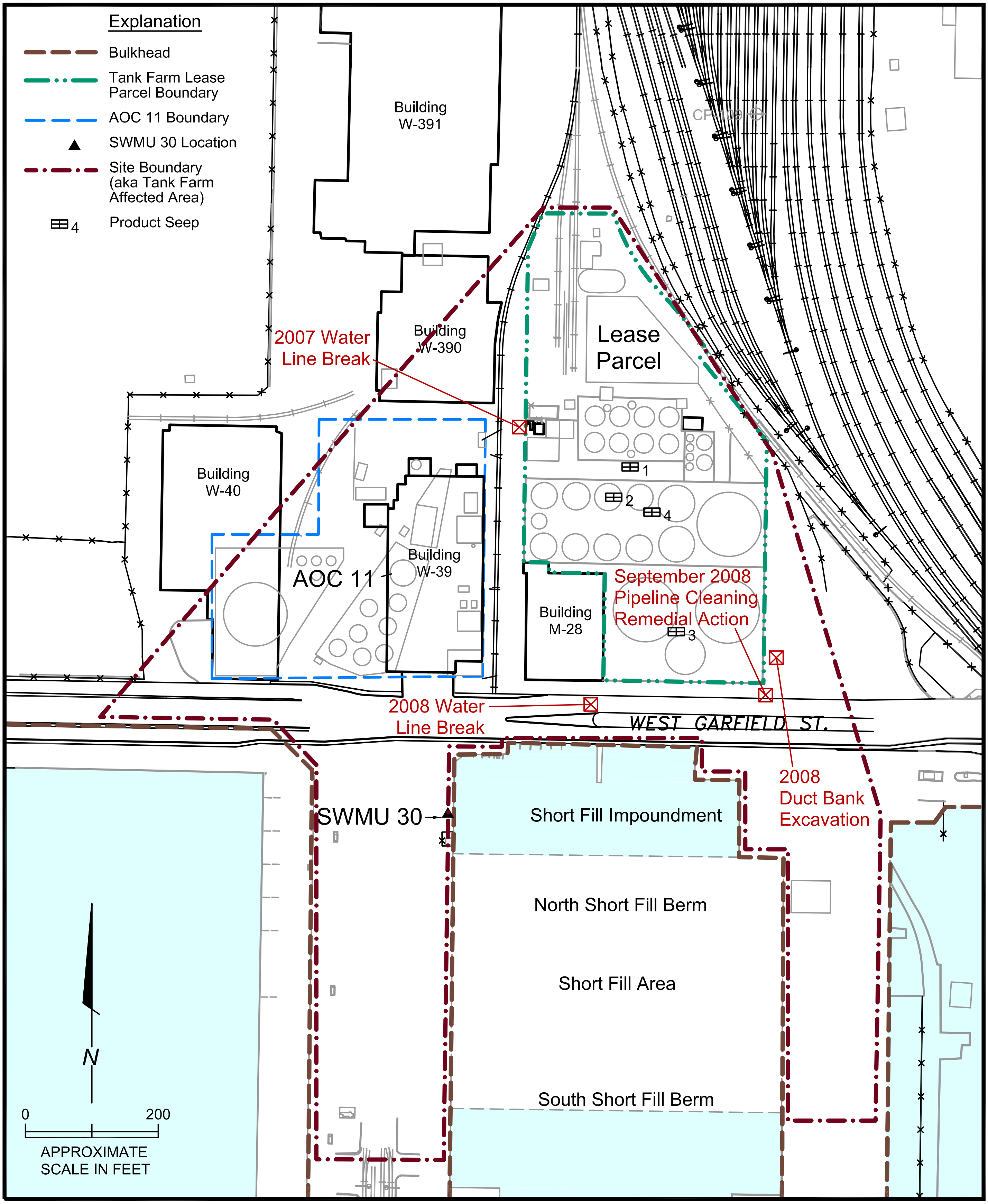
Site Plan
Port of Seattle Terminal 91 Tank Farm Site
Seattle, Washington

FIGURE
4

948.002.16.001	948-00216001_DCAP_4 6		2/10
JOB NUMBER	DRAWING NUMBER	REVIEWED BY	DATE



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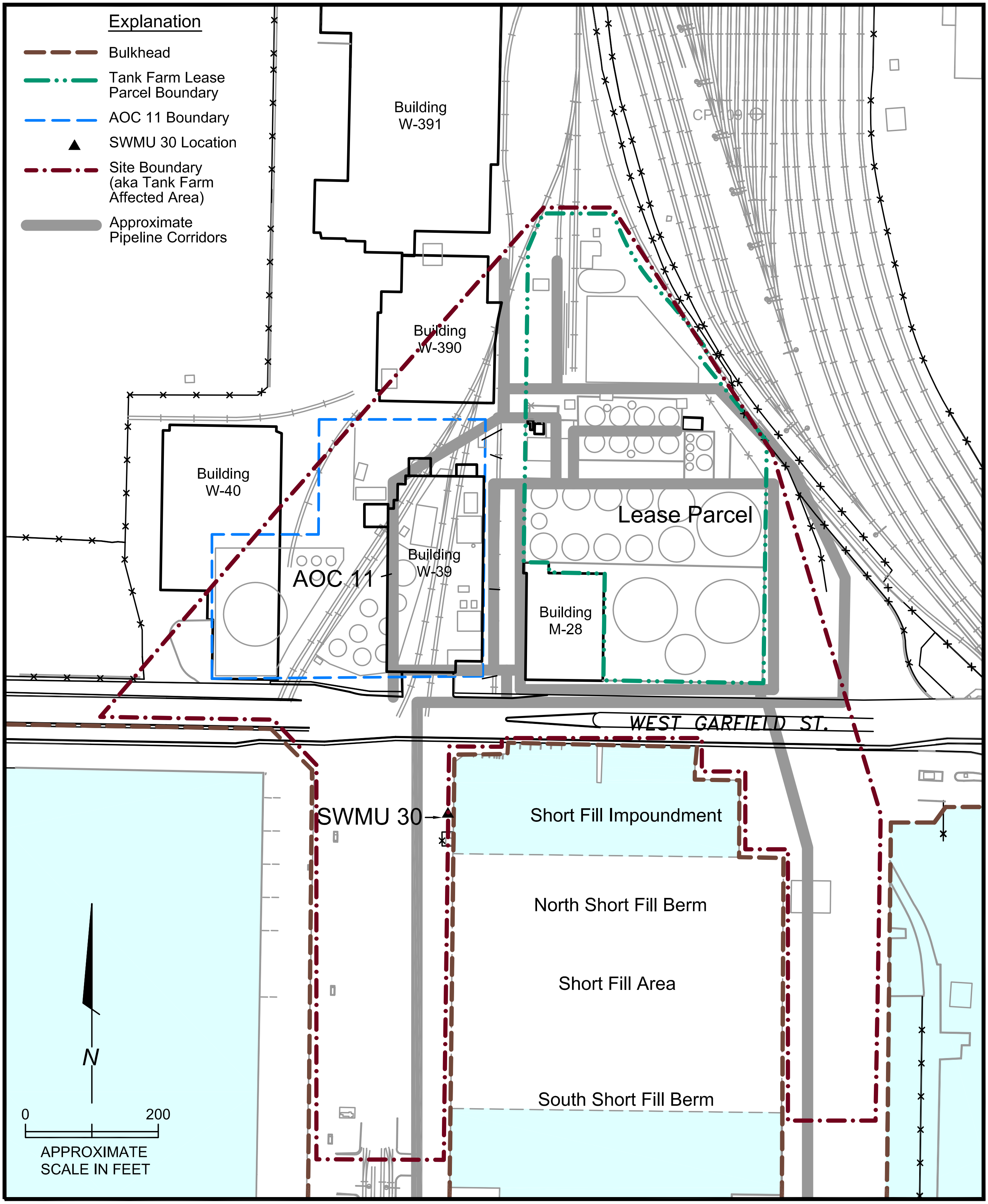
Location of Interim Remedial Actions
Port of Seattle Terminal 91 Tank Farm Site
Seattle, Washington

FIGURE 5

JOB NUMBER	DRAWING NUMBER	REVIEWED BY	DATE
948.002.16.001	948-00216001_DCAP_5		2/10



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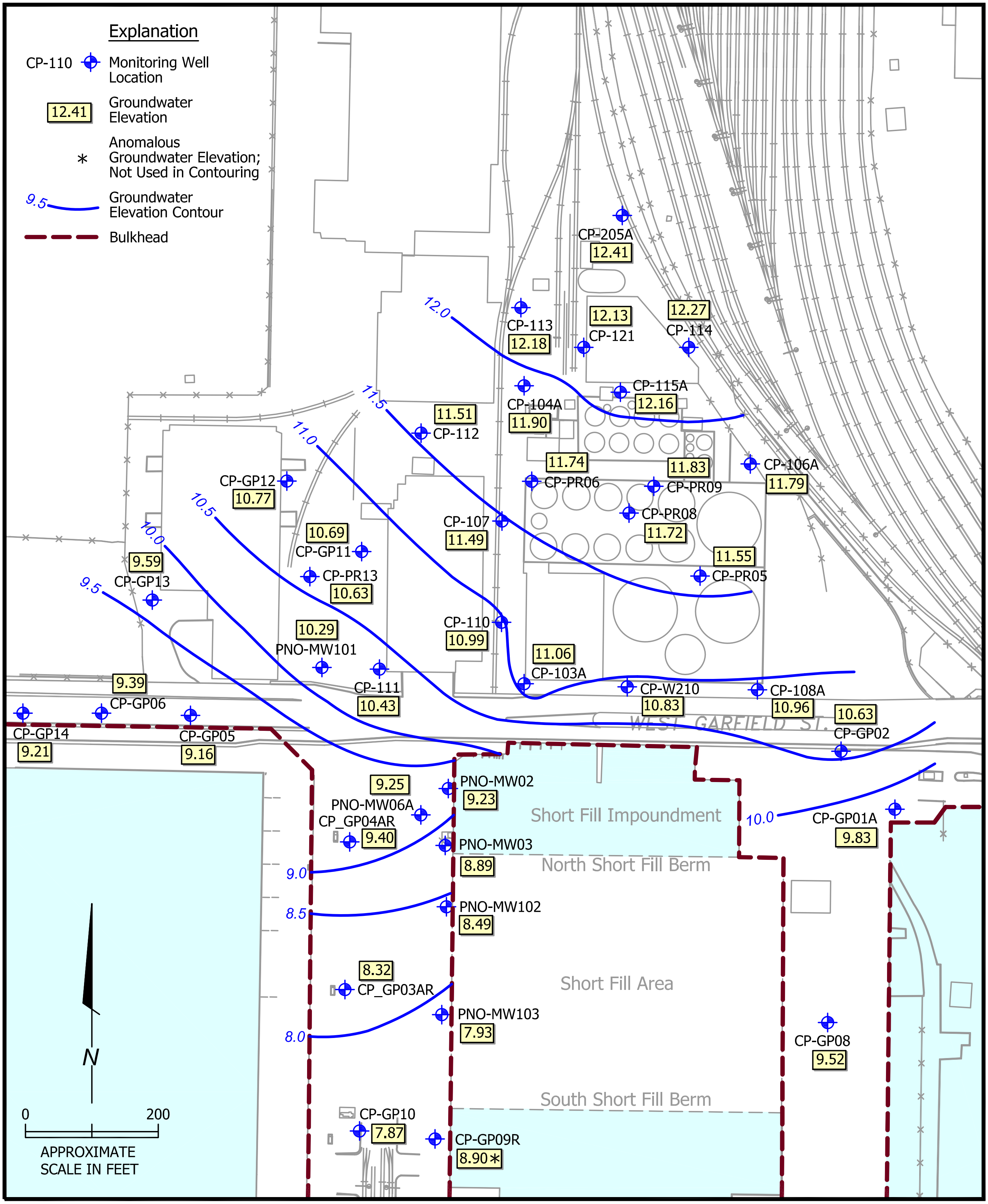
Pipeline Corridors
Port of Seattle Terminal 91
Seattle, Washington

FIGURE
6

JOB NUMBER	DRAWING NUMBER	REVIEWED BY	DATE
948.002.16.001	948-00216001_DCAP_4 6		2/10



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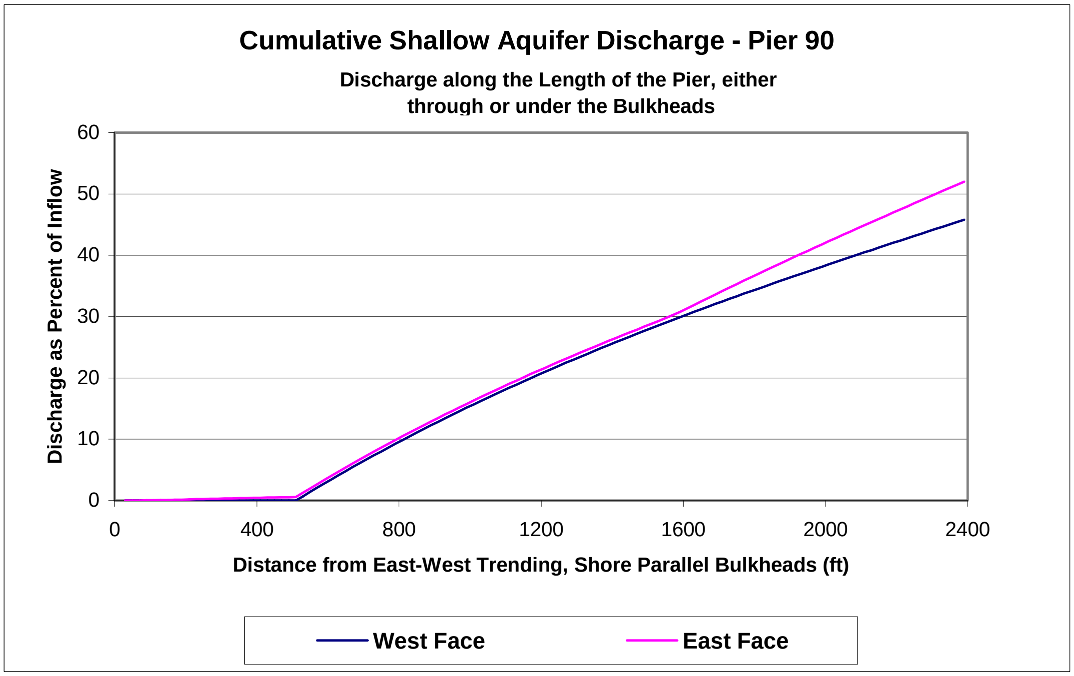
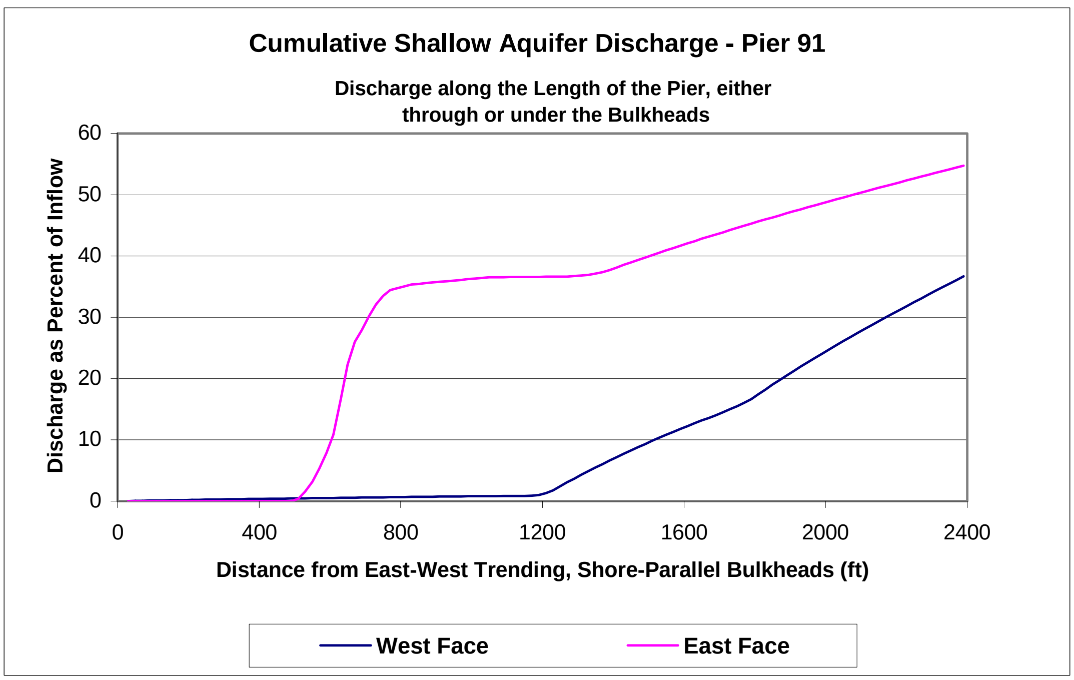
Shallow Aquifer Water Level Elevations - March 10, 2008
Port of Seattle Terminal 91 Tank Farm Site
Seattle, Washington

FIGURE 7

JOB NUMBER	DRAWING NUMBER	REVIEWED BY	DATE
948.002.16.001	948-00216001_DCAP_7		2/10





Source - Groundwater Seepage Evaluation Report (Aspect Consulting, 2004)

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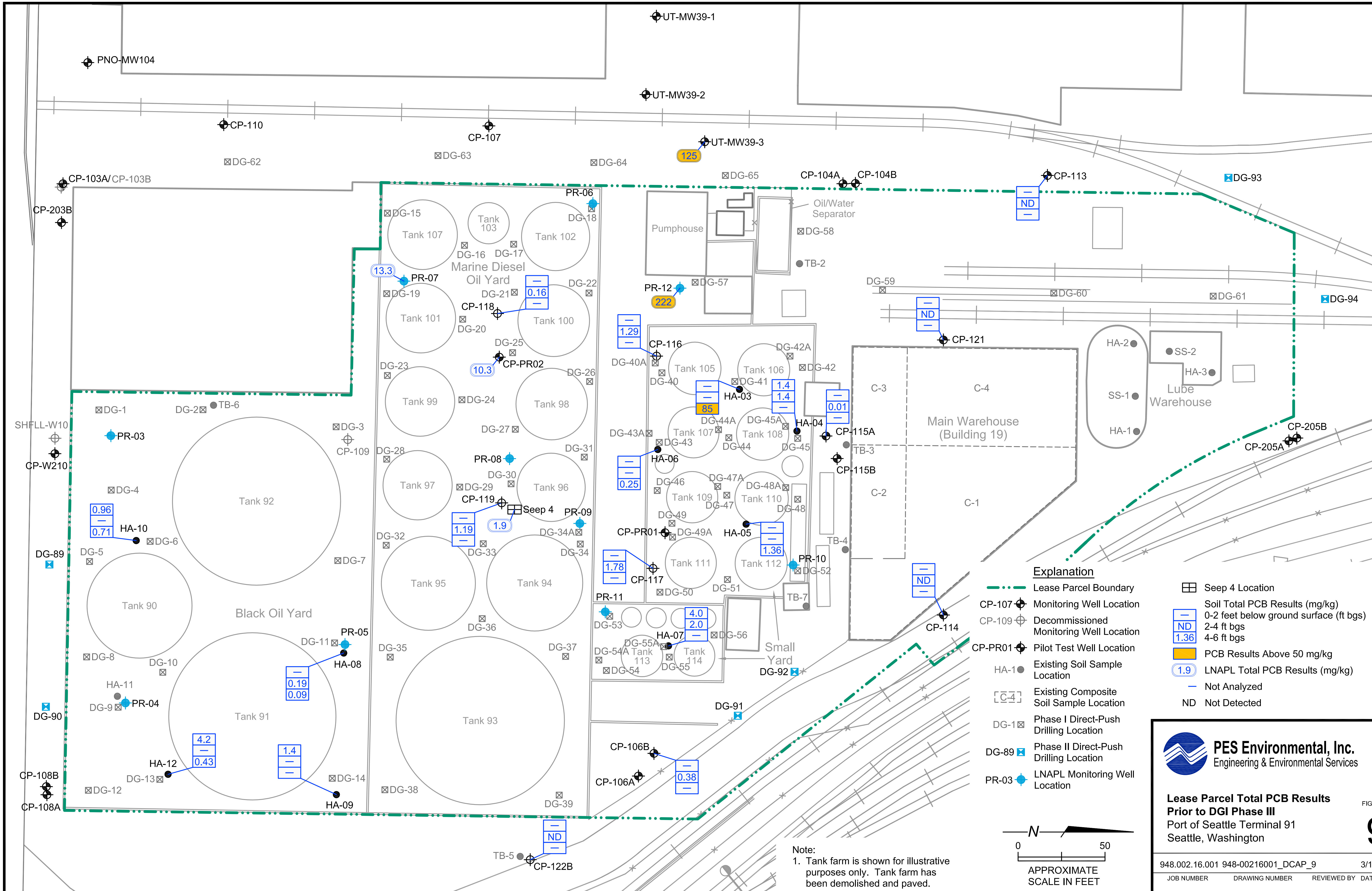
Shallow Aquifer Discharge, Piers 90 and 91
Port of Seattle Terminal 91
Seattle, Washington

FIGURE
8

948.002.16.001	948-00216001_DCAP_8		2/10
JOB NUMBER	DRAWING NUMBER	REVIEWED BY	DATE



Lease Parcel Total PCB Results
Prior to DGI Phase III
Port of Seattle Terminal 91
Seattle, Washington

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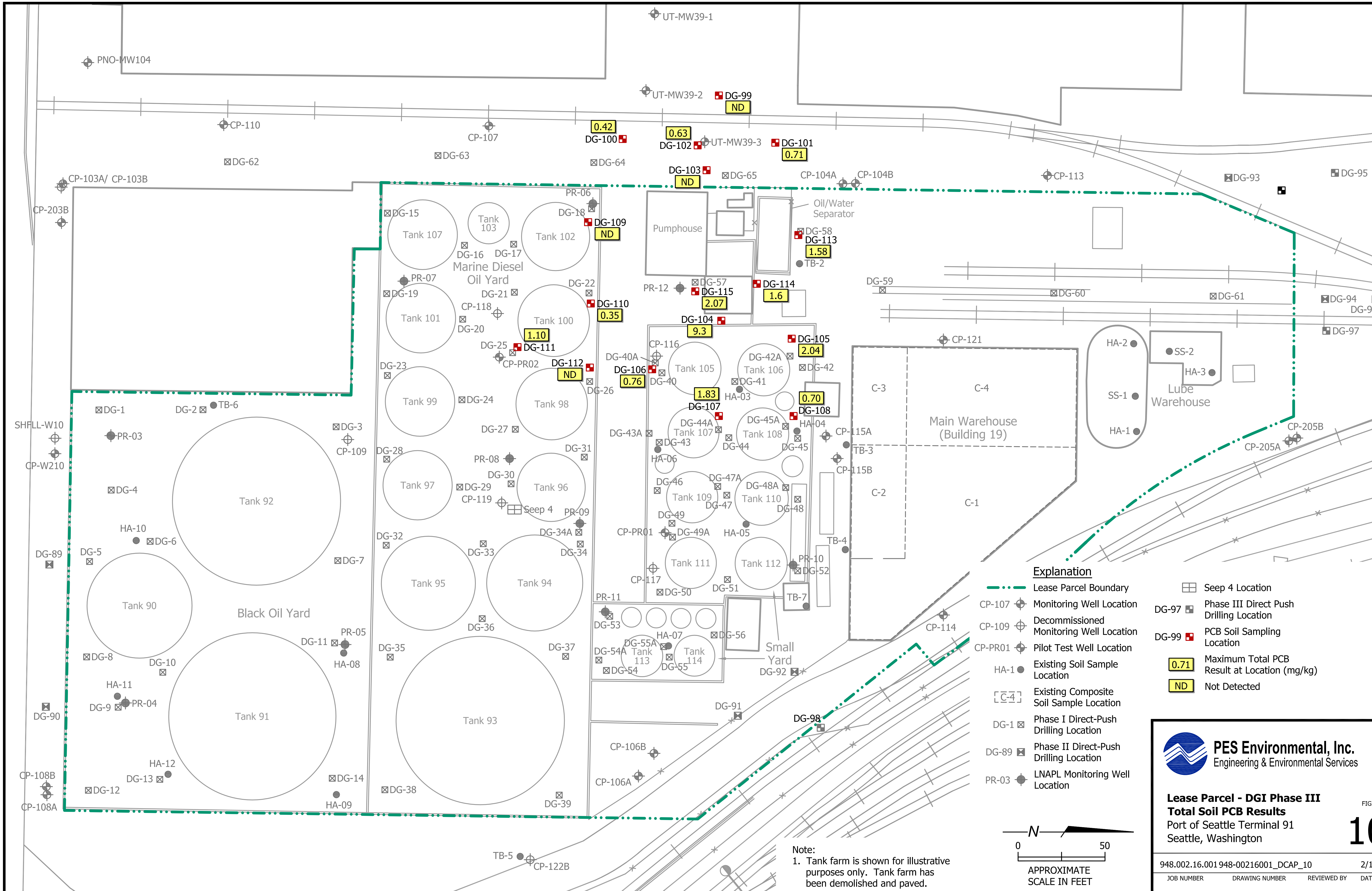
FIGURE 9

JOB NUMBER	DRAWING NUMBER	REVIEWED BY	DATE
948.002.16.001	948-00216001_DCAP_9		3/10



Note:

1. Tank farm is shown for illustrative purposes only. Tank farm has been demolished and paved.

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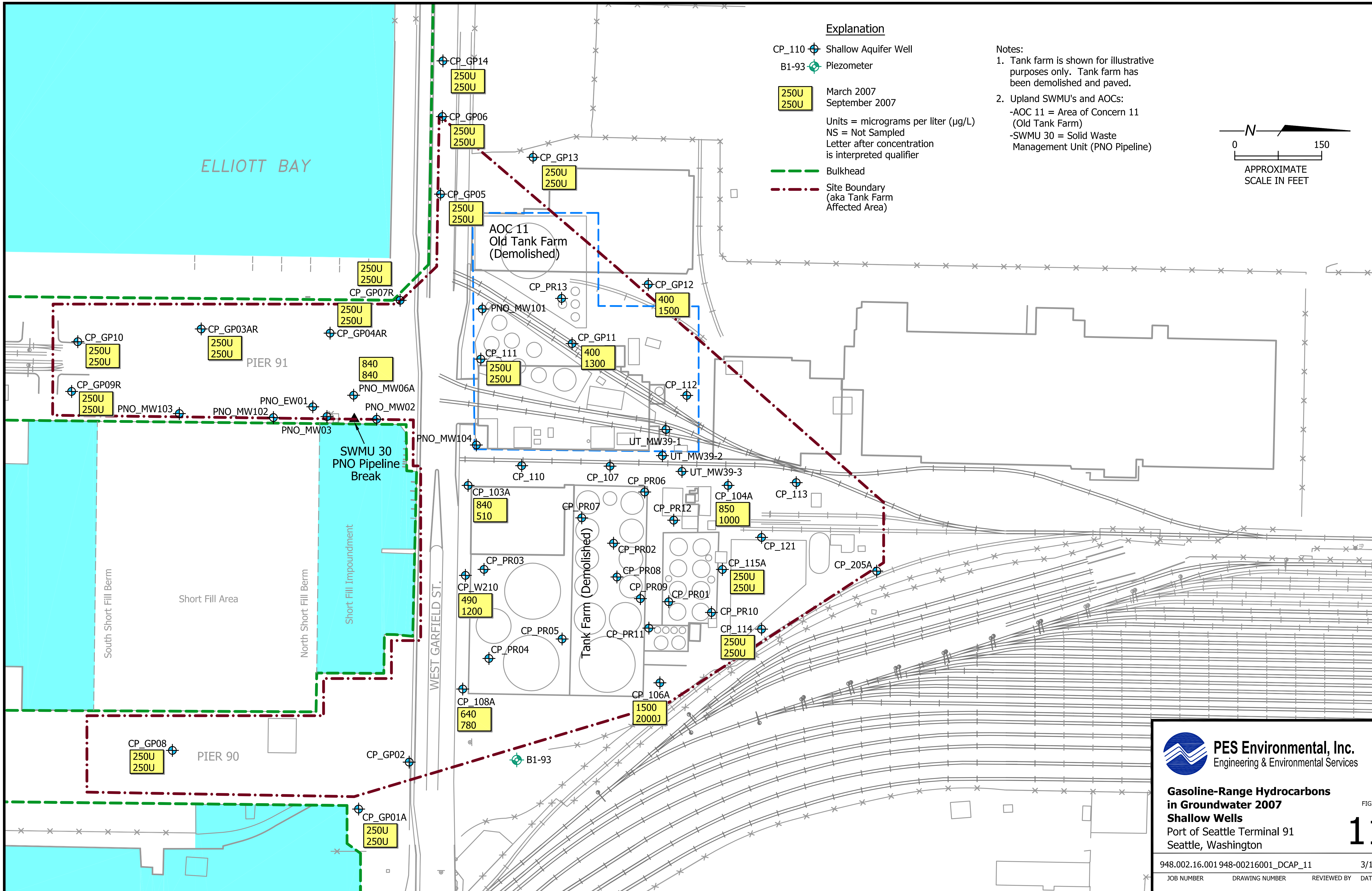
Lease Parcel - DGI Phase III
Total Soil PCB Results
Port of Seattle Terminal 91
Seattle, Washington

FIGURE
10

948.002.16.001	948-00216001_DCAP_10		2/10
JOB NUMBER	DRAWING NUMBER	REVIEWED BY	DATE



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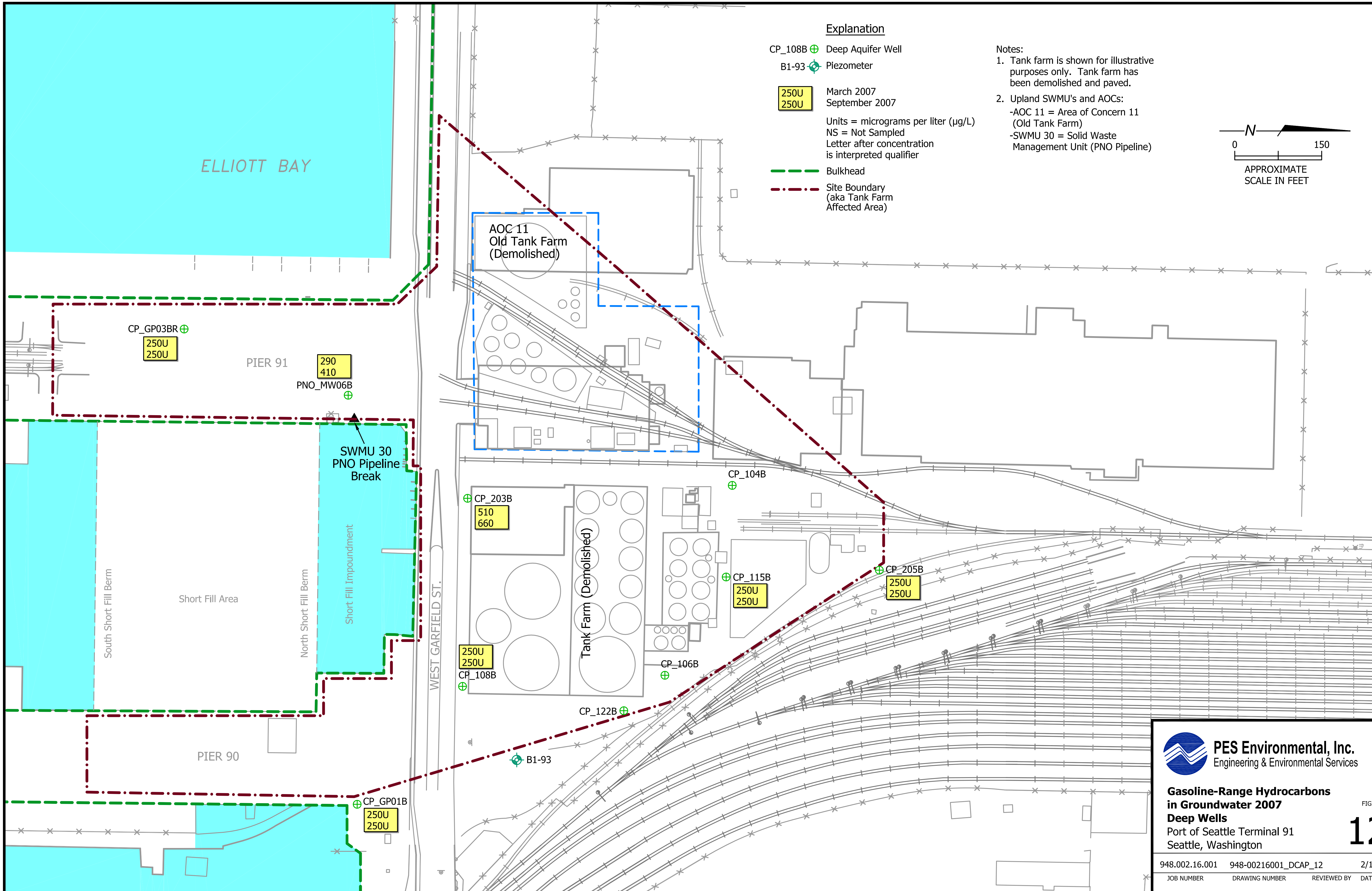
Gasoline-Range Hydrocarbons in Groundwater 2007 Shallow Wells
Port of Seattle Terminal 91
Seattle, Washington

FIGURE 11

JOB NUMBER	DRAWING NUMBER	REVIEWED BY	DATE
948.002.16.001	948-00216001_DCAP_11		3/10



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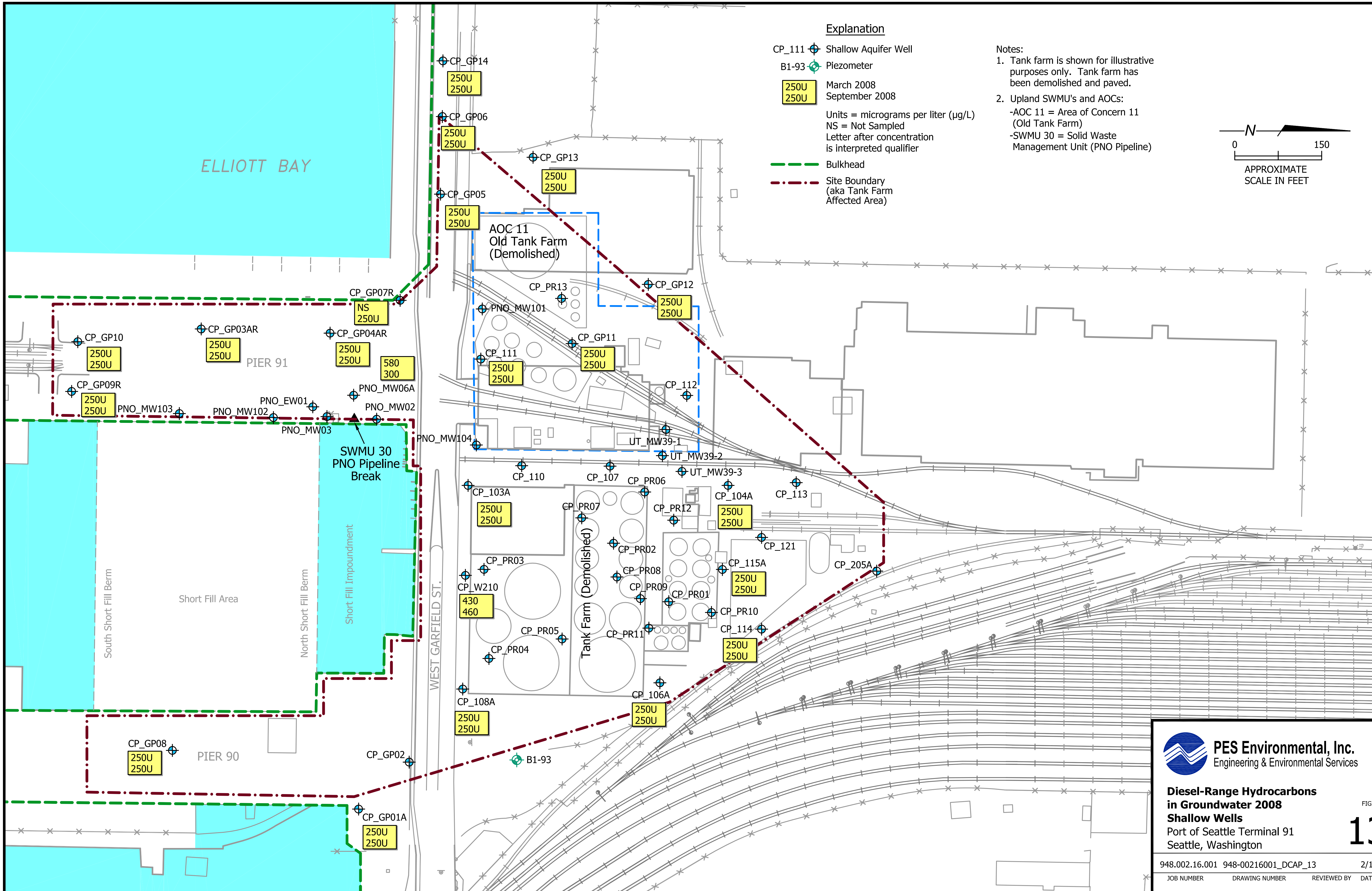
Gasoline-Range Hydrocarbons in Groundwater 2007
Deep Wells
Port of Seattle Terminal 91
Seattle, Washington

FIGURE
12

948.002.16.001	948-00216001_DCAP_12		2/10
JOB NUMBER	DRAWING NUMBER	REVIEWED BY	DATE

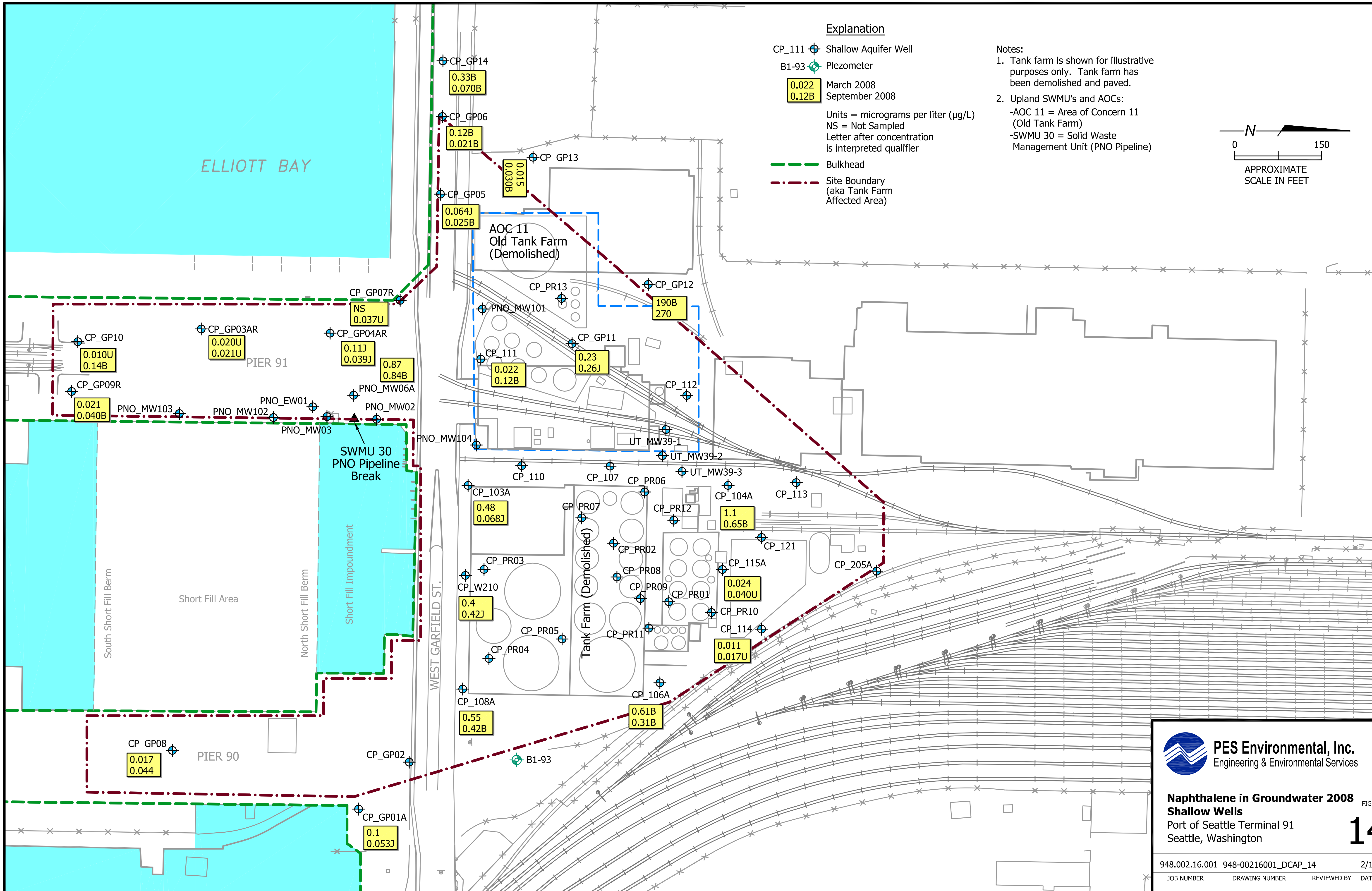


Diesel-Range Hydrocarbons in Groundwater 2008 Shallow Wells

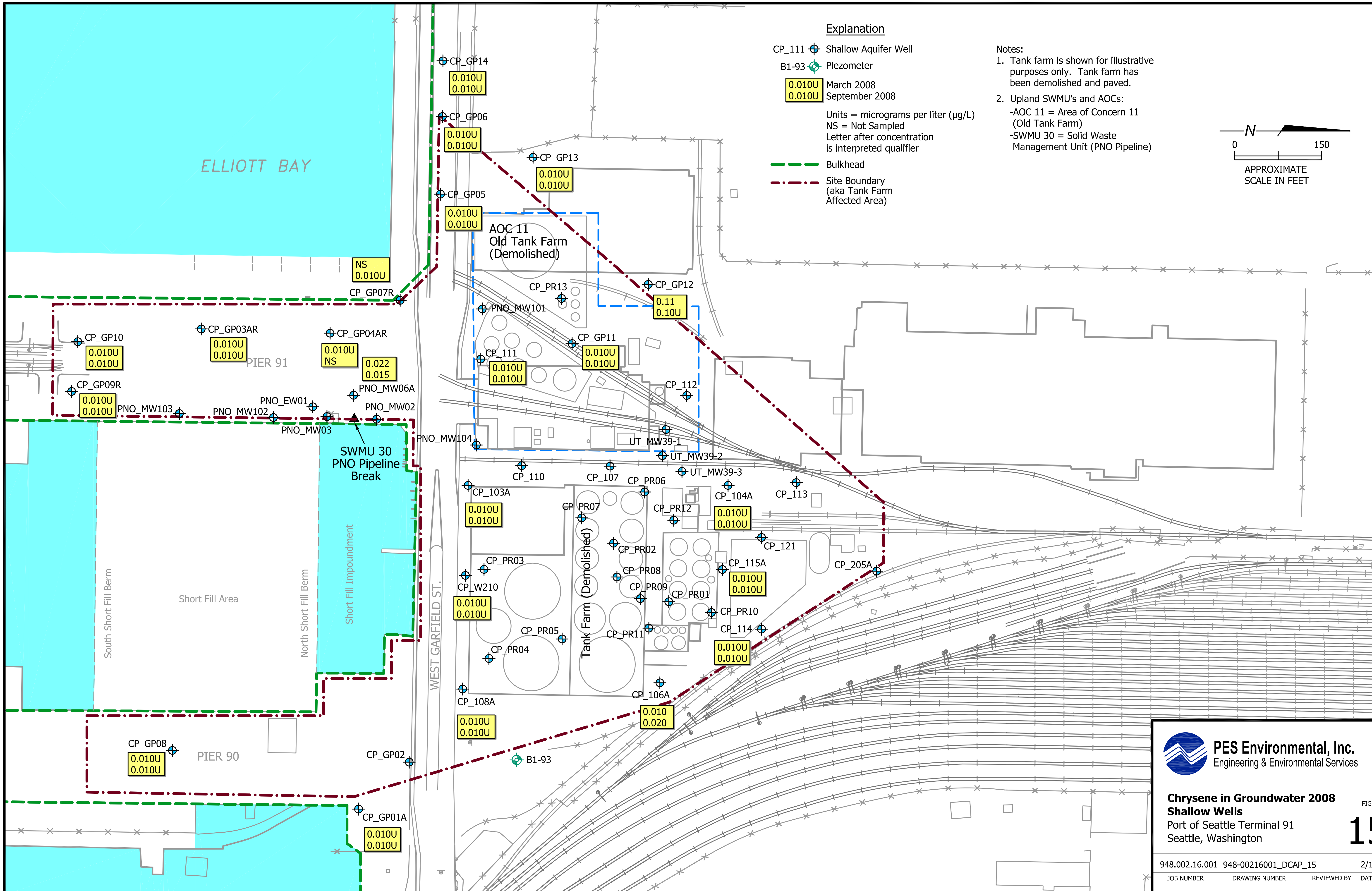
Port of Seattle Terminal 91
Seattle, Washington

FIGURE 13

JOB NUMBER	DRAWING NUMBER	REVIEWED BY	DATE
948.002.16.001	948-00216001_DCAP_13		2/10



Naphthalene in Groundwater 2008
Shallow Wells
Port of Seattle Terminal 91
Seattle, Washington



Explanation
CP_111 Shallow Aquifer Well
B1-93 Piezometer
0.010U March 2008
0.010U September 2008
Units = micrograms per liter (µg/L)
NS = Not Sampled
Letter after concentration is interpreted qualifier
Bulkhead
Site Boundary (aka Tank Farm Affected Area)
Notes:
1. Tank farm is shown for illustrative purposes only. Tank farm has been demolished and paved.
2. Upland SWMU's and AOCs:
-AOC 11 = Area of Concern 11 (Old Tank Farm)
-SWMU 30 = Solid Waste Management Unit (PNO Pipeline)
N
0
150
APPROXIMATE SCALE IN FEET
ELLIOTT BAY
PIER 91
PIER 90
Short Fill Area
South Short Fill Berm
North Short Fill Berm
Short Fill Impoundment
WEST GARFIELD ST.
AOC 11 Old Tank Farm (Demolished)
Tank Farm (Demolished)
SWMU 30 PNO Pipeline Break
CP_GP14 0.010U 0.010U
CP_GP06 0.010U 0.010U
CP_GP13 0.010U 0.010U
CP_GP05 0.010U 0.010U
CP_GP07R NS 0.010U
CP_GP12 0.11 0.10U
CP_PR13
PNO_MW101
CP_GP11 0.010U 0.010U
CP_111 0.010U 0.010U
CP_112
CP_GP10 0.010U 0.010U
CP_GP03AR 0.010U 0.010U
CP_GP04AR 0.010U NS
PNO_MW06A 0.022 0.015
CP_GP09R 0.010U 0.010U
PNO_MW103
PNO_EW01
PNO_MW102
PNO_MW03
PNO_MW02
PNO_MW104
UT_MW39-1
UT_MW39-2
UT_MW39-3
CP_110
CP_107
CP_PR06
CP_104A 0.010U 0.010U
CP_113
CP_103A 0.010U 0.010U
CP_PR07
CP_PR12
CP_121
CP_PR02
CP_PR03
CP_PR08
CP_115A 0.010U 0.010U
CP_205A
CP_W210 0.010U 0.010U
CP_PR09
CP_PR01
CP_PR10
CP_114 0.010U 0.010U
CP_PR05
CP_PR11
CP_PR04
CP_108A 0.010U 0.010U
CP_106A 0.010 0.020
CP_GP08 0.010U 0.010U
CP_GP02
B1-93
CP_GP01A 0.010U 0.010U
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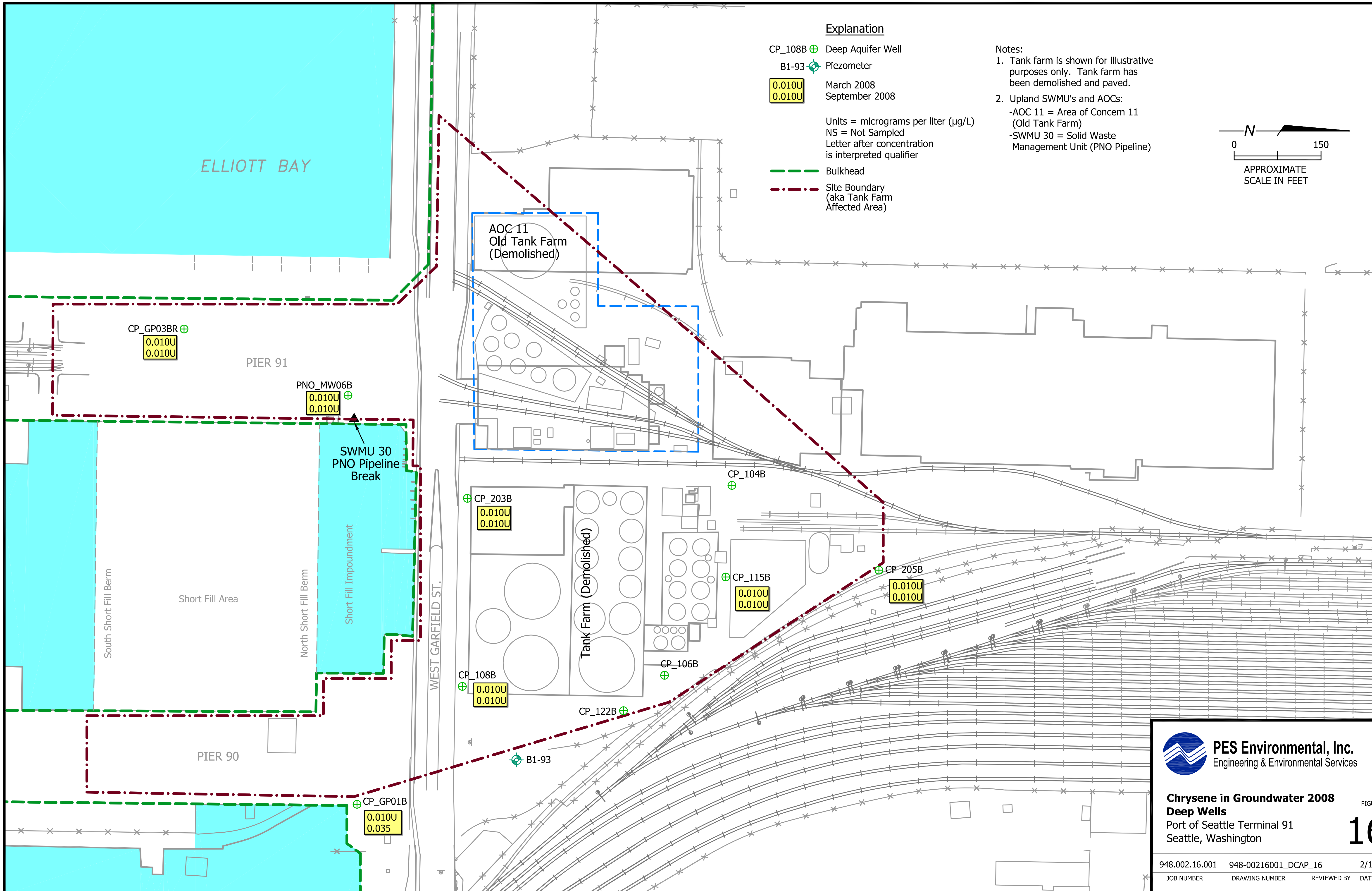
Engineering & Environmental Services
Chrysene in Groundwater 2008
Shallow Wells
Port of Seattle Terminal 91
Seattle, Washington
FIGURE
15
948.002.16.001
948-00216001_DCAP_15
2/10
JOB NUMBER
DRAWING NUMBER
REVIEWED BY
DATE



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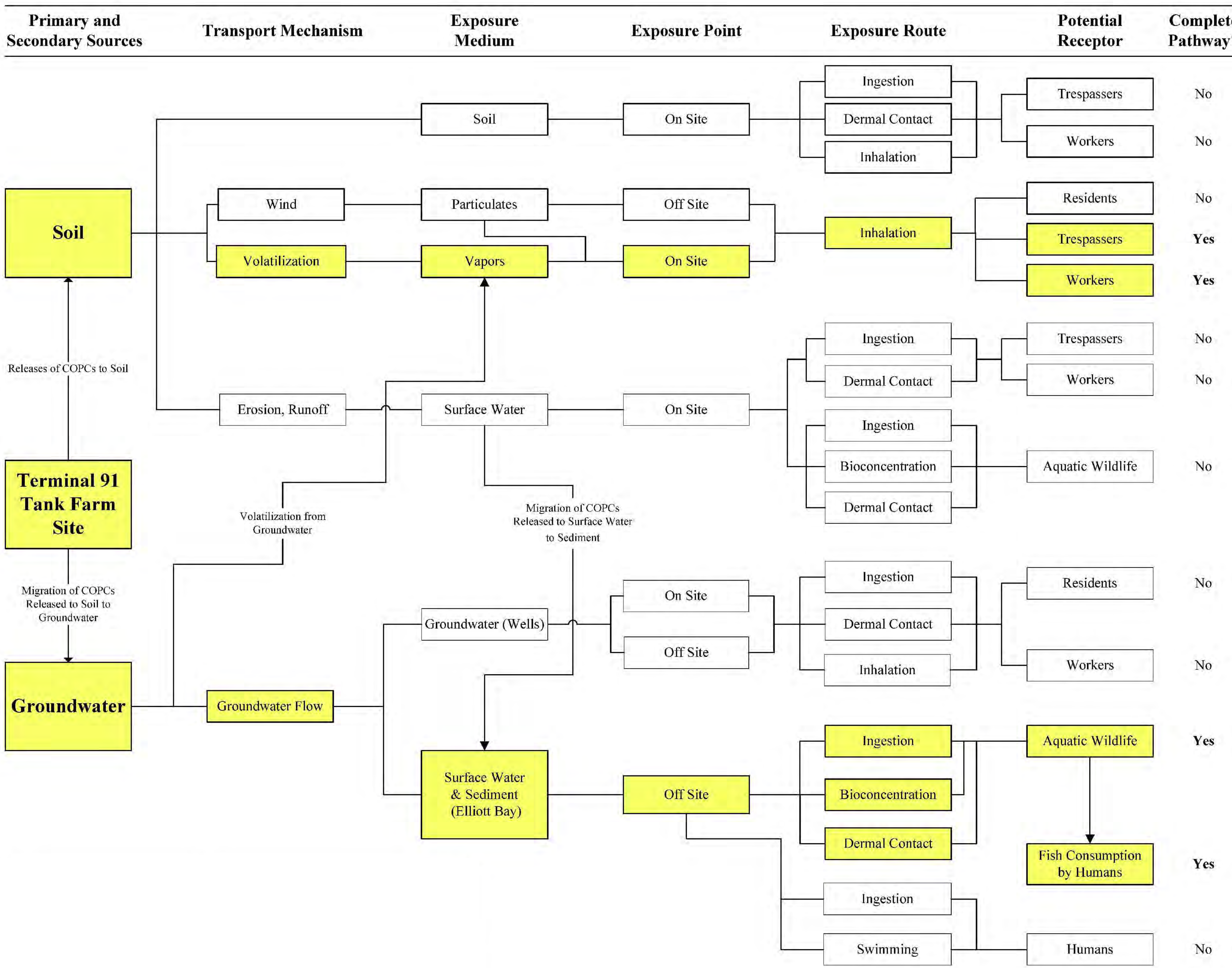
Chrysene in Groundwater 2008
Deep Wells
Port of Seattle Terminal 91
Seattle, Washington

FIGURE
16

JOB NUMBER	DRAWING NUMBER	REVIEWED BY	DATE
948.002.16.001	948-00216001_DCAP_16		2/10



Rationale

The site is almost completely paved or is covered by buildings. As an institutional control, the Port of Seattle will not demolish the pavement. Occasional workers (such as trench utility workers) with the potential to encounter impacted soil in trenches will be notified prior to those activities.

Inhalation of particulates is not a complete exposure pathway for off-site or on-site receptors because the site is almost completely paved or is covered by buildings. Inhalation of indoor air impacted by vapor intrusion from soil and/or vapor intrusion from groundwater is a potentially-complete exposure pathway for on-site current/future trespassers and for on-site current/future workers.

The site is almost completely paved or is covered by buildings, which minimizes erosion of soils. Storm water is either discharged to the sanitary sewer or collected in catch basins and discharged via storm drains, which further limits erosion from the site. The only surface water impoundment near the site is the short fill impoundment. The Port of Seattle plans to fill or cover the impoundment. As an institutional control, the Port of Seattle will not demolish the pavement.

Groundwater flows directly into Elliott Bay. There are no residents on or downgradient of the site. As an institutional control, the Port of Seattle will institute restrictive covenants to make this site permanently unavailable for drinking water use.

No drinking water source is available on site. As an institutional control, the Port of Seattle will institute restrictive covenants to make this site permanently unavailable for drinking water use. Workers with the potential to encounter groundwater in trenches will be notified prior to those activities.

Impacted groundwater/surface water may reach Elliott Bay and be taken up by aquatic wildlife in surface water and/or sediment.

Impacted groundwater/surface water may reach Elliott Bay and be taken up by aquatic wildlife in surface water and/or sediment which are then consumed by humans.

Elliott Bay is too saline to use as a drinking water supply. Due to the industrial nature of the site vicinity, recreational uses such as swimming are unlikely.

Source - "Conceptual Site Model, Terminal 91 Tank Farm Site," Pioneer Technologies Corporation

PES Environmental, Inc.
Engineering & Environmental Services

Conceptual Site Model
Port of Seattle Terminal 91 Tank Farm Site
Seattle, Washington

PLATE
17

948.002.06.008	948-00216001_DCAP_17		2/10
JOB NUMBER	DRAWING NUMBER	REVIEWED BY	DATE

Legend

- Shallow Standard Point of Compliance Well
- Shallow Standard and Conditional Point of Compliance Well
- Deep Standard Point of Compliance Well
- Deep Standard and Conditional Point of Compliance Well
- Background Well Locations
- SWMU 30 Location
- AOC 11 Boundary
- Upland Monitoring Well Used in Background Evaluation

Notes:

Model Toxic Control Act (MTCA)

Standard Point of Compliance as defined in MTCA WAC 173-340-720(8)(b)

Conditional Point of Compliance as defined in MTCA WAC 173-340-720(8)(c)

Shallow wells are screened at a maximum depth of 21 feet below ground surface.

Deep wells are screened at a maximum depth of 60 feet below ground surface.

Solid Waste Managment Unit (SWMU)

Area of Concern (AOC)

The tank farm is shown for illustrative purposes only. The above-ground portions of the tank farm were demolished and paved in 2005.

N

0 100 200 400 Feet

Map Reference: PIONEER Technologies Corporation, August 2008.

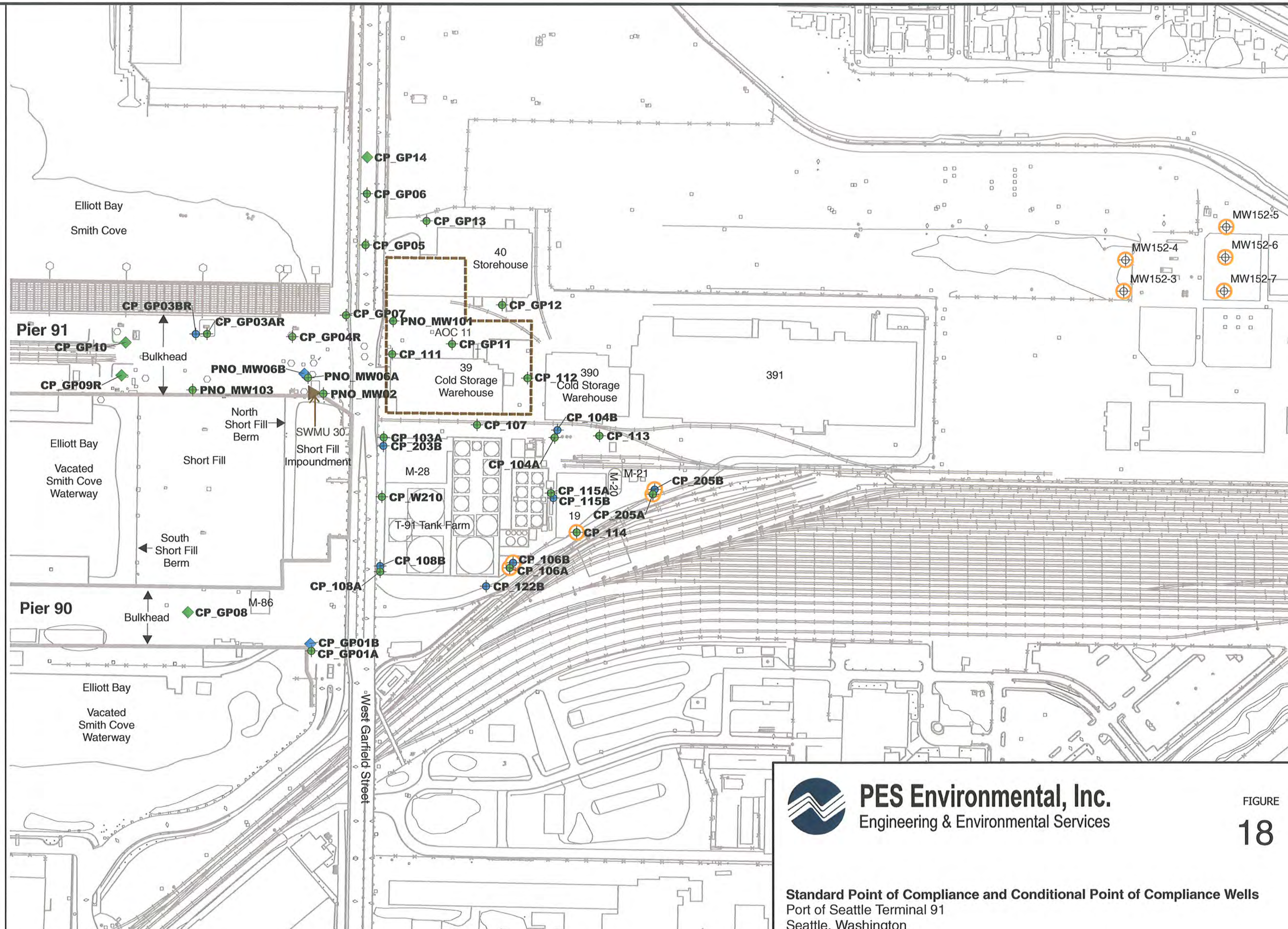


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FIGURE 18

Standard Point of Compliance and Conditional Point of Compliance Wells
Port of Seattle Terminal 91
Seattle, Washington

JOB NUMBER	DRAWING NUMBER	REVIEWED BY	DATE
948.002.16.001	948-00216001_DCAP_18		2/10

Legend

- Shallow SPOC Well With At Least One Exceedance of Final FS CUL
- Shallow Well Without Exceedances of Final FS CULs
- SWMU 30 Location
- AOC 11 Boundary

Notes:

Feasibility Study (FS)

Cleanup Level (CUL)

See Table 7-3 for a list of Final FS CULs.

Model Toxic Control Act (MTCA)

Standard Point of Compliance (SPOC) as defined in MTCA WAC 173-340-720(8)(b)

Shallow wells are screened at a maximum depth of 21 feet below ground surface.

Solid Waste Managment Unit (SWMU)

Area of Concern (AOC)

The tank farm is shown for illustrative purposes only. The above-ground portions of the tank farm were demolished and paved in 2005.

N

0 125 250 500 Feet

Map Reference: PIONEER Technologies Corporation, August 2008.

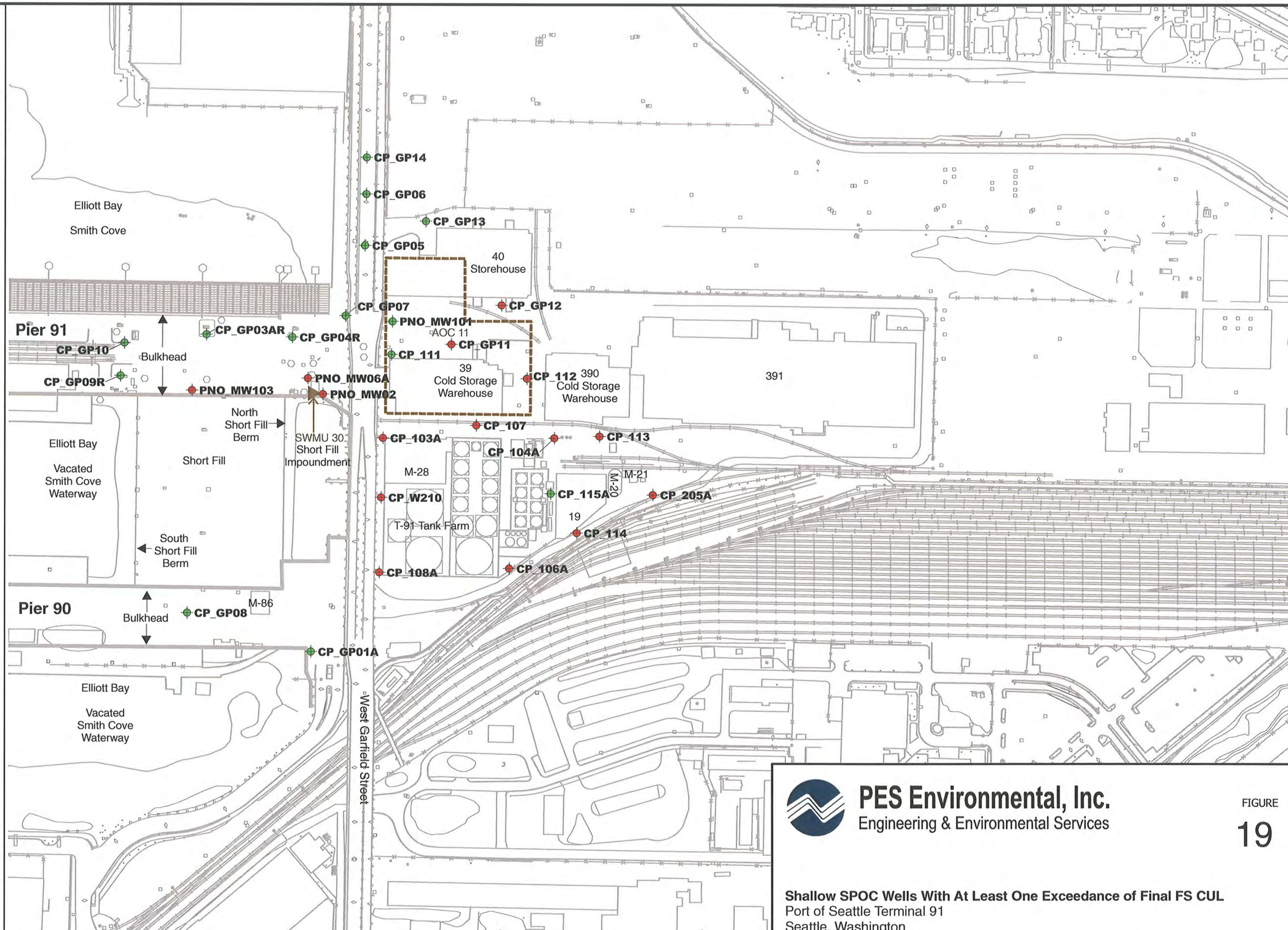

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FIGURE
19

Shallow SPOC Wells With At Least One Exceedance of Final FS CUL
Port of Seattle Terminal 91
Seattle, Washington

JOB NUMBER	DRAWING NUMBER	REVIEWED BY	DATE
948.002.16.001	948-00216001_DCAP_19		2/10

Legend

- Deep SPOC Well With At Least One Exceedance of Final FS CUL
- Deep Well Without Exceedances of Final FS CULs
- Background Well Locations
- SWMU 30 Location
- AOC 11 Boundary

Notes:

Feasibility Study (FS)

Cleanup Level (CUL)

See Table 7-4 for a list of Final FS CULs.

Model Toxic Control Act (MTCA)

Standard Point of Compliance (SPOC) as defined in MTCA WAC 173-340-720(8)(b)

Deep wells are screened at a maximum depth of 60 feet below ground surface.

Solid Waste Managment Unit (SWMU)

Area of Concern (AOC)

The tank farm is shown for illustrative purposes only. The above-ground portions of the tank farm were demolished and paved in 2005.

N

0 125 250 500 Feet

Map Reference: PIONEER Technologies Corporation, August 2008.

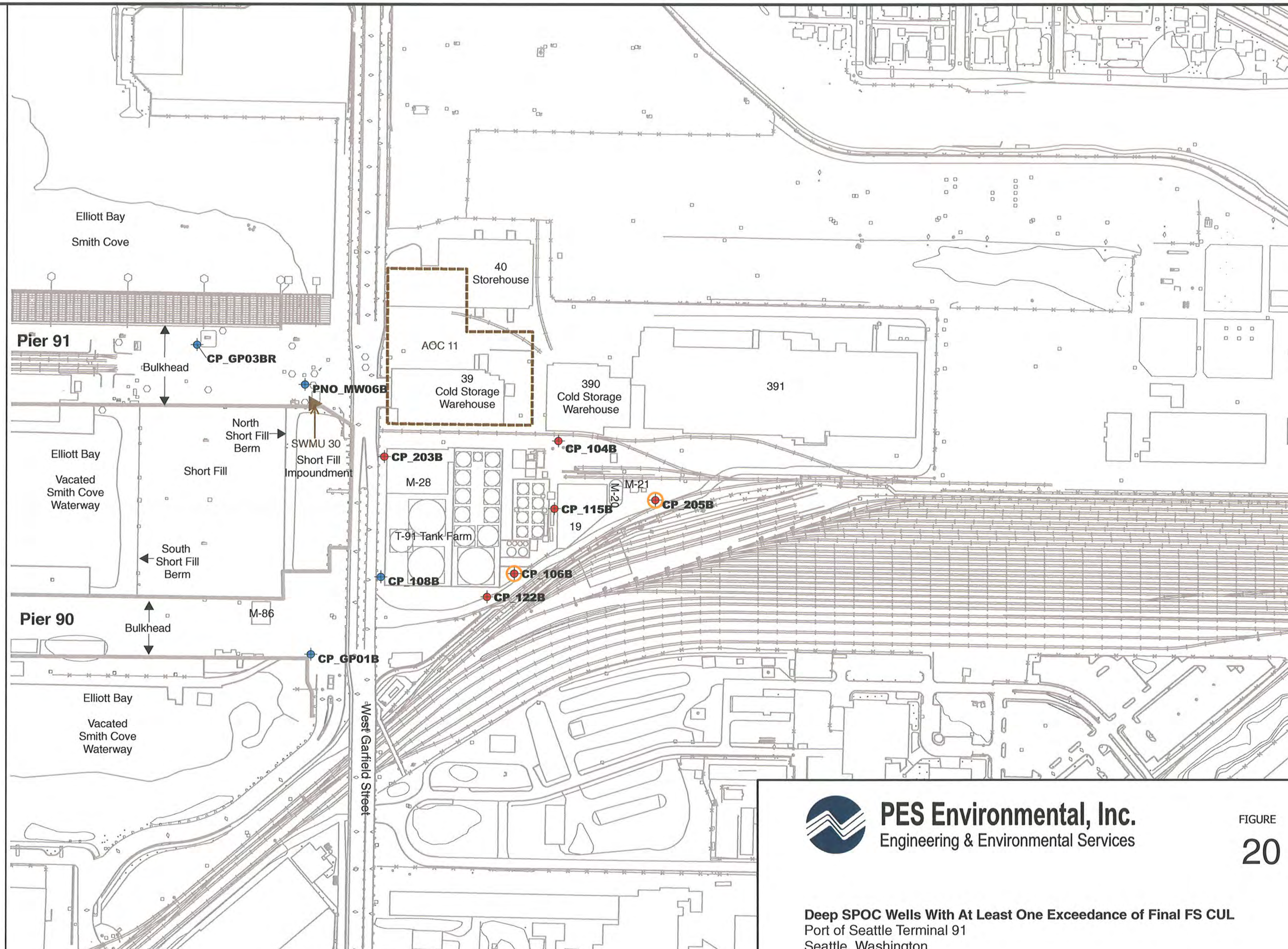

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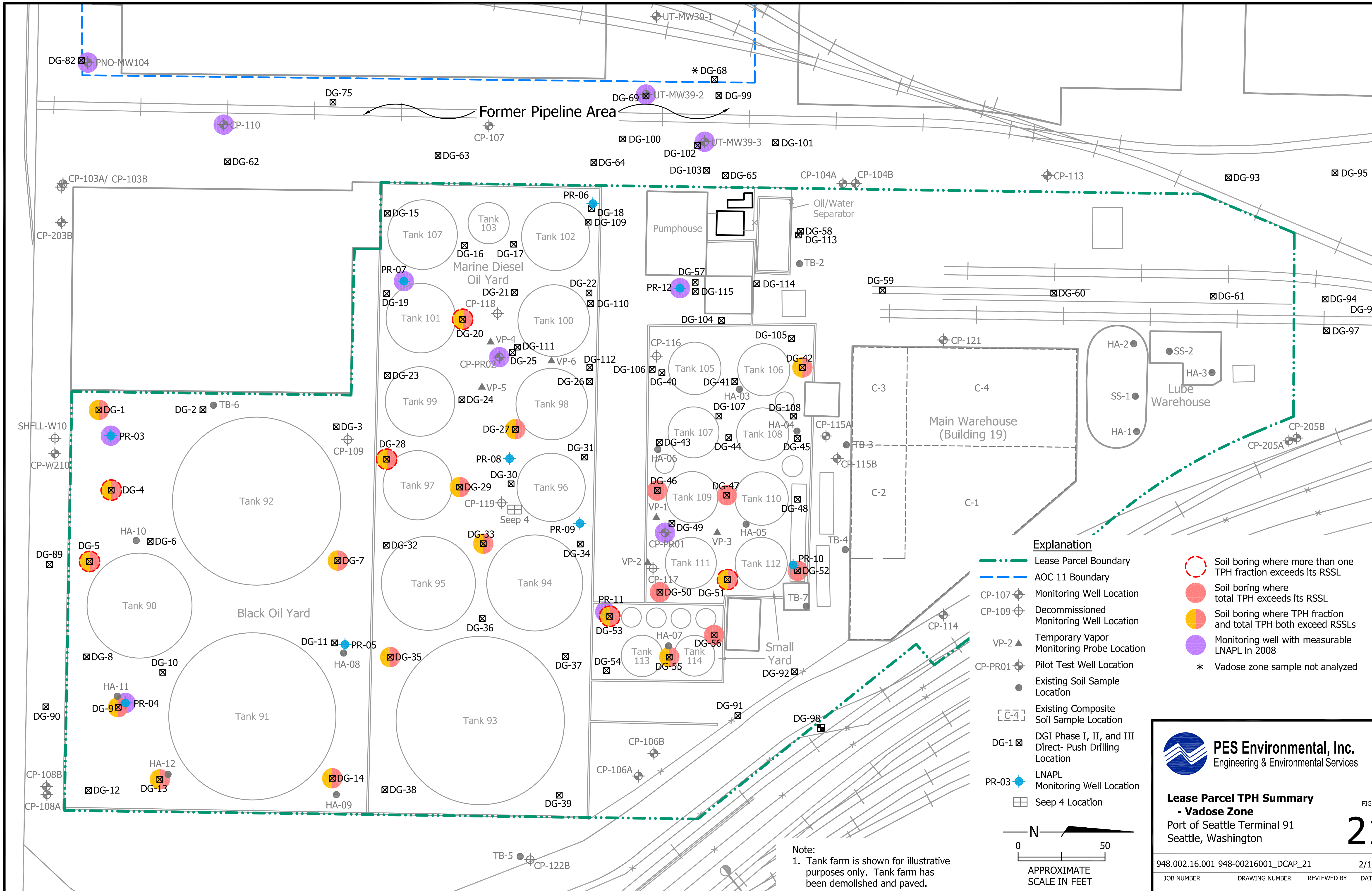
FIGURE 20

Deep SPOC Wells With At Least One Exceedance of Final FS CUL
Port of Seattle Terminal 91
Seattle, Washington

JOB NUMBER	DRAWING NUMBER	REVIEWED BY	DATE
948.002.16.001	948-00216001_DCAP_20		2/10



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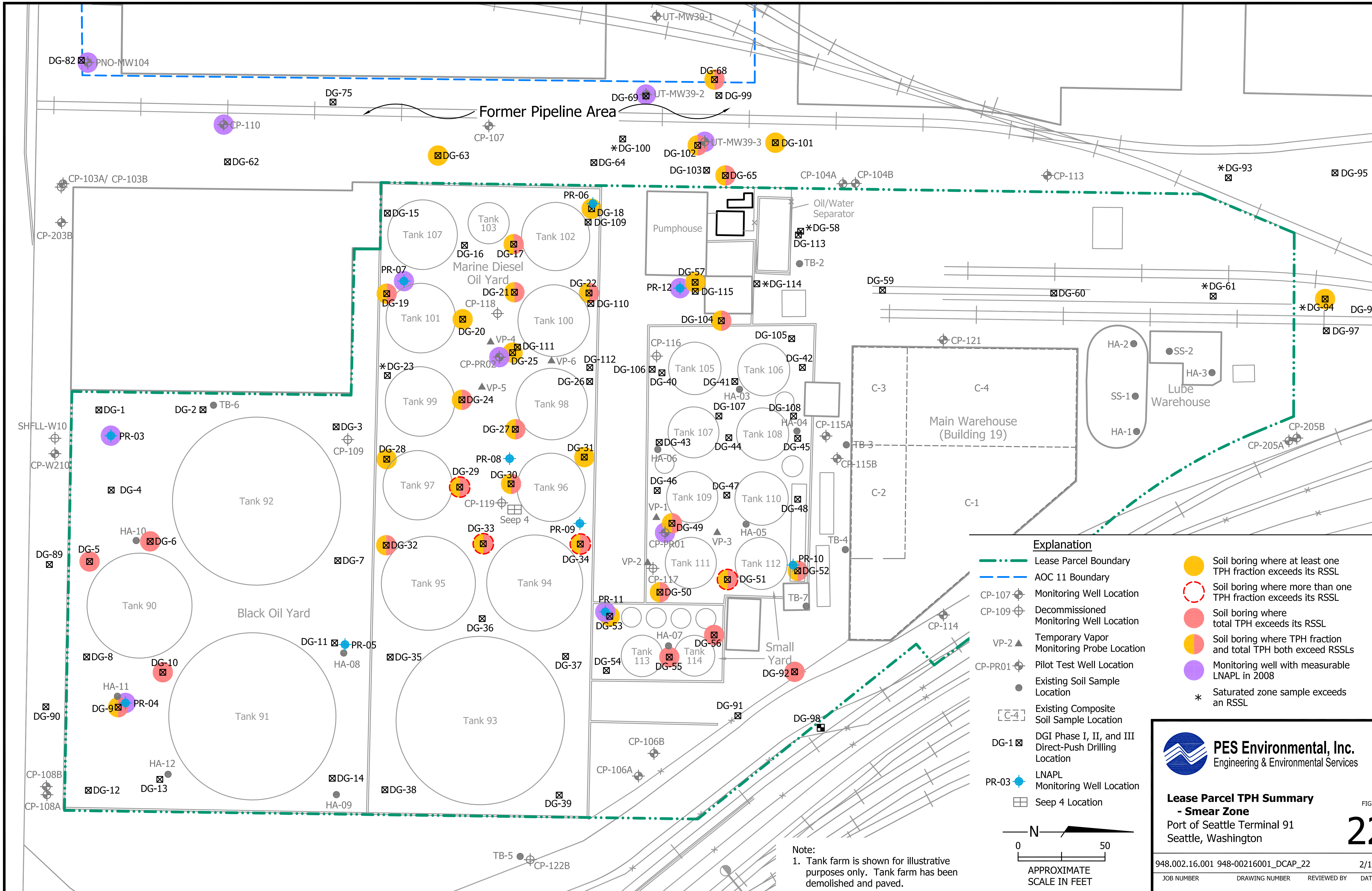
Lease Parcel TPH Summary
- Vadose Zone
Port of Seattle Terminal 91
Seattle, Washington

FIGURE
21

JOB NUMBER	DRAWING NUMBER	REVIEWED BY	DATE
948.002.16.001	948-00216001_DCAP_21		2/10



Former Pipeline Area
Marine Diesel Oil Yard
Black Oil Yard
Main Warehouse (Building 19)
Lube Warehouse
Pumphouse
Oil/Water Separator
Small Yard
Seep 4
Tank 90
Tank 91
Tank 92
Tank 93
Tank 94
Tank 95
Tank 96
Tank 97
Tank 98
Tank 99
Tank 100
Tank 101
Tank 102
Tank 103
Tank 105
Tank 106
Tank 107
Tank 108
Tank 109
Tank 110
Tank 111
Tank 112
Tank 113
Tank 114
C-1
C-2
C-3
C-4
Explanation
Lease Parcel Boundary
AOC 11 Boundary
CP-107 Monitoring Well Location
CP-109 Decommissioned Monitoring Well Location
VP-2 Temporary Vapor Monitoring Probe Location
CP-PR01 Pilot Test Well Location
Existing Soil Sample Location
C-4 Existing Composite Soil Sample Location
DG-1 DGI Phase I, II, and III Direct-Push Drilling Location
PR-03 LNAPL Monitoring Well Location
Seep 4 Location
Soil boring where at least one TPH fraction exceeds its RSSL
Soil boring where more than one TPH fraction exceeds its RSSL
Soil boring where total TPH exceeds its RSSL
Soil boring where TPH fraction and total TPH both exceed RSSLs
Monitoring well with measurable LNAPL in 2008
Saturated zone sample exceeds an RSSL
N
0
50
APPROXIMATE SCALE IN FEET
Note:
1. Tank farm is shown for illustrative purposes only. Tank farm has been demolished and paved.
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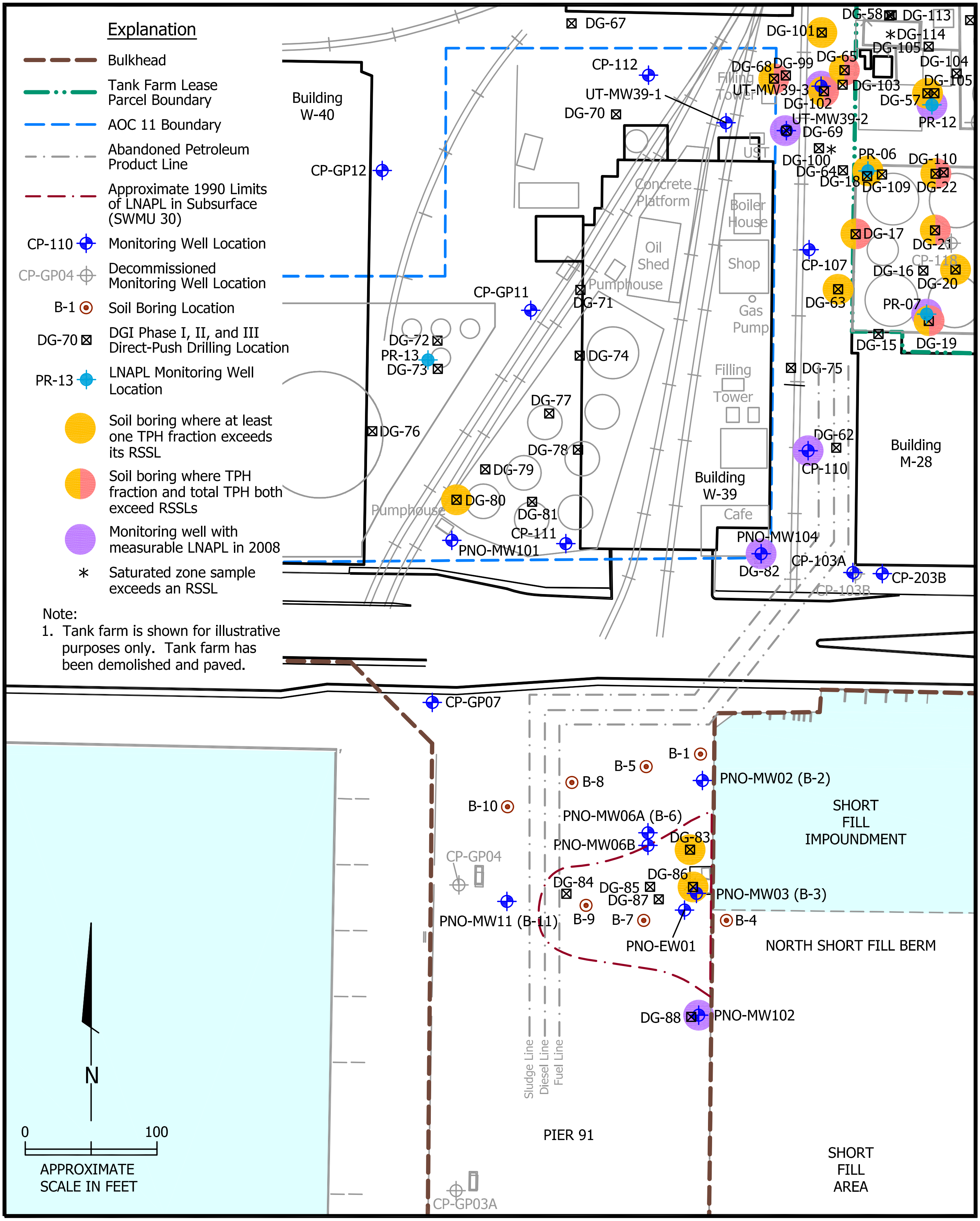
Lease Parcel TPH Summary - Smear Zone
Port of Seattle Terminal 91
Seattle, Washington
FIGURE
22
948.002.16.001
948-00216001_DCAP_22
2/10
JOB NUMBER
DRAWING NUMBER
REVIEWED BY
DATE



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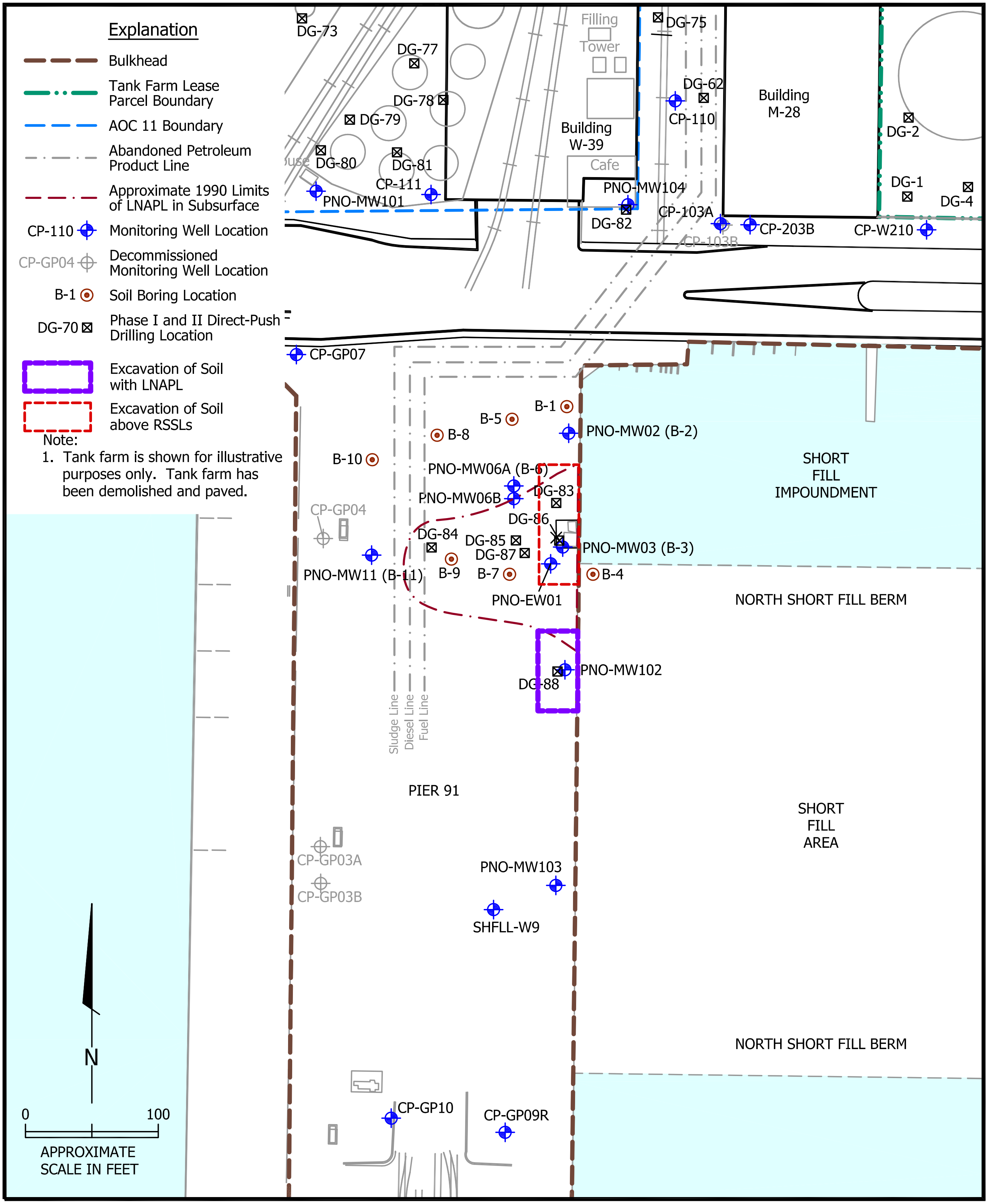
AOC 11 and SWMU 30 TPH Summary - Smear Zone
Port of Seattle Terminal 91
Seattle, Washington

FIGURE **23**

JOB NUMBER	DRAWING NUMBER	REVIEWED BY	DATE
948.002.16.001	948-00216001_DCAP_23		2/10



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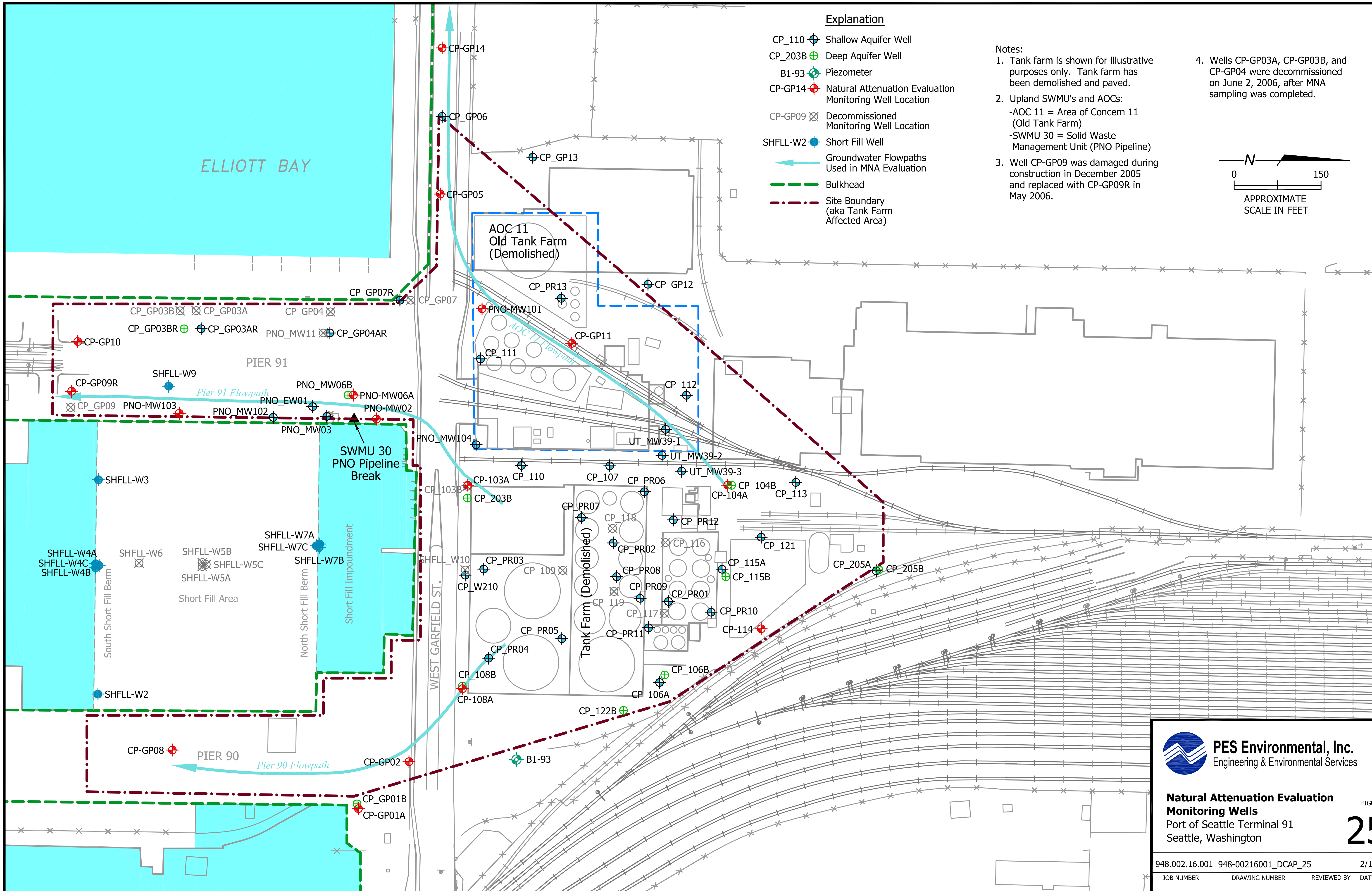
SWMU 30 - Limited Excavation
Port of Seattle Terminal 91
Seattle, Washington

FIGURE
24

948.002.16.001	948-00216001_DCAP_24		2/10
JOB NUMBER	DRAWING NUMBER	REVIEWED BY	DATE



Explanation
CP_110 Shallow Aquifer Well
CP_203B Deep Aquifer Well
B1-93 Piezometer
CP-GP14 Natural Attenuation Evaluation Monitoring Well Location
CP-GP09 Decommissioned Monitoring Well Location
SHFLL-W2 Short Fill Well
Groundwater Flowpaths Used in MNA Evaluation
Bulkhead
Site Boundary (aka Tank Farm Affected Area)
Notes:
1. Tank farm is shown for illustrative purposes only. Tank farm has been demolished and paved.
2. Upland SWMU's and AOCs:
-AOC 11 = Area of Concern 11 (Old Tank Farm)
-SWMU 30 = Solid Waste Management Unit (PNO Pipeline)
3. Well CP-GP09 was damaged during construction in December 2005 and replaced with CP-GP09R in May 2006.
4. Wells CP-GP03A, CP-GP03B, and CP-GP04 were decommissioned on June 2, 2006, after MNA sampling was completed.
N
0
150
APPROXIMATE SCALE IN FEET
ELLIOTT BAY
AOC 11
Old Tank Farm
(Demolished)
AOC 11 Flowpath
PIER 91
Pier 91 Flowpath
SWMU 30
PNO Pipeline
Break
PIER 90
Pier 90 Flowpath
Short Fill Area
South Short Fill Berm
North Short Fill Berm
Short Fill Impoundment
WEST GARFIELD ST.
Tank Farm (Demolished)
CP-GP14
CP_GP06
CP-GP05
CP_GP13
CP_GP12
CP_GP07R
CP_GP07
CP_GP03B
CP_GP03A
CP_GP04
CP_GP03BR
CP_GP03AR
PNO_MW11
CP_GP04AR
CP-GP10
CP-GP09R
CP_GP09
SHFLL-W9
PNO-MW103
PNO_MW102
PNO_EW01
PNO_MW03
PNO_MW06B
PNO-MW06A
PNO-MW02
PNO-MW101
CP_PR13
CP-GP11
CP_111
CP_112
PNO_MW104
UT_MW39-1
UT_MW39-2
UT_MW39-3
CP-103A
CP_103B
CP_203B
CP_110
CP_107
CP_PR06
CP_PR07
CP_118
CP_PR12
CP_104B
CP-104A
CP_113
CP_116
CP_PR02
CP_121
SHFLL-W3
SHFLL-W4A
SHFLL-W4C
SHFLL-W4B
SHFLL-W6
SHFLL-W5B
SHFLL-W5C
SHFLL-W5A
SHFLL-W7A
SHFLL-W7C
SHFLL-W7B
SHFLL_W10
CP_W210
CP_PR03
CP_109
CP_PR08
CP_PR09
CP_PR01
CP_115A
CP_115B
CP_205A
CP_205B
CP_119
CP_117
CP_PR10
CP_PR05
CP_PR11
CP-114
CP_PR04
CP_108B
CP-108A
CP_106B
CP_106A
CP_122B
SHFLL-W2
CP-GP08
CP-GP02
B1-93
CP_GP01B
CP-GP01A
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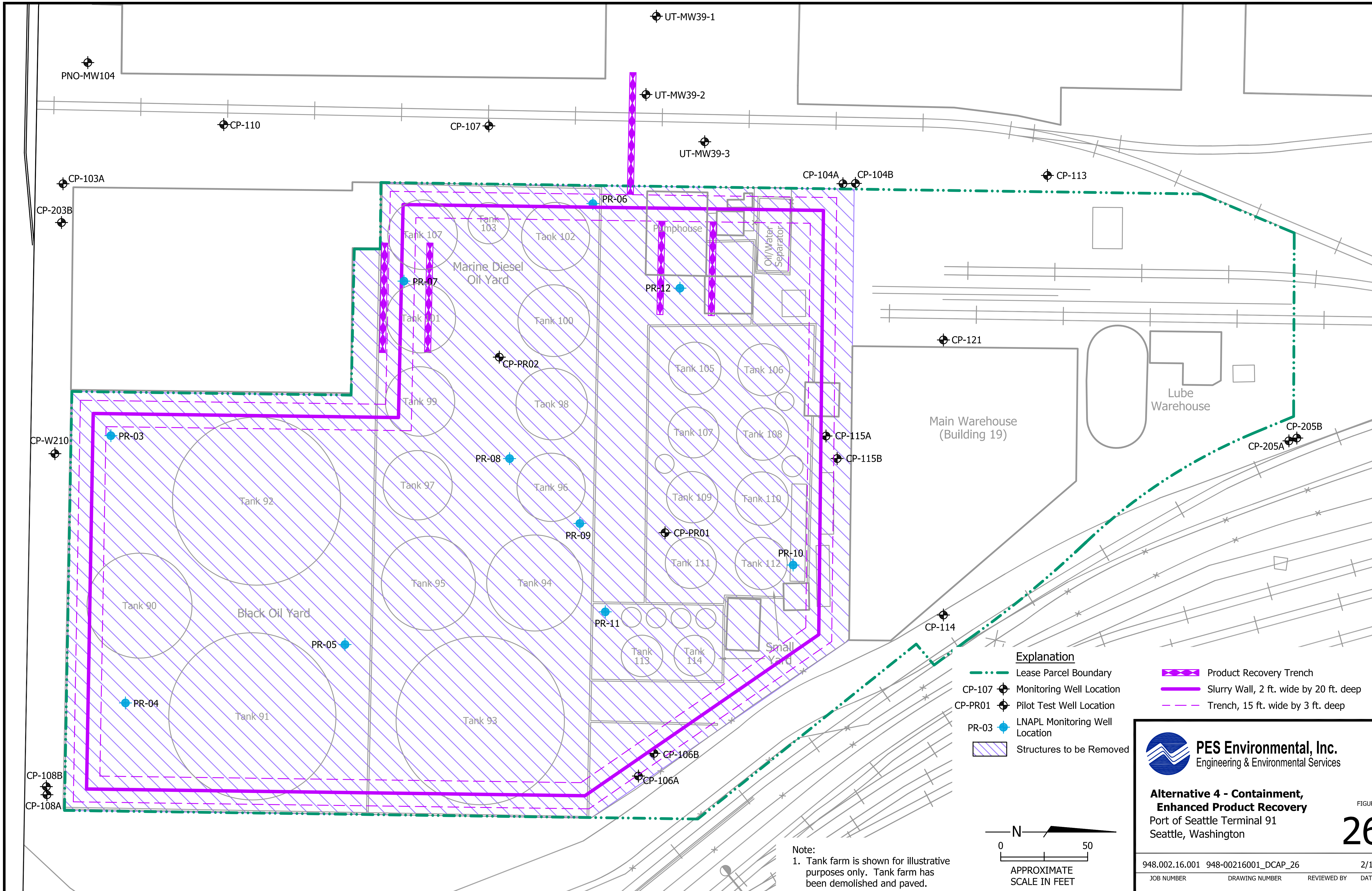
Natural Attenuation Evaluation
Monitoring Wells
Port of Seattle Terminal 91
Seattle, Washington
FIGURE
25
948.002.16.001 948-00216001_DCAP_25 2/10
JOB NUMBER DRAWING NUMBER REVIEWED BY DATE



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Alternative 4 - Containment, Enhanced Product Recovery
Port of Seattle Terminal 91
Seattle, Washington

FIGURE
26

JOB NUMBER	DRAWING NUMBER	REVIEWED BY	DATE
948.002.16.001	948-00216001_DCAP_26		2/10