Marine Trades Area Site
Port Angeles, Washington

Final
Remedial Investigation/ Feasibility Study

Prepared for

Marine Trades Area Group

Prepared by

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LIMITATIONS

This report has been prepared for the exclusive use of the Marine Trades Area Group*;* their authorized agents, and regulatory agencies. It has been prepared following the described methods and information available at the time of the work. No other party should use this report for any purpose other than that originally intended, unless Floyd|Snider agrees in advance to such reliance in writing. The information contained herein should not be utilized for any purpose or project except the one originally intended. Under no circumstances shall this document be altered, updated, or revised without written authorization of Floyd|Snider.

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List of Abbreviations and Acronyms

Acronym/ Abbreviation	Definition
ARAR	Applicable or relevant and appropriate requirement
AST	Aboveground storage tank
bgs	Below ground surface
BTEX	Benzene, toluene, ethylbenzene, and xylenes
CA	Cleanup Area
CAP	Cleanup Action Plan
Chevron	Chevron USA, Inc.
COC	Contaminant of concern
CSM	Conceptual site model
CUL	Cleanup level
Ecology	Washington State Department of Ecology
FS	Feasibility study
FSI	Floyd & Snider Inc.
FSM	Floyd Snider McCarthy, Inc.
GFM	Groundwater flux model
HAZWOPER	Health and Safety for Hazardous Waste Operations and Emergency Response
ISCO	In-situ chemical oxidation
ITT Rayonier	ITT Rayonier Corporation
J&E Model	Johnson & Ettinger Vapor Intrusion Model
Landau	Landau Associates, Inc.
LNAPL	Light non-aqueous phase liquid
MSL	Mean sea level
MTA	Marine Trades Area
MTA Site	Marine Trades Area Site
MTBE	Methyl tertiary butyl ether
MTCA	Model Toxics Control Act
NAVD88	North American Vertical Datum of 1988
NPDES	National Pollutant Discharge Elimination System
NRWQC	National Recommended Water Quality Criteria
ORCAA	Olympic Region Clean Air Agency
OSHA	Occupational Safety and Health Act
PCOC	Potential contaminant of concern
PCP	Pentachlorophenol
PID	Photoionization detector
POC	Point of compliance
Port	Port of Port Angeles
POTW	Publicly-owned treatment works
PRB	Permeable reactive barrier
QAPP	Quality Assurance Project Plan
QC	Quality control

Acronym/ Abbreviation	**Definition**
RAO	Remedial Action Objective
RI	Remedial investigation
RI/FS	Remedial investigation/feasibility study
SAP	Sampling and Analysis Plan
SCR	Site Characterization Report
SEPA	State Environmental Policy Act
SVE	Soil vapor extraction
SVOC	Semivolatile organic compound
TAP	Toxic air pollutant
TAME	Tertiary amyl methyl ether
TDS	Total dissolved solids
TEE	Terrestrial ecological evaluation
TPH	Total petroleum hydrocarbons
TPH-D	Diesel-range total petroleum hydrocarbons
TPH-G	Gasoline-range total petroleum hydrocarbons
UIC	Underground injection program
USEPA	U.S. Environmental Protection Agency
UST	Underground storage tank
VER	Vacuum-enhanced recovery
VOC	Volatile organic compound
WAC	Washington Administrative Code
WISHA	Washington Industrial Safety and Health Act

Geologist Certification

The geological and hydrogeological facts and conclusions within this document were prepared by or under my responsible charge and that to my knowledge and belief this document was prepared in accordance with the requirements of Chapter 18.220 RCW.

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1.0 Introduction

1.1 REGULATORY STATUS

This Remedial Investigation/Feasibility Study (RI/FS) report was prepared as a requirement of a 2005 Agreed Order No. DE 03TCPSR-5738 between the Washington State Department of Ecology (Ecology), the Port of Port Angeles (Port), and Chevron USA, Inc. (Chevron) (the "RI/FS Parties")[1]. The Marine Trades Area Site (MTA Site), located in Port Angeles, Washington (Figure 1.1) has had a long history of environmental investigations related to petroleum releases. The prior work is described in a Site Characterization Report (SCR; FSM 2003a).

Per the Agreed Order, the RI/FS Parties undertook a series of supplemental field investigations to fill data gaps identified in the RI work plan approved by Ecology. This supplemental work lasted until 2009. This document synthesizes all of the pre- and post Agreed Order data into a single RI report which is followed by a FS report. Based on the cumulative investigative work summarized in this report, Ecology determined that two separate areas of contamination with separate and distinct source areas existed within the MTA Site defined in the 2005 Agreed Order. As a result of the investigation completed to date, Ecology reached the decision to remove the eastern area of contamination and the K Ply property from the MTA site.

This RI/FS has been revised so that it supports remedy selection for western area of contamination only. This area will continue to be referred to as the MTA Site, but no longer includes the eastern area of contamination and the K Ply property. Elements of the RI/FS pertaining to the K Ply property; including text, tables, and figures; have been left in the document to support the decision to separate the eastern area of contamination and K Ply property into a separate site. The 2005 Agreed Order was amended to split the K Ply property from the MTA Site and to require a draft cleanup action plan for MTA Site. A new agreed order for the K Ply Site was signed in 2012 which requires that a separate RI/FS be prepared for the K Ply Site. Refer to Section 2.1. Ecology does not consider the RI/FS for the MTA Site to be a definitive report on environmental conditions at the K Ply property.

1.2 PUBLIC PARTICIPATION

A public participation plan was prepared by the RI/FS Parties in 2005. The plan explained the RI/FS activities to be conducted at the MTA Site and provided the public with the opportunity to learn about the site and provide comment and input on the site cleanup activities as required under WAC 173-340-600 of the Model Toxics Control Act (MTCA). No significant public comment was received. Ecology has prepared a new public participation plan associated with the 2013 MTA agreed order amendment.

1.3 ORGANIZATION OF RI/FS REPORT

The remainder of this report is organized as follows:

- **Section 2.0** defines the site boundaries and describes the complex history of the MTA Site and the various pre-2005 Agreed Order investigation activities.

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[1] The Marine Trades Area Group, which is providing funding for this RI/FS, consists of the Port of Port Angeles (Port), Chevron USA, Inc. (Chevron), and Atlantic Richfield Company (ARCO).

- **Section 3.0** describes the RI investigative activities that were performed per the 2005 Agreed Order.
- **Section 4.0** presents the findings of the RI and a synthesis of past and current data concerning the nature and extent of the contaminants of concern.
- **Section 5.0** identifies the contaminants of concern and describes the conceptual site model for the MTA Site.
- **Section 6.0** presents regulatory requirements for cleanup and proposed cleanup standards.
- **Section 7.0** identifies and screens various remedial technologies.
- **Section 8.0** describes the remedial alternatives identified for the MTA Site.
- **Section 9.0** presents a detailed analysis of the remediation alternatives.
- **Section 10.0** presents the preferred cleanup action alternative for the MTA Site.

2.0 Background

2.1 DEFINITION OF MTA SITE

The Marine Trades Area Site (MTA Site) is located in Sections 3 and 4, Township 30 North, Range 6 West, Willamette Meridian in Clallam County. Per the 2005 Agreed Order, the MTA Site comprised three areas:

1. The Marine Trades Area (MTA), a portion of the Port of Port Angeles east of Tumwater Creek where mostly marine-related trades, such as boat building or repair, currently occur.
2. The former K Ply plywood mill (K Ply Mill Building; also formerly operated as PenPly).
3. The Pettit Oil (former Chevron) bulk fuel plant.

The boundaries of these areas and the MTA Site are illustrated in Exhibit B of the May 17, 2005 Agreed Order as shown on Figure 2.1. As shown on this figure, the MTA Site boundaries are Tumwater Creek on the west, the Port Angeles Harbor shoreline on the north, the east side of the K Ply facility to the east, and Marine Drive to the south, with one parcel (currently Pettit Oil) at 638 Marine Drive on the south side of Marine Drive. The MTA Site boundaries were based on extensive prior investigations that identified known sources of petroleum hydrocarbons and other contaminants in this general area. The MTA Site is primarily of environmental concern due to legacy contamination from the large number of bulk fuel facilities with numerous pipelines and fuel storage tanks that occupied this area.

The MTA (a sub-area of the larger MTA Site), so named because of its use for maritime commerce such as boat building and repair, consists of several parcels where petroleum bulk fuel plants were formerly located. The western portion of the MTA was formerly known as the Port of Port Angeles Log Sort Yard and was the subject of a now-closed 1994 Agreed Order with Ecology.

As noted in Section 1.1, this RI/FS has been revised so that it can be considered complete for the contamination only on the west side of the MTA Site, which consists of the petroleum hydrocarbon-contaminated groundwater and soil lying under and downgradient of the Westport Marine facility and Pettit Oil. The contamination found on the east side of the MTA Site near and under the K Ply mill building is separate and distinct (i.e., not comingled) from that under the MTA. New boundaries for the MTA and K Ply Sites, established under the K Ply Agreed Order (DE 9546, Exhibit A) and proposed 2013 MTA Agreed Order Amendment, are included on Figure 2.2. Because this RI/FS was originally developed to include entire MTA Site, but now will only be considered a complete RI/FS for the west side of the MTA Site, it contains information concerning the K Ply Site that will be revised in a future RI/FS after the K Ply/PenPly mill has been demolished and additional characterization has been performed.

2.2 SITE DESCRIPTION AND CURRENT LAND USE

The MTA Site is a relatively flat land composed of approximately 21 acres located in a broad industrial area of Port Angeles adjacent to Port Angeles Harbor. Tumwater Creek defines the western boundary of the MTA Site and the K Ply property defines the eastern boundary. This RI/FS will be used to support remedy selection for the west side of the MTA Site only. At the northern edge of the MTA Site and K Ply Mill Building is a wooden bulkhead that is supported by riprap at the shoreline of Port Angeles Harbor; while the bulkhead is continuous, a right angle bend near the Port's Marine Terminal office, divides the bulkhead into a section in front of the MTA (referred to as the MTA Bulkhead) and a section in front of the former K Ply mill (K Ply Bulkhead). The ground surface elevation varies between approximately 14 and 17 feet above mean sea level (MSL) with the ground surface gently sloping toward Tumwater Creek and Port Angeles Harbor.

Much of the western half of the MTA (Lot 2) is owned and occupied by the Westport Marine facility, which was constructed in 2003. The facility consists of a metal frame building separated into three bays approximately 65 feet in height, with office space, storage areas, mechanical room, fabrication area, and tool room located south of the bays. Two of the bays are used for assembling large pleasure yachts and the third bay is used for painting. The bays are supported by concrete footings that extend approximately 30 inches below grade. The floor of the facility is a concrete slab-on-grade with a thickness up to 12 inches.

Platypus Marine (formerly Admiral Marine) currently uses the eastern half of the MTA (Lot 1) for repair of large yachts. Two permanent steel buildings, including a pile-supported structure built in 1995, are present as well as several large open air, fabric-covered sheds. A large portion of the ground surface in the eastern half of the MTA is unpaved. The K Ply Mill, located east of Cedar Street, was built in the 1941. Plywood and veneer manufacturing operations ceased in 2007 and were restarted in March, 2010 under new management and the name Peninsula Plywood Group, LLC (PenPly).

Many underground utilities are present in the MTA. Underground power is located beneath Cedar Street and below some eastern and northern portions of the property. Water supply pipes are located beneath Marine Drive, Cedar Street, Tumwater Street, and the former alley location north of Marine Drive, including a large 48-inch industrial water supply line oriented east-west beneath the southern portion of the MTA and the alley between K Ply and Peninsula Fuel Company. This supply pipe is located in the approximate area of the original shoreline prior to the placement of fill on tidelands at the MTA Site earlier in the century. Sanitary sewers are located beneath Marine Drive, Cedar Street and the eastern portion of the former alley located north of Marine Drive. Formerly, petroleum supply piping crisscrossed the area; however, most of the known piping has been removed. Storm and sewer drains are located beneath Marine Drive. Two catch basins, an oil/water separator and a storm drain were constructed in 1996 in the portion of the MTA used by Platypus Marine. The catch basins are located approximately 40 feet south of the west end of the maintenance building. A storm drain runs from these catch basins southeast to Cedar Street and northeast beneath Cedar Street to the harbor. An oil/water separator was also installed in 1996 on the western half of the MTA to drain water from log storage operations. Effluent from this oil/water separator was directed to Tumwater Creek. The oil/water separator was removed when the Westport Marine facility was constructed.

Currently at the Westport Marine facility, stormwater roof runoff discharges at two locations. The stormwater, which drains the east side of the Westport facility roof, discharges to the main stormwater conveyance pipe running down Cedar Street. The Cedar Street storm drain discharges to the harbor just east of the Travel Lift Pier at the western edge of the K Ply Bulkhead. The stormwater draining the west side of the Westport facility roof collects in catch basins along Tumwater Street and discharges into Tumwater Creek. Stormwater roof runoff from the Port's Marine Terminal office discharges to the Harbor at two locations. A single catch basin located south of the Terminal Warehouse discharges to the harbor in the rip rap below Terminal 3. Also, a second single catch basin located directly south of Terminal 3 discharges to the Harbor in the rip rap below Terminal 3. Stormwater roof runoff at Platypus Marine discharges through an oil/water separator to the main stormwater conveyance system running below Cedar Street, then discharges to the Harbor. The Westport Marine Facility, Port's Marine Terminal, and K Ply discharges are all currently regulated under the National Pollution Discharge Elimination System (NPDES) Industrial Stormwater General Permit, and Platypus Marine is regulated under a NPDES Boatyard Stormwater General Permit. Stormwater directed to storm sewers that discharge to surface water, therefore, is primarily from roof runoff or paved surfaces that prevent contact with soil. In unpaved areas of the MTA and K Ply sites, stormwater infiltrates through gravel.

Tumwater Creek originates in the uplands to the south of the MTA Site and flows north through a culvert located beneath Marine Drive, Tumwater Street, and along the western boundary of the MTA Site. Between the discharge end of the culvert and the harbor, Tumwater Creek is confined between concrete bulkheads and appears to have a gravelly soil bottom. As explained in Section 4.5.1 below, Tumwater Creek is a "losing" stream (i.e., surface water generally discharges to groundwater).

A continuous wooden bulkhead separates the northern boundaries of the MTA and K Ply Property from Port Angeles Harbor. Construction drawings obtained from the Port indicate that the bulkhead was constructed in the 1920s to hold back the hydraulic dredge fill used to raise the MTA Site from marine tidelands to its current elevation. The construction drawings indicate that the bulkhead is not a single structure but rather a set of two to three parallel "stepped" bulkheads (two-step, three-step) separated from each other by 16 feet. Each bulkhead "step" is constructed of horizontal wooden planking nailed to rows of creosoted pilings. Each step is 6 to 8 feet lower than the next. Two to three steps were necessary to raise the MTA Site in stages from the variable pre-existing natural tideland elevations to approximately 16 feet above MSL.

Pettit Oil occupies a 1/2 acre site approximately 800 feet from the shoreline. It has been in operation as a bulk fuel and lubricant storage and distribution facility for over eighty years. It consists of an office and warehouse. In 2010, 11 empty aboveground storage tanks (ASTs) on the south side of the facility were removed due to damage by a 2009 flooding event.

2.3 SITE OPERATIONAL HISTORY

The following paragraphs on site operational history are based on a prior report on past site use (FSM 2002). Refer to that document for additional details on the operational history of the MTA Site. Figure 2.3 is a depiction of historical operations.

Prior to being filled by dredge sands in the mid-1920s, the area of the MTA Site and neighboring properties was a tidal flat with several small operating wood mills. The Port's log yard operations began in this area in approximately 1926. At approximately the same time, Standard Oil constructed a wooden pier at the Port for oil-barge unloading activities (Standard Oil Dock). In 1946, Standard Oil constructed their bulk fuel plant in the northwest portion of the Port's log yard, immediately south of their dock facilities (Standard Oil Dock Bulk Plant).

From the mid-1920s to mid-1960s, the area was further developed with the construction of the Peninsula Plywood (PenPly) facility in 1941 east of the Port's log yard area. An addition to the main mill building was constructed on the south end of the building on a raised concrete slab between 1955 and 1964. The facility was operated as a plywood and veneer manufacturing facility as PenPly from 1941 through 1989 (from 1971 to 1989 by ITT Rayonier), and as K Ply from 1989 through 2007. Plywood and veneer manufacturing operations were halted between 2007 and 2010, at which time the facility was re-opened as PenPly under new management.

A total of eight bulk fuel plants operated in the general area during this period as well, two of which were located west of Tumwater Creek (Figure 2.3). Chevron's predecessor, Standard Oil, in addition to the Standard Oil Dock, operated a bulk fuel plant south of Marine Drive, in the location of present-day Pettit Oil at 638 Marine Drive (refer to Figure 2.3). ARCO's predecessor, Richfield Oil, operated a bulk fuel plant across Marine Drive (and downgradient) from the Standard Bulk Fuel Plant. A former Shell Oil Bulk Plant was located south of the former Chevron Bulk Fuel Plant at 220 Tumwater Access Road. General Petroleum Corporation, predecessor to Mobil Oil, operated a bulk plant at 535 Marine Drive, which was later operated as Peninsula Fuel Company. Phillips Petroleum Company, and later D&D Distributors, operated a former bulk plant across Cedar Street at 617 Marine Drive. The two former bulk plants west of Tumwater Creek include one operated by Texaco (later Bauman Olympic) at 727 Marine Drive, and the Unocal Bulk Plant located further west at 738 Marine Drive and operated by Bill Earley Distributors.

Oil for these facilities was unloaded at the Standard Oil Dock or, after 1967, at the Port's Marine Terminal No. 1 and delivered through eight buried pipelines that traversed the Port's log yard area and led to the various bulk plants. The individual pipeline routes may have consisted of single or multiple pipes typically 4" in diameter. Pipelines operated by Chevron and Atlantic Richfield or their predecessors were located on the MTA property.

Several petroleum release incidents were reported in the area in the late 1960s to 1970, including the following incidents:

- Gasoline and/or diesel fumes that emanated from a ditch dug for the City of Port Angeles' interceptor sewer lines along Marine Drive.
- Similar fumes and a small explosion in an abandoned storm sewer manhole located in the PenPly machine shop.
- Petroleum fumes from a manhole located at the intersection of Cedar Street and the alley.
- A small oil seepage observed percolating up through gravels and creating a small oil slick in the harbor near the mouth of Tumwater Creek.

Subsequently, three of the eight oil companies abandoned their pipelines and fuel was delivered to their bulk plants from the Standard Oil Dock by tanker trucks. The other five bulk fuel plants continued receiving fuel through their pipelines into the 1980s. By the early 1980s, five of the eight bulk fuel plants ceased operations, and their aboveground fuel storage tanks were salvaged and removed. The Port purchased the former D&D Distributors/Phillips 66 Bulk Plant, former ARCO, and former Shell Oil Bulk Plant sites by 1984. In the mid- to late-1980s, several environmental studies were conducted after petroleum contamination and other hazardous substances were encountered on the various bulk plant sites and the K Ply facility. A summary of available information concerning the petroleum pipelines at the MTA Site is summarized in the Current Situation Report (Floyd Snider McCarthy 2002). Records reviewed indicate that by 1989, the fuel pipelines were either abandoned in place and filled with water or removed from the Port's property. The document record indicates that Pipeline 8 was to be abandoned in place in 1967 (Landau 2009b). The pipelines encountered during construction of Westport Marine were found to have been drained of fuel and contained water.

Other facilities that were historically operated within the MTA Site include a sawmill and related maintenance building, logging truck repair shop, retail grain supply store, undersea cable saline cure tanks, ship repair facilities, and railroad lines.

2.4 SUMMARY OF PREVIOUS INVESTIGATIONS

This section presents the findings of several significant prior site investigations, along with the history of associated regulatory involvement. The narrative is presented separately for each of the three main areas of the MTA Site (MTA, Pettit Oil, and K Ply) as each were initially investigated separately with significant work at the MTA performed under an earlier 1994 Agreed Order between the Port and Ecology.

2.4.1 Investigations Prior to the 1994 Agreed Order

2.4.1.1 Marine Trades Area

Petroleum contamination in this area was discovered during a 1990 geotechnical investigation by Shannon & Wilson related to the development of the Marine Terminal Log Yard. An environmental site assessment was performed to assess the site soil contamination and potential groundwater contamination (Rittenhouse-Zeman & Associates 1990). As part of this assessment, Rittenhouse-Zeman & Associates dug 10 test pits and installed four monitoring wells (MW-1 through MW-4) to evaluate soil and groundwater conditions. Tidal fluctuations were also measured as part of the assessment. Elevated gasoline-range total petroleum hydrocarbons (TPH-G) and diesel-range total petroleum hydrocarbons (TPH-D) were detected in soil and groundwater. The Port notified Ecology about these findings on October 22, 1990.

Ecology performed an “initial investigation” on the Marine Terminal Log Yard on March 4, 1992. The Port continued groundwater monitoring and during June 1992, Ecology added the log yard to their database of known or suspected contaminated sites. In August 1992 Ecology assigned a ranking score of 1 (highest risk) to the Marine Terminal Log Yard.

2.4.1.2 Pettit Oil

In 1987, a subsurface study was conducted on the current Pettit Oil Facility (former Chevron Bulk Fuel Plant) located at 638 Marine Drive by GeoEngineers, Inc. that included the installation of seven monitoring wells (GeoEngineers 1987). In 1988, Chevron, conducted a subsurface petroleum hydrocarbon evaluation at the former Chevron Bulk Fuel Plant and installed three additional wells to better define the probable source and migration route of the petroleum hydrocarbon contamination beneath the site. The results indicated that the primary petroleum hydrocarbons present in the subsurface soils were TPH-D with free product occurring in several on-site wells.

2.4.1.3 K Ply

In 1988, ITT Rayonier Corporation (ITT Rayonier), then owner of the PenPly Mill (later renamed K Ply) contracted Landau Associates, Inc. (Landau) to conduct the first environmental evaluation on the mill site, which is located on land owned by the Port, to support a sale of the facility. The evaluation included standard sources of environmental information for property transfers, including company and agency file reviews. A limited number of soil and groundwater samples were collected from various locations throughout the facility as a part of the study, and submitted for analysis for potential contaminants that were stored and used in the plywood manufacturing process. Significant amounts of hydraulic fluid, gasoline, and diesel contamination were detected in subsurface soils beneath the facility, with free product (a mixture of hydraulic oil and gasoline) detected on the water table near the hydraulic presses. Also, TPH-G and TPH-D (diesel to heavy oil) were identified in soil and groundwater near the former plywood panel oiler beneath the southwest corner of the facility. Low concentrations of pentachlorophenol (PCP), phenol-formaldehyde, and methylene chloride were detected in soil near source areas for these materials, and were attributed to past spillage. Backhoe test pits were excavated to the water table near the southwest corner of the building and exposed fuel pipelines and groundwater containing an oily substance that laboratory tests indicated was diesel or fuel oil (Landau 1988). The source of the petroleum was attributed to a potential release from upgradient Peninsula Fuel Company, not to the pipelines.

According to the 1988 Landau report, two underground storage tanks (USTs) were located adjacent to the west side of the K Ply building, including one 1,000-gallon gasoline UST and one 6,000-gallon fuel oil UST[2] (Landau 1988). The report indicates that the USTs were taken out of service in 1974 and removed by 1984, though no other reports documenting tank removal activities were identified. Sampling in 1988 found hydrocarbons (measured by the total oil and grease methodology) in soil above the water table in this area at concentrations up to 1,300 mg/kg.

In 1989, ITT Rayonier installed 10 shallow groundwater wells beneath the mill building to determine if the petroleum contamination identified was present in recoverable amounts. Measurable quantities of hydraulic oil, ranging from 0.2 to 2.1 feet in thickness, were encountered in wells installed near the hydraulic presses. The hydraulic oil in Well PP-3, southeast of the hydraulic presses, contained a mixture of hydraulic oil and gasoline, and a soil sample from this location contained 1,600 parts per million (ppm) TPH-G. Gasoline odor was also noted at PP-4 and PP-5, located further east beneath the building (Landau 1989). Landau proposed a remedial action plan that involved containment structures beneath the hydraulic presses, a hydraulic oil recovery system, groundwater pumping, and free product monitoring.

A remedial action plan for the PCP-contaminated soils beneath the former panel oiler location was developed in 1989. Further sampling indicated that PCP was detected at concentrations up to 720 ppm in soil, but Landau concluded that PCP contamination had not reached the groundwater at concentrations exceeding regulatory cleanup levels. In addition to PCP contamination, soil samples from this area in 1988 contained 4,300 mg/kg TPH-G in soil collected above the water table (Landau 1988).

Based on this information, Ecology prepared a remedial action order dated May 16, 1990 (No. DE 90-S255) for ITT Rayonier, limited to the recovery of the hydraulic oil and cleanup of the PCP contamination of soils beneath the K Ply facility. SEACOR was subcontracted by ITT Rayonier to install a hydraulic oil recovery system and containment structures beneath the hydraulic presses, and excavate PCP-contaminated soils in the vicinity of the panel oiler location. The recovery of hydraulic oil under the remedial action order is ongoing. Groundwater wells located under the facility are also tested routinely by ITT Rayonier as part of the oil recovery monitoring. In addition to measured free product in these wells, sample results from

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[2] Landau subsequently communicated to the MTA Group that the 1988 report was in error and that the tanks contained plywood form oil instead.

these wells indicate persistent levels of TPH-G and benzene in groundwater under the K Ply facility.

2.4.2 Investigations 1995 through 2001

2.4.2.1 Marine Trades Area

The Port entered into Agreed Order No. DE94TC-S342 with Ecology on December 12, 1994, to investigate the extent and potential source(s) of petroleum hydrocarbon contamination in soil and groundwater at the MTA Site. The 1994 Agreed Order included K Ply, the former Shell Oil Bulk Plant, off-shore areas and the log yard east of the Bauman Olympic (Texaco) Bulk Plant. The Agreed Order called for investigation work to assess the potential for contamination, but was limited in extent as it did not require a full RI/FS. The scope defined in the Agreed Order included installing 24 groundwater monitoring wells; analyzing soil and groundwater samples for total petroleum hydrocarbons (diesel and gasoline), and benzene, toluene, ethylbenzene, and xylenes (BTEX); measuring water levels; and surveying new and existing wells (including selected off-site wells).

Results are detailed in two source investigation reports by Shannon & Wilson (1995, 1996). The reports are based on two phases of subsurface investigation, two rounds of groundwater sampling, three surface water samples from Tumwater Creek, and a tidal influence study. The sampling was intended to evaluate the following potential source areas: Texaco/Bauman's, former Shell Oil Bulk Plant, former ARCO Bulk Plant, former D&D Distributors/Phillips 66 Bulk Plant, Chevron, and Standard Oil bulk fuel facilities, and former fuel supply lines 1, 5, and 7. Gasoline contamination in soil and groundwater was found to be widespread and generally concentrated in the western portion of the main log sort yard. Diesel contamination in soil and groundwater was widespread but less consistent, which was thought to indicate localized releases. No contaminants were detected in soil or groundwater west of Tumwater Creek or in surface water sampled from Tumwater Creek, which was consistent with the finding that the creek acts as a hydraulic barrier to groundwater flow. Higher contaminant concentrations were detected in soil from 5.5 to 10 feet below ground surface (bgs) compared with shallower soil (3 to 5 feet bgs), generally supporting smear zone contamination from hydrocarbons migrating along the water table, rather than releases downward from near surface sources.

Conditions upgradient and downgradient of the Port's log sort yard were investigated by Shannon & Wilson during a 1995-1996 "Phase I" source investigation. Several borings were located on the adjacent former Shell Oil Bulk Plant on Tumwater Street to the south of Pettit Oil, and several were located across Marine Drive on the Marine Terminal Log Yard. Samples collected from both sides of Marine Drive indicated that groundwater contained elevated concentrations of TPH-G, TPH-D, and BTEX, and soils contained elevated concentrations of TPH-D and TPH-G.

A "Phase II" source investigation was performed in 1996 consisting of well installation and sampling TPH-D and TPH-G groundwater contamination in areas of soil contamination. Free product was not detected in any wells. The tidal study performed as part of the Phase II investigation found that changing tide levels can affect groundwater levels at distances of greater than 600 feet from the shore, and that a temporary gradient reversal occurs in the aquifer immediately adjacent to the MTA and K Ply bulkheads during high tides. With the submittal of the source investigation reports and subsequent groundwater monitoring reports, the Port met its obligations specified in the 1994 Agreed Order (Ecology 1994).

Groundwater data for benzene, TPH-G, and TPH-D from 1996 through 2000 are presented in Appendix A Figures A.1, A.2, and A.3. These figures compare historical to recent groundwater plume extents. Except for the emergence of the Cedar Street Benzene Plume (refer to Sections 3.2 and 4.4) and the appearance of newly-identified contamination beneath K Ply based on recent data, these maps illustrate overall decreasing trends in contaminant concentrations and plume areas.

2.4.2.2 AT&T Site

In 1996, there was a report of a release and a subsequent cleanup, removal, and disposal of contaminated soils at the AT&T Port Angeles Cable Storage Area, located within the MTA north of the Platypus Marine building on Front Street. Two former ASTs that contained a saline solution were reportedly used by AT&T for conditioning undersea communications cable. A tar-like substance was identified in the tanks and on the ground surface in the vicinity of the ASTs, approximately 1 to 3 inches deep, covering an area 65 feet long by 8 feet wide. The substance and underlying soil was sampled and found to contain carcinogenic polycyclic aromatic hydrocarbons (Geraghty & Miller, Inc. 1996). A total of approximately 130 tons of tar and underlying soil were subsequently excavated and disposed of off-site. Excavation proceeded until underlying soil was sampled and found to be less than MTCA Method A cleanup levels. The excavated area was backfilled and compacted. There were no indications that the substance affected site groundwater. The Phase II and soil removal reports were submitted to Ecology and filed as final independent cleanup reports (Ecology 1997a). The site was added to Ecology's Toxics Cleanup Program Facility Site/Site Information System database of known or suspected sites in 1997 and is currently considered resolved by Ecology (Ecology 1997b).

Other than routine groundwater monitoring and hydraulic oil recovery by K Ply, there was little environmental investigation at the MTA Site from 1997 through 2000.

2.4.2.3 Pettit Oil

In 2000, groundwater sampling was conducted at Pettit Oil for a number of analytes, including petroleum hydrocarbons and BTEX. The sampling results agreed with prior groundwater sampling events, and indicated that the primary petroleum hydrocarbons present in the subsurface soils were TPH-D with free product occurring in several on-site wells. Additionally, a number of fuel additives were analyzed in this sampling event in Monitoring Wells MW-6 and RZ-2. These additives included: ethanol, tertiary butyl alcohol (TBA), MTBE, di-isopropyl ether (DIPE), ethyl tertiary butyl ether (ETBE), and tertiary amyl methyl ether (TAME). Lead has not been analyzed in groundwater at Pettit Oil. Methanol was analyzed in a later sampling event, in 2003, in MW-5 and MW-6. No fuel additives were detected in either sampling event. A summary of the analytical results is presented in Appendix B.

2.4.3 Investigations 2001 through 2003

In 2001, Floyd|Snider prepared a Current Situation/Conceptual Site Model Report that (1) summarized past investigation and remediation work done on and adjacent to the MTA Site, (2) collected information on the history and ownership of properties within and adjacent to the MTA Site, (3) developed a preliminary site conceptual model, and (4) identified data gaps necessary for completing an RI for the MTA Site (FSM 2002).

To develop a comprehensive conceptual site model, an area significantly larger than the current MTA Site boundaries was considered to include potential off-site contamination sources from the large number of former bulk plants in the area. All known historical uses of the MTA Site were used to identify potential contaminants of concern (PCOCs) including not only the operation of bulk fuel plants and pipelines but a former sawmill, maintenance building (currently occupied by Platypus Marine), a logging truck repair shop, former Clallam Grain facility, former railroad that extended along the shoreline and east-west through the MTA Site, and the disposal of debris when the site was first filled.

In soil and groundwater, the PCOCs that were identified included TPH-D, TPH-G, semivolatile organic compounds (SVOCs) and metals possibly used in wood preservatives (e.g., pentachlorophenol, arsenic, copper, chromium), lead and methyl tertiary butyl ether (MTBE; gasoline additives), and volatile solvent compounds from past and current shipyard maintenance activities. In sediments, TPH-G, benzene, 4-methylphenol, and wood debris were carried forward as PCOCs. The PCOCs identified in soil, groundwater, and sediments are discussed further in Section 5.0.

Based on the results of the Current Situation/Conceptual Site Model Report, the Port, Chevron, and ARCO collectively agreed to collect additional environmental data in advance of construction of a new boat building facility over the log sort yard. This new information is detailed in the Port of Port Angeles Site Characterization Report (SCR; FSM 2003a) and included: logs of geotechnical soil borings; soil boring and soil gas vapor survey under the future Westport Marine building footprint, and modeling of the soil vapor data to assess the need for a vapor barrier under the building; site-wide groundwater sampling for an expanded range of PCOCs; and a test pit evaluation to support management of shallow bark-rich soil to be exported during construction.

The MTA also initiated site-wide groundwater sampling in January 2003 to assess PCOCs in groundwater and soil by analyzing groundwater samples for an expanded range of analytes that included chlorinated volatile organic compounds (VOCs), SVOCs, gasoline additives, and lead in addition to analyses for petroleum compounds, TPH-G, TPH-D, and BTEX (FSM 2003a).

Toluene, ethylbenzene, and xylenes (TEX) were detected in groundwater during the expanded-list sampling event and have also been detected in recent sampling (refer to Section 4.4). The distribution of these compounds generally correlates with that of benzene, although the concentrations are typically different. No chlorinated solvent compounds were detected in any well. Samples were also analyzed for a variety of gasoline additives such as MTBE, tertiary amyl methyl ether (TAME), 1,2-dichloroethane, ethanol, and lead. Except for MTBE and lead, these additives were not detected. Lead was not detected at a concentration greater than 7 µg/L.

Eight wells, including the three most downgradient wells at that time, MW9, MW10, and MW12, were also sampled for SVOCs. The three downgradient wells were also sampled 1 to 2 hours following a low tide to minimize dilution by tidally-influenced gradients. Total dissolved solids (TDS) and salinity were also measured. Other than several relatively low detections (i.e., less than 100 µg/L) of naphthalene and methyl naphthalene related to TPH-D, SVOCs were not detected. The salinity and TDS concentrations indicate that fresh and not marine waters were sampled. Based on the lack of elevated concentrations of other non-petroleum related contaminants in groundwater, it was determined that there were no significant non-petroleum related contaminants of concern (COCs) at the MTA Site. TPH-G, TPH-D, and benzene in both soil and groundwater were identified as site COCs, based on exceedances of MTCA A cleanup levels (refer to Section 5.0). The results of the SCR greatly improved the understanding of site conditions and were helpful in identifying data gaps and probable petroleum source areas in soil.

Additionally, the 2003 work determined that the risk of vapor migration from underlying benzene and gasoline-contaminated soil was less than levels of concern in the area of the MTA where construction of the Westport Marine building was planned. Regardless, the RI/FS Parties decided that installation of a vapor barrier was prudent under the more confined office areas of the Westport Marine structure. The installation of the 40-mil geomembrane vapor barrier is documented in the SCR submitted to Ecology (FSM 2003a).

The upper bark rich soil resulting from historical log storage operations was excavated within the footprint of the Westport Marine facility and hauled off-site, aided by a test pit program that did not find contaminants at concentrations greater than cleanup levels in soil removed from the MTA Site. Underlying granular fill soil was excavated and recompacted on-site. In conjunction with trenching for deeper subsurface utilities, petroleum-contaminated soil was encountered. Approximately 50 tons of soil was transported off-site to a permitted landfill (FSM 2003a).

Also encountered were several abandoned fuel pipelines. No evidence of contamination was found under removed sections. Details of the pipelines and their removal are contained in the SCR Addendum (FSM 2003b).

Finally, the SCR presented an outline for a phased investigation to fill remaining data gaps. Filling these data gaps has been the focus of investigative work at the MTA Site since the signing of the current Agreed Order on May 17, 2005, as described in the following sections (Ecology 2005).

2.5 SUMMARY OF REMEDIAL INVESTIGATION ACTIVITIES 2005-2007

Data collected during prior investigations identified the possibility of multiple areas of soil contamination and plumes of contaminated groundwater; however the full extent and sources of these areas of soil contamination and groundwater plumes were not well identified. The major objective of the RI was to define the nature and extent of petroleum contamination in soil and groundwater site-wide and identify possible source areas with sufficient detail to support remediation decisions. Specifically, the RI field sampling and analysis addressed the following data gaps that were identified in the RI Work Plan:

- Establish groundwater quality downgradient of the Pettit Oil Facility, along the Marine Drive property boundary.
- Establish the eastern extent of the dissolved benzene plume in groundwater beneath the Westport Marine facility.
- Study the effects of tidal fluctuation on groundwater flow, specifically vertical gradients, and tidal effect on chemical concentrations.
- Investigate if the bulkhead is acting as a barrier that is trapping or slowing the migration of petroleum products released from the upgradient properties.
- Establish the concentrations of benzene in groundwater near the bulkhead in front of K Ply.

- Identify potential upgradient sources of benzene contamination beneath the K Ply facility.[3]
- Establish current site-wide groundwater quality through sampling of existing and new wells.

Field work and data quality evaluation by the RI/FS Parties were conducted according to the Ecology-approved Sampling and Analysis Plan (SAP) and Quality Assurance Project Plan (QAPP) presented in the RI Work Plan (Floyd|Snider 2005). Relevant details of the RI activities performed are described below; for additional information, refer to the Remedial Investigation Report (Floyd|Snider 2007). The results of the RI activities are presented in Section 4.0. RI laboratory reports are presented in Appendix C, and monitoring well and soil boring logs are presented in Appendix D.

In addition, the RI established a conceptual site model (CSM) that describes the release, transport, and potential exposure pathways of the site COCs, TPH-G, TPH-D, and benzene, in soil and groundwater. The conceptual site model has been updated in this RI/FS based on more recent data (refer to Section 5.0).

2.5.1 Remedial Investigation Activities at Pettit Oil Facility

Due to the adequacy of prior investigations, RI activities at the Pettit Oil facility were designed to fill data gaps concerning contaminant concentrations and the presence of separate phase hydrocarbons at the downgradient property boundary.

2.5.1.1 Monitoring Well Installation (December 2004)

In December 2004, SAIC, on behalf of Chevron, installed three additional monitoring wells, MW-8, MW-9, and MW-10 to fill the data gap at the downgradient property boundary (refer to Figure 3.1). Details of monitoring well construction are presented in Table 3.1. Soil samples were collected during drilling of the new wells and were analyzed for TPH-D (diesel and lube oil), TPH-G, and BTEX.

2.5.1.2 Groundwater Sampling

In April 2005 through May 2007, groundwater samples were collected routinely from monitoring wells at Pettit Oil by Gettler-Ryan Inc. on behalf of Chevron according to standard procedures. Samples were analyzed for TPH-D (diesel and lube oil) by NWTPH-$D_{x,}$ TPH-G by NWTPH-G, and BTEX by U.S. Environmental Protection Agency (USEPA) Method 8021.

Results of the well installation and groundwater testing were provided to Ecology through report submittal by Chevron. The results of groundwater sampling at the Pettit Oil Facility are incorporated into this RI and are summarized in Section 4.4.3.

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[3] This RI data objective was originally intended to address the source of benzene in groundwater in the vicinity of the hydraulic oil release beneath the northern end of the K-Ply facility, not the subsequently discovered plume that extends beneath Cedar Street; refer to Section 3.0.

2.5.1.3 Aboveground Storage Tank Removal

In February 2010, a flooding event at the Pettit Oil Facility dislodged several of the empty fuel storage ASTs from their moorings. The tanks were subsequently removed from the site. No releases of petroleum occurred as a result of the flooding event or tank removal. This change to site conditions opened up remedial alternatives not previously considered feasible, including excavation of soil from the area previously covered by the ASTs.

2.5.2 Remedial Investigation Activities at Marine Trades Area

Remedial investigative activities at the MTA were carried out in several phases between October 2005 and May 2007. Related characterization activities were conducted to fill feasibility study data gaps in January 2008, as described in the following section.

2.5.2.1 Eastern Extent of the Benzene Plume under the Marine Trades Area

The monitoring well network that existed at the MTA Site prior to RI activities was not sufficient to adequately define the eastern extent of the benzene plume beneath the MTA (MTA Plume). This gap was in part a result of the loss of Monitoring Well MW-2 during construction of the Westport Marine facility and the loss of Monitoring Well MW-7, formerly located along the eastern boundary of the MTA.

To determine the eastern extent of elevated benzene in groundwater, groundwater screening samples were collected using a direct-push Geoprobe in locations east of the Westport Marine facility and along Cedar Street. In October 2005, groundwater samples were collected at Locations 60, 62, 64, 66, 68, and 69, shown on Figure 3.1. Samples were submitted for NWTPH-G and BTEX analysis.

The results of investigation along Cedar Street precipitated additional investigation described in Section 3.0.

2.5.2.2 Soil and Groundwater Quality at the Bulkhead and Tidal Influence

To determine conditions at the wooden bulkhead that separates the uplands portion of the MTA from the waters of Port Angeles Harbor, soil quality was established along the bulkhead through the advancement of soil borings at Locations 70, 72, 74, and 76, as shown on Figure 3.1. Selected soil samples from these locations from above and beneath the water table were submitted to a laboratory for NWTPH-D_x and NWTPH-G/BTEX analyses.

In addition to soil quality, the concentration of TPH-G and benzene in groundwater adjacent to and underneath the base of the wooden bulkhead (a possible point of discharge of groundwater to marine waters) was also not well defined prior to RI activities. In coordination with soil boring advancement, groundwater screening samples were collected from Locations 70, 72, 74, and 76 using a direct-push probe and submitted for NWTPH-G/BTEX analysis. Groundwater samples were collected at 5-foot intervals below the groundwater surface until the maximum depth of the sampling pump was reached, at approximately 30 to 40 feet. Specific conductivity measurements were collected at each depth, to indicate if denser, brackish marine waters were encountered. Shallow groundwater flow from the bulkhead to Port Angeles Harbor was expected to occur above this “salt water wedge,” with limited tidal mixing at the water table. No increase in conductivity was observed with depth, as discussed in more detail in Section 4.0.

2.5.2.3 Contamination in the Vicinity of the Former D&D Distributors/Phillips 66 Bulk Plant

Data collected by Landau in 1988 and during the initial Port investigation activities in the mid-1990s indicated that diesel (and possibly gasoline contamination) was present near the intersection of Cedar Street and the alleyway containing a large 48-inch diameter industrial water supply line. The Port's source investigation exploration locations were later covered by the Platypus Marine building. Releases in this area may be from petroleum product releases that occurred from the former D&D Distributors/Phillips 66 Bulk Plant facility or from an historical fuel pipeline installed parallel to the former alleyway.

To evaluate the extent of these potential releases, in October 2005, borings were advanced at two locations along the alleyway west of the Platypus Marine facility (Locations 60 and 62; Figure 3.1) and at three locations along Cedar Street directly east of Platypus Marine (Locations 80, 82, and 84). Soil samples from approximately 3 to 5 feet below the water table were submitted to the laboratory for NWTPH-D_x and NWTPH-G/BTEX analysis.

2.5.2.4 Potential Upgradient Sources for the Benzene Plume under K Ply

As described in Section 2.0, gasoline/benzene contamination was originally identified beneath the K Ply mill in 1988 and subsequent groundwater monitoring data collected in support of the recovery of hydraulic oil under the K Ply facility have indicated BTEX compounds in groundwater at K Ply. Whether this BTEX contamination originates from a source or sources upgradient of the K Ply facility was an identified RI data gap. Potential upgradient sources include the former Peninsula Fuel facility and/or the former D&D Distributors/Phillips 66 Bulk Plant facility and associated pipelines, and/or utilities that may have aided transport of historical releases of petroleum from former bulk facilities within the MTA.

In order to evaluate these potential upgradient sources, soil and groundwater screening samples were collected from three areas in October 2005. Soil and groundwater screening samples were collected from Locations 80, 82, and 84 in the area east of the Platypus Marine facility to evaluate the former D&D Distributors/Phillips 66 Bulk Plant facility as a potential source of BTEX compounds. Groundwater screening samples were collected from Locations 90 through 95 to evaluate the former Peninsula Fuel facility as a potential source of BTEX compounds. These included two locations along Cedar Street (90 and 91) that are sidegradient to the former Peninsula Fuel facility and also sidegradient to the now-abandoned 8-inch sanitary sewer line under Cedar Street; and four locations (92, 93, 94, and 95) immediately downgradient of the former Peninsula Fuel facility. Refer to Figure 3.1 for sampling locations.

To evaluate whether or not BTEX compounds released from the bulk fuel plants have migrated along utilities in this area (the 48-inch industrial water line and/or an abandoned storm sewer located in the alley between Peninsula Fuel and K Ply), groundwater screening samples were collected directly downgradient of the 48-inch industrial waterline at Locations 96, 97, 98, and 99 and submitted for NWTPH-G/BTEX analysis. The issue of upgradient sources is discussed further in Section 4.4.2.

2.5.2.5 Site-wide Groundwater Quality

Although groundwater sampling has been performed on a regular basis at the K Ply and Pettit Oil facilities, prior to the initiation of RI activities, the last set of groundwater samples from the majority of wells within the MTA was collected in January 2003. A more current data set from wells within the MTA was necessary to characterize site-wide groundwater quality. Two rounds of groundwater sampling took place after the installation of eight new monitoring wells, as described below. Sampling was also coordinated to occur with routine sampling at the Pettit Oil Facility.

Floyd|Snider, on behalf of the RI/FS Parties, proposed eight new monitoring wells to be installed at the MTA Site in a letter to Ecology dated September 6, 2006. Monitoring well locations were based on the results of several phases of direct-push probe soil and groundwater sampling conducted between October 2005 and June 2006. Following Ecology approval, Floyd|Snider installed and developed the eight monitoring wells in 2007 (refer to Figure 3.1 for monitoring well locations). Well construction logs were provided in the 2007 RI Report (Floyd|Snider 2007).

Between January 30 and February 1, 2007, Floyd|Snider sampled existing and newly installed MTA wells and a limited number of K Ply wells according to standard low-flow procedures. Samples were submitted under chain-of-custody for analysis of TPH-G by NWTPH-Gx, TPH-D by NWTPH-Dx, and BTEX compounds by USEPA Method 8021B. At approximately the same time, Gettler-Ryan Inc., on behalf of Chevron, also collected groundwater samples from all monitoring wells at Pettit Oil that did not display free-product, and submitted the samples for analysis of TPH-G, TPH-D, and BTEX. For wells adjacent to the bulkhead, sampling was coordinated with the daily minus tide, when groundwater gradients are steepest and the least amount of saline mixing was thought to occur.

Three wells located at the K Ply facility east of Cedar Street were sampled as part of the January 2007 site-wide groundwater sampling event. These wells included PP-7, PP-13, and PP-15. Water level elevations were also measured in Monitoring Wells PP-6 and PP-9 to assist in determination of groundwater flow direction during the sampling event.

In addition, water table elevation measurements were collected throughout a tidal cycle to monitor potentiometric fluctuations associated with the changing tides. Four of the monitoring wells installed in January 2007 were completed as two nested pairs composed of one shallow (screened from 5 to 15 feet bgs) and one deeper well (screened from 20 to 25 feet bgs). Water level measurements from these wells were collected to determine the vertical gradient behind the bulkhead structure. In addition, synoptic water levels were measured in all MTA Site monitoring wells (i.e., all measurements were collected within approximately 1 hour of each other).

A second round of groundwater sampling was conducted from May 7 to 8, 2007. The purpose of the second round was to collect an additional set of data from the newly-installed wells along the bulkhead, assess seasonal variability in all site wells, measure tidal influence in bulkhead wells, and to survey the base elevation of Tumwater Creek.

2.5.3 Contaminants of Concern

As indicated in Section 2.4.3, a broad list of PCOCs was identified during past investigative activities using a screening process that followed USEPA and MTCA guidance for the identification of PCOCs. This process began with researching historical uses of the MTA Site (FSM 2002). These uses include the operation of the bulk fuel plants and pipelines that stored and conveyed refined petroleum products. Other identified historical uses include a sawmill, maintenance building, the Harper Brothers logging truck repair shop, Clallam Grain, the AT&T

saline tanks, ship repair shops, railroad lines, and the disposal of debris when the tidelands where the site is now located were first filled.

In soil and groundwater, the PCOCs that were identified include those related to petroleum and also gasoline additives (e.g., BTEX, TPH-D, TPH-G, lead, and MTBE); SVOCs and metals, both possibly used in wood preservatives (e.g., pentachlorophenol, arsenic, copper, chromium); and possible volatile solvent compound usage from past and current shipyard maintenance activities.

In order to narrow down this broad list and identify the site COCs, a groundwater sampling event was conducted in January 2003 with an expanded analyte list that included all of the above PCOCs. The results of this sampling were presented to Ecology in the SCR (FSM 2003a). In that report, site-specific risk-based screening criteria were developed under MTCA by considering all relevant exposure pathways. For soil, the screening criteria were based on MTCA criteria for protection and propagation of wildlife, direct human exposure to soil (industrial scenario), and protection of ambient air. For groundwater, the maximum beneficial use was identified as recharge to Port Angeles Harbor, and so risk-based screening levels were derived based on state and federal criteria for protection of surface water as well as protection of ambient and indoor air. The most protective of all relevant screening criteria were compared to the highest concentrations detected previously in site soils supplemented by the results of the 2003 groundwater samples.

This process identified TPH-G, TPH-D, and benzene as site groundwater COCs, based on exceedances of MTCA A cleanup levels. No other compounds were detected in groundwater at concentrations greater than the groundwater screening concentrations. A number of low-level detections were observed including several VOCs found in gasoline, namely toluene, ethylbenzene, xylenes, 1,2,4-trimethylbenzene, isopropylbenzene, n-butylbenzene, n-propylbenzene, sec-butylbenzene, and 2-methylnapthalene. Other SVOCs detected at concentrations less than the screening criteria include naphthalene, phenol, and bis(2-ethylhexyl)phthalate. Lead, the only metal detected, was measured at concentrations significantly less than screening levels. Based on the lack of significant detections of non-petroleum-related contaminants in groundwater, (e.g., solvents, metals) it was determined that non-petroleum contaminants should not be retained as COCs in groundwater at the MTA Site. A summary of all detected compounds in site wells from the January 2003 expanded-list sampling is presented in Appendix B.

Concerning subsurface soil, historical data indicated exceedances of Method A cleanup levels for benzene, TPH-D, and TPH-G; therefore, these compounds were retained as site soil COCs. The maximum concentrations of BTEX compounds in soil were less than direct contact worker exposure based screening levels. Current day surface soils were eliminated from consideration because they were either covered by buildings or pavement where historical activities occurred or had been removed from the site, reworked and/or covered with several feet of imported fill during construction of Westport Marine. Based on the absence of significant detections of non-petroleum contaminants in soil, only benzene, TPH-D, and TPH-G were retained as COCs for subsurface soil. Subsurface soil COCs have since been updated based on more recent analysis to include TEX (refer to Section 5.0).

3.0 Additional Investigation Activities

Following completion of the Remedial Investigation Report (Floyd|Snider 2007), additional data gaps associated with feasibility study goals were identified. Additional field sampling and analysis were conducted in 2008 to address the FS data gaps. These gaps included improving the estimation of the extent of soil contamination adjacent to the bulkhead north of Westport Marine on the MTA property (the MTA Bulkhead), and assessing the potential applicability of several remedial approaches to site contaminants.

Additionally, as described in more detail below, a significant effort was associated with characterization of the extent and source of a previously-unidentified benzene plume in groundwater that appeared to originate beneath the K Ply facility. Investigative activities at K Ply required several phased investigations over a multi-year period involving coordination with Rayonier (the former facility owner) and Ecology. In addition to the RI field work conducted by the RI/FS Parties, additional sampling and analysis in the vicinity of the K Ply mill and surrounding area was conducted in 2009 by Landau on behalf of Rayonier, with input from the RI/FS Parties. The results of this recent work by Landau and all prior characterization activities are incorporated into this report.

3.1 FEASIBILITY STUDY DATA GAPS INVESTIGATION NORTH OF WESTPORT MARINE FACILITY (JANUARY 2008)

Additional characterization was undertaken by the RI/FS Parties to support a more detailed evaluation of alternatives for remediation of contamination in and around the Westport Marine facility area. The work was completed in accordance with the January 4, 2008 Work Plan Addendum (Floyd|Snider 2008). A more accurate characterization of the extent of contamination adjacent to the MTA Bulkhead was undertaken to evaluate the feasibility of excavation. Additional soil and groundwater parameters were measured to assess the potential applicability of remedial technologies including in-situ chemical oxidation (ISCO), natural attenuation, and bioremediation, and to support potential development of site-specific soil cleanup levels. The results of this additional investigation were presented in a data report to Ecology (Floyd|Snider 2008) and are incorporated into the results presented in Section 4.0.

On February 1 and February 4, 2008, groundwater samples were collected from existing upgradient Monitoring Wells MW-3 and MW-4, and existing MTA Bulkhead Wells MW-10 and MW-25. These existing wells were sampled to provide upgradient condition information, and to provide data for the evaluation of natural attenuation, bioremediation, and in-situ treatment options. Wells were sampled according to standard low-flow sampling procedures using a peristaltic pump and disposable tubing. Samples were analyzed for BTEX compounds, TPH-G, and TPH-D.

Between February 4, and February 8, 2008, soil and groundwater samples were collected from 38 locations on the Westport Marine property. The locations of Geoprobe borings (labeled FS-1 thru FS-30) and hollow-stem auger borings (labeled MW-26 thru MW-33) are illustrated on Figure 3.1. Boring locations were planned to provide information regarding nature and extent of soil and groundwater contamination at the bulkhead and in the area upgradient of the bulkhead. Well locations and borings with co-located groundwater samples were selected to intersect the known groundwater plume in this area, and along flow paths through the known groundwater plume. One monitoring well, MW-33, was installed in the southeastern portion of the property near the Platypus Marine facility to replace the previous site well MW-2, destroyed by site activities.

Soil and water samples were analyzed for BTEX and TPH-G. The majority of impacted samples collected were also analyzed for TPH-D, and selected samples were analyzed for additional parameters for specific data objectives, including evaluation of natural attenuation, in-situ remediation treatability, and calculation of site-specific soil cleanup levels.

For use in potentially developing site-specific cleanup levels under MTCA guidelines based on direct contact and/or the leaching pathway, soil was sampled from locations selected to represent the most heavily impacted soil for both TPH-G and TPH-D concentrations. The data collected for site-specific cleanup determination included inputs required for the MTCA Method B direct contact model, and calculation of soil cleanup levels using the 3-phase model for leaching pathway evaluation. Results include volatile petroleum hydrocarbons (VPH), extractable petroleum hydrocarbons (EPH), polycyclic aromatic hydrocarbons (PAHs) including naphthalene, and selected volatile organic compounds including methyl-tert butyl ether (MTBE), n-hexane, ethylene dibromide (EDB), and 1,2-dichloroethane (EDC). Soil properties assessed include soil bulk (in-place) density, porosity, organic carbon, and moisture content.

To evaluate the potential effectiveness of in-situ chemical oxidation (ISCO) for treating site soils, soil samples were subjected to a variety of chemical and physical analyses including focused bench-scale testing. Two samples were submitted for ozone demand bench testing, which was selected as a specific approach based on preliminary evaluation of ISCO technologies. Ozone demand provides an indication of overall soil oxidant demand (SOD). A limited number of representative soil samples were analyzed for selected metals, including iron, chromium, chromium (VI), and selenium, to consider the potential for changing redox conditions to release metals to groundwater. Soil properties including moisture content, pH, and organic carbon were measured as indications of treatability by oxidation and basic inputs for pilot study design. Soil particle size analysis was conducted to help assess the effectiveness of delivery of in-situ treatment reagents into the subsurface.

The following groundwater analytical testing was performed to characterize conditions in support of potential further evaluation of groundwater remediation using ISCO, bioremediation, and/or natural attenuation, if appropriate as part of the RI/FS:

- Water quality data, including major anions and cations, alkalinity, and the field parameters pH, ORP, temperature, and specific conductivity, were collected as baseline and for evaluation of all three of these remedial approaches.
- Baseline metals concentrations in groundwater were measured to identify whether pilot study treatment releases metals to groundwater from soils.
- Chemical oxidant demand and total organic carbon analyses were conducted for indications of the oxidant demand and oxidizable matter in site groundwater for assessing ISCO treatability.
- Total and dissolved iron and manganese were measured for evaluating ISCO due to their sensitivity to redox conditions.
- Key nutrients or energy sources consumed by relevant bacteria were measured to better understand natural attenuation processes in groundwater. These include orthophosphate, total nitrogen, nitrate, phosphorus, sulfate, total and dissolved iron,

and total and dissolved manganese, along with other natural attenuation parameters organic carbon, alkalinity, and the field parameters listed above.

The use of ISCO, bioremediation, and natural attenuation were evaluated as part of the screening of remedial technologies potentially suitable for addressing cleanup objectives described in Section 7.0 and Table 7.1. The results of this evaluation indicated that, under site conditions in which contaminated soil is present adjacent to and upgradient of the shoreline, natural attenuation, bioremediation, and ISCO were not suitable technologies for use as treatment at the shoreline to prevent discharge of contaminated groundwater into Port Angeles Harbor.

3.2 INVESTIGATION OF BENZENE AT THE K PLY FACILITY

Investigative activities at the K Ply facility focused on identifying the full extent of the Cedar Street benzene plume at this facility, the potential sources of benzene contamination and establishing the concentrations of benzene in groundwater near the bulkhead in front of K Ply (K Ply Bulkhead).

Field activities were carried out in phases between October 2005 and May 2007, in accordance with the Ecology-approved SAP and QAPP presented in the RI Work Plan (Floyd|Snider 2005). Additional sampling and analysis in the vicinity of the K Ply mill and surrounding area was conducted by Landau on behalf of Rayonier in January and February 2009. K Ply data gathering activities are described in the following sections. Refer to the RI Report (Floyd|Snider 2007) for additional information on the investigation of the benzene contamination in the vicinity of K Ply.

3.2.1 Discovery of Cedar Street Benzene Plume (October 2005)

As described in Section 2.5.2.1, initial RI activities in October 2005 included a series of soil borings and groundwater samples along Cedar Street to determine the eastern extent of the MTA Plume, originating to the west of K Ply. The results of two samples, as discussed in Section 4.0, indicate anomalously high concentrations of benzene in the area of Cedar Street between K Ply and Platypus Marine. Detailed delineation of soil and groundwater contamination in this area was determined to be necessary following consultation with Ecology, especially since prior work by Shannon & Wilson in the 1990s did not indicate significant benzene contamination in this area. Multiple additional rounds of direct-push probe groundwater screening samples were collected to delineate the extent and source area of this newly-identified benzene plume. These activities are described in the following sections.

3.2.2 Delineation of Cedar Street Benzene Plume (November to December 2005)

In November and December 2005, a direct-push probe soil and groundwater investigation was conducted according to an Ecology-approved RI Work Plan (Floyd|Snider 2005). A total of 18 soil and 14 groundwater samples were collected from 19 boring locations along Cedar Street, as shown on Figure 3.1. Soil samples were collected for laboratory analysis from the uppermost saturated zone based on the results of headspace screening using a photoionization detector (PID). Groundwater screening samples were collected from the upper 3 to 5 feet of the aquifer by a Geoprobe using the peristaltic pump/retractable screen methodology. Soil samples were submitted to a laboratory for TPH-G and BTEX analyses and groundwater samples were submitted for volatile organic analysis by USEPA Method 8260B, to determine whether there were other volatile contaminants associated with the plume, to help identify a source. At Location 68, two groundwater samples were collected from two discrete depths, to determine the vertical distribution of benzene in the aquifer.

The results of this initial round of delineation samples, presented in Section 4.0, confirmed the existence of a significant benzene plume. The benzene concentrations were most elevated immediately adjacent to the K Ply mill. Additional delineation was proposed in this potential source area and in the downgradient reaches of the plume.

3.2.3 Further Delineation of the Cedar Street Benzene Plume (May to June 2006)

Between May 30 and June 1, 2006, an additional phase of direct-push probe soil and groundwater investigation was conducted. The primary objectives of this additional site characterization were to define the full extent of the Cedar Street Benzene Plume and confirm the potential source area. These data were also needed for decisions regarding the locations of permanent monitoring wells. An additional objective was to define the extent of benzene contamination along the K Ply Bulkhead, which lies downgradient of a release of hydraulic oil mixed with gasoline currently being remediated by Rayonier.

A total of 4 soil and 24 groundwater samples (including 3 quality assurance samples) were collected from 21 locations along both sides of Cedar Street (including on the K Ply facility) and along a section of the MTA and K Ply Bulkheads, as shown on Figure 3.1. Soil samples were screened for VOCs using a PID. Soil samples were collected for laboratory analysis where visibly-contaminated or odiferous soil was observed in soil cores. Groundwater samples were collected via Geoprobe from the upper 3 to 5 feet of the aquifer by the peristaltic pump/retractable screen methodology. Groundwater and soil samples were submitted for TPH-G/BTEX analyses. In addition, selected groundwater and soil samples were submitted for TPH-D, VOC, and per Ecology request, formaldehyde analyses (a component of plywood glue). The field sampling procedures were performed according to the specifications in the RI Work Plan.

3.2.4 Investigation of the Source of the Cedar Street Plume (January to February 2008)

To address continuing uncertainty over the source of the Cedar Street Plume, a scope of work for additional investigation was developed by Landau, on behalf of Rayonier, with input from the RI/FS Parties. The investigation went further than previous efforts by probing beneath the K Ply Mill Building and through the raised concrete slab at the south end of the mill, and by a more detailed hydrogeologic evaluation made possible by installation of several piezometers.

Landau completed soil and groundwater investigation and piezometer installation activities using a direct-push probe between January and February 2009 (Landau 2009a, 2009b). Soil and groundwater samples were collected in areas of the site where data gaps had been identified to assess concentrations of benzene and TPH-G. At the request of the RI/FS Parties, Landau also submitted a subset of soil samples for TPH-D, a site-wide COC. In addition, test pit explorations with soil samples were completed near the former form oil USTs between the mill building and Cedar Street, and shallow soil and catch basin samples were also collected underneath and near the paint shed. The investigation also included a records review to identify potential pathways and source areas. Results of the investigation are summarized in Sections 4.3.6.1 and 4.4.2.

4.0 Remedial Investigation Findings

In this section, the relevant findings from pre-RI investigations are synthesized with the RI and post-RI investigations described above.

4.1 GEOLOGY

The general stratigraphic sequence beneath the MTA Site is dredged fill placed over natural beach deposits underlain by glacial deposits over bedrock (Shannon & Wilson 1993). Dredged fill material from Port Angeles Harbor was hydraulically placed in the area from approximately 1890 to 1940. This dredged fill material consists of loose to very dense, sand, silty sand, and sandy silt with abundant shell fragments. The thickness of the fill beneath the MTA Site generally varies from 5 to 10 feet, and appears to be thicker near the shoreline, where it is encountered to depths of approximately 15 feet. In portions of the site including the shoreline area north of Westport Marine, a 4- to 6-inch clayey silt layer is locally present at the apparent contact between fill and native deposits.

Beach deposits underlying the dredged fill consist of unconsolidated, fine to coarse sand with variable amounts of silt and gravel, and interbeds of silt and fine sand, and occasional shell fragments. Based on two early geotechnical borings drilled to a depth of approximately 78 feet near the shoreline, the beach deposits appear to be about 30 feet thick, though these deposits likely thin toward the bluff south of the MTA Site (Shannon & Wilson 1993).

Glacial drift deposits underlie the beach deposits reportedly at a depth of approximately 45 feet, based on two geotechnical borings near the shoreline, and consist of stratified sand, gravel, silt, clay, and till. Drift deposits extend inland at least as far as Marine Drive and presumably extend south into the bluff, where they are overlain by glacio-fluvial sands. The thickness of the glacial deposits ranges up to 300 feet.

The bedrock underlying the glacial deposits in the Port Angeles area is believed to be the upper member of the Twin River Formation (late Eocene to early Miocene). This formation consists of olive gray to greenish gray, poorly indurated and poorly sorted massive mudstone, claystone, and siltstone, with thin beds of calcareous claystone and sandstone. The depth to the Twin River Formation or its thickness in the Port Angeles area is unknown (Shannon & Wilson 1993).

4.2 HYDROGEOLOGY AND GROUNDWATER FLOW

A shallow, unconfined aquifer is present beneath the MTA Site that first occurs in the granular dredged fill and beach deposits. The base of the aquifer has not been well defined, as it occurs below the approximately 20-foot depth of most site environmental explorations. Groundwater recharge to the aquifer occurs from upgradient groundwater inflow from the south and from the infiltration of precipitation into unpaved portions of the MTA Site (Shannon & Wilson 1993).

The elevation of the piezometric surface ranges from greater than 7 feet[4] at the southern edge of the MTA Site to approximately 5 feet near the shoreline at the northern edge of the MTA Site. Ground surface elevations across the MTA Site range from approximately 17 to 14 feet, with groundwater first occurring at depths of approximately 9 to 10 feet bgs.

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[4] Elevations are given relative to NAVD88.

Based on potentiometric elevation data collected on January 31 and May 8, 2007, the groundwater flow direction is generally northerly, with a horizontal gradient of approximately 0.002 feet/feet in this direction (refer to Table 4.1 and Figure 4.1). This gradient agrees with the tide-corrected gradient range of 0.002 to 0.006 and net gradient of 0.002 calculated as part of the earlier tidal study (Shannon & Wilson 1996).

Based on pressure transducer data from five monitoring wells at various distances from the bulkhead, (current wells, MW-9 and MW-14, and former wells, MW-1, MW-15, and MW-17), Shannon & Wilson calculated a horizontal hydraulic conductivity range of approximately 5,000 to 13,000 feet/day (or 1.8 to 4.5 cm/s) and a net seepage velocity of 35 to 85 feet/day (Shannon & Wilson 1996). These values, however, are not consistent with the predominant soil types (silty sand and sand with silt as determined by boring log information). Though it is unclear what the source of the apparent error was in the previous calculations, there are sufficient reasons to doubt the unusually high hydraulic conductivity and seepage velocity. Based on boring log information that indicate the predominant soil types at the MTA Site range from silty sand to sand with silt, a horizontal hydraulic conductivity is instead estimated to be in the range of 12 feet/day or 4.2 X 10^{-3} cm/sec, and the seepage velocity to be approximately 0.08 feet/day or 2.8 X 10^{-5} cm/sec. This seepage velocity is more consistent with the observed rate of contaminant transport observed at the MTA Site; refer to section 4.2 and Appendix C of the RI for additional information (Floyd|Snider 2007).

Based on recent measurements and a compilation of studies conducted at the present locations of the MTA, Pettit Oil, K Ply, and other nearby properties, there is some variability in the general northerly direction of groundwater flow toward the waters of Port Angeles Harbor (Shannon & Wilson 1993). As shown in Figure 4.1, the groundwater flow direction beneath Pettit Oil and the western part of the MTA is more to the northeast compared to the groundwater flow direction further east. The flow direction beneath the eastern side of the MTA is northerly and transitions to a northwesterly flow direction beneath K Ply.

The greater variability in the water table elevation and apparent groundwater flow directions adjacent to the shoreline is attributed to the influx of water from Tumwater Creek and tidal variations. A previous investigation measured tidal influence on the potentiometric surface in monitoring wells as far as 600 feet inland (Shannon & Wilson 1996). The study also identified temporary gradient reversals along the shoreline, in which high tide levels temporarily drive up the potentiometric surface of groundwater near the shore above groundwater elevations further inland. The effect of the reversals is accounted for in the tide-corrected gradients, which indicate that the net groundwater flow direction is northward into Port Angeles Harbor.

The relative influence of tides on shallow versus deep groundwater can be measured by comparing the tidal efficiency of shallow and deep monitoring wells. Figure 4.2 illustrates the changing head in monitoring wells, including the well pair MW-21A and MW-21B, with falling tidal elevations. As this graph shows, the tides exerted greater influence on groundwater measured by the deeper well of the pair, MW-21B, than groundwater measured by the shallower well. This finding is consistent with the expected results: deeper parts of the aquifer, though not confined, release more water from specific storage than from specific yield. The greater drop in head in MW-21B over a tidal cycle can therefore be explained by the faster response of the aquifer to equilibrate to the changing tides through pressure changes compared with the relatively slower process of gravity drainage of aquifer sands (i.e., specific yield) in MW-21A.

This tidal influence is discussed further in Sections 4.5 and 4.7.

4.3 SOIL QUALITY AND SOURCE AREAS

Soil quality based on TPH-G/benzene and TPH-D results from recent and past investigations is presented in Figures 4.3 and 4.4, respectively[5], and in Table 4.2. For simplicity, TEX results are not presented in Figure 4.3 but are shown in Table 4.2. Review of Table 4.2 demonstrates that elevated concentrations of BTEX are all co-located with TPH-G detections, an expected result given their gasoline source. On these figures, the sample result with the highest concentration (at any depth) is displayed. In most places, this sample was collected from a depth close to or at the water table.

The solid blue colored areas in Figure 4.3 represent the extent of elevated TPH-G in soil over three ranges of concentration: soil with TPH-G greater than 30 mg/kg (equivalent to the MTCA Method A soil cleanup level, for reference), soil with TPH-G greater than 500 mg/kg, and soil hot spots with TPH-G greater than 5,000 mg/kg. The solid green colored areas of Figure 4.4 identify areas of soil with TPH-D greater than 2,000 mg/kg (equivalent to the MTCA Method A soil cleanup level for reference) and within those areas, hot spots with TPH-D greater than 10,000 mg/kg. Identifying the extent of TPH-G and TPH-D using these types of contours is useful because it helps focus attention on hot spots and potential source areas or areas of possible light non-aqueous phase liquid (LNAPL).

Several general observations can be made based on examination of these figures:

1. TPH-G soil contamination exists in four main areas of the MTA Site:
   - near and along the MTA Bulkhead (former Chevron Dock Bulk Plant area),
   - under the Westport Marine Building (former ARCO bulk plant area),
   - under the K Ply Mill Building (unidentified surface spills),
   - in the alley between K Ply and the former Peninsula Fuel Company (location of multiple former fuel pipelines and downgradient of former Mobil bulk plant).
2. With the exception of the soil beneath the southern portion of the K Ply mill, benzene is rarely detected in site soils.
3. TPH-D (or heavier) soil contamination exists at significant concentrations in four main areas:
   - at Pettit Oil (former Chevron bulk plant),
   - in the alley between Peninsula Fuel and the K Ply mill (location of multiple former fuel pipelines and downgradient of former Mobil bulk plant),
   - under the northern portion of the K Ply mill (location of hydraulic presses),
   - near the MTA Bulkhead (source unknown).

As noted above, BTEX compounds are typically found co-located with TPH-G soil contamination, and are present near and along the MTA Bulkhead, and under the K Ply Mill Building.

The distribution of gasoline and diesel range or heavier petroleum at each of the potential source areas is discussed below.

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[5] It should be noted that soil results shown on these figures were collected over a period of nearly 20 years and were analyzed by various methods. Results based on outdated analytical methodologies or results that have been superseded by more recent or representative sampling have been excluded.

4.3.1 Former ARCO Bulk Plant

Both TPH-D and TPH-G were detected at elevated concentrations in soils in the area of the former ARCO Bulk Plant (current location of the Westport Marine facility).

4.3.1.1 TPH-G

The extent of elevated TPH-G in soil at the former ARCO Bulk Plant covers approximately 1 acre and extends across most of the former facility and over 100 feet downgradient (north) from this area. The location of the gasoline-contaminated soil indicates that a release occurred from within the former AST storage area that either spread downgradient or combined with releases to the north of the facility along former Pipeline 1. This affected area is now almost entirely covered by the Westport Marine facility and its vapor barrier, with a small area of contaminated soil east of the Westport Marine building footprint.

TPH-G concentrations suggestive of residual LNAPL saturation were detected in 1996 at P29 (10,100 mg/kg, at 5 to 6.5 feet bgs) as well as a 2002 soil boring samples, B5, in which a maximum TPH-G concentration of 11,730 mg/kg was observed. However, no indications of free product have ever been noted in either wells or soil samples in this area.

The shallowest depth that hydrocarbon odors were noted in the 1996 and 2002 borings was 5 feet bgs. This is consistent with fact that the former ARCO Bulk Plant was located in a depression (to contain spills) that was later filled in by the Port.

4.3.1.2 TPH-D

TPH-D was found at two nearby locations near the center of the former ARCO Bulk Plant at concentrations greater than 2,000 mg/kg. These data suggest a small diesel release probably occurred at the ARCO Bulk Plant. The upgradient extent of diesel associated with the former ARCO Bulk Plant appears to be bound by results from MW-4, in which TPH-D was detected at a concentration of 97 mg/kg in soil above the water table.

4.3.2 Former D&D Distributors/Phillips 66 Bulk Plant

The former D&D Distributors/Phillips 66 Bulk Plant located at 617 Marine Drive was immediately east of the former ARCO Bulk Plant. Several small areas of soil contaminated with TPH-D were identified during investigations in this area prior to the RI.

4.3.2.1 TPH-G

Gasoline contamination in soil was not detected in samples collected from Soil Borings 62, 80, 82, and 84, indicating that there has not been a significant release of gasoline to soil in the former D&D Distributors/Phillips 66 Bulk Plant area. These findings also indicate that the pipeline that serviced this bulk plant (Pipeline 5) was not a significant source of TPH-G to soils in this area.

4.3.2.2 TPH-D

High levels of TPH-D were detected at the water table near the northeastern corner of the facility (28,000 mg/kg at P30) in 1995. However, TPH-D was not detected to the west of Platypus Marine in recent Soil Boring 62, or to the east of Platypus Marine in Soil Borings 80 or 84. In Soil Boring 82, TPH-D was detected at only 28.5 mg/kg. The detection of TPH-D in Soil Boring 82 was accompanied by a detection of oil-range hydrocarbons at a concentration of 489 mg/kg, which suggests the TPH-D result may be a result of chromatographic overlap from heavier petroleum compounds. Based on these results, the 1995 detections at P30 and TP-3 appear to be highly localized as they were not detected in nearby RI borings completed in 2005–2006.

4.3.3 Southern Site boundary with Former Peninsula Fuel Company

Soil samples were collected from borings located at the southern boundary of the MTA Site, along the northern and western boundary of former Peninsula Fuel located at 535 Marine Drive (east of D&D Distributors/Phillips 66 Bulk Plant). Subsequent to the RI sampling, Landau collected soil samples in this vicinity as part of the 2009 investigation of potential sources of the Cedar Street Plume.

4.3.3.1 TPH-G/Benzene

A small area of smear zone soil contaminated with TPH-G is present at the edge of the MTA Site near the northwest corner of the former Peninsula Fuel Company. This area extends from boring location B1 (2,200 mg/kg TPH-G) in the west to B4 (1,500 mg/kg TPH-G) in the east. The extent of the contamination in this area in the MTA Site is constrained by non-detect results on the north, east, and west. No analytical results are available to the south, from within the former Peninsula Fuels property.

Additionally, in the alleyway north of the former Peninsula Fuel Company and just south of the K Ply, TPH-G was identified in soil from B8 (830 mg/kg) and B9 (660 mg/kg). Benzene was detected at 1.2 mg/kg in soil from B8.

4.3.3.2 TPH-D

TPH-D soil contamination is present in the same approximate area as the TPH-G soil contamination at the edge of the MTA Site near the northwest corner of the former Peninsula Fuels. The TPH-D concentrations detected in soil from Soil Boring 92 (11,800 mg/kg) are consistent with older analytical results reported by Landau from soil samples collected from near the water table from this area in 1988 (e.g., PS18 at 1,745 mg/kg TPH by USEPA Method 418.1; not included on Figure 4.4; Landau 1988) as well as two borings located further downgradient north of the Peninsula Fuel Company (2,000 mg/kg at PP7 and 5,300 mg/kg at PP8; Landau 1989). Subsequent testing by Landau in 1989 confirmed that diesel was present at these locations.

The finding of TPH-D at concentrations greater than 10,000 mg/kg indicates a local source. This finding is consistent with the intermittent presence of a thin layer of free diesel product noted in Well PP-7, as discussed in Section 4.4.3.

4.3.4 Former Standard Oil Dock Bulk Plant

Historically, the former Standard Oil Dock Bulk Plant occupied the area north of the former ARCO Bulk Plant. Prior investigations between the former Standard Oil Dock Bulk Plant and the former ARCO Bulk Plant identified the presence of a number of “hot spots” of TPH-G and TPH-D soil contamination. More recent data indicate that the areal extent of TPH-G and associated benzene, ethylbenzene, and xylenes contamination in soil that exceed MTCA Method A concentrations is widespread within the MTA Bulkhead area. The recent RI borings indicate substantially more mass of TPH-G in soil between formerly identified “hot spots.” However, the extent of TPH-D soil contamination that exceeds Method A levels is more limited than previous data indicated.

The current use of this area includes a paved roadway and a gravel parking lot used by Westport Marine.

4.3.4.1 TPH-G

Results from soil borings along the MTA Bulkhead have defined the downgradient extent of TPH-G contamination, where it extends to the MTA Bulkhead at concentrations up to 7,260 mg/kg TPH-G (FS-1). In addition to this location, four other hotspot areas are apparent in which TPH-G is present at the smear zone at concentrations greater than 5,000 mg/kg: the area represented by MW-31, located adjacent to the MTA Bulkhead further east; and the areas surrounding FS-28/P33, FS-17, FS-13, and P28. Non-detect samples define the boundary of the soil contamination to the west and south. The bulk of the TPH-G soil contamination in this area is located at the smear zone but displays no evidence of a separate phase LNAPL. Analytical results, PID measurements, and observations of odors and sheen indicate minor areas of vadose zone contamination especially in the vicinity of FS-17, where 6,260 mg/kg TPH-G was detected at a depth of 4-6 feet bgs. Indications of vadose zone TPH-G contamination were also identified from PID soil screening results beginning at about 5 feet bgs at nearby MW-32, MW-27, FS-10 and FS-29.

4.3.4.2 TPH-D

While not as widespread as TPH-G, soil contaminated with TPH-D at the smear zone is present north of Westport Marine in an area approximately 200 feet long in front of the MTA Bulkhead. The highest concentration detected in this area is 12,500 mg/kg at FS-2, and concentrations greater than 2,000 mg/kg are present across a broad area that extends approximately 100 feet south of the bulkhead, based on available data. The detection of TPH-D at shallow depths above the water table at MW-10 (2,000 mg/kg) suggests a nearby source such as the Standard Oil Dock Bulk Fuel Plant and/or the pipelines that led to it from the former fueling dock.

Historical data indicate that a concentrated area of diesel-contaminated soil is located at the southern edge of the former Standard Oil Dock Bulk Plant, now the northeast corner of the Westport Marine building. This area of TPH-D soil contamination is based on samples collected in 1995 at P18 (24,000 mg/kg) and MW-17 (19,000 mg/kg; Shannon & Wilson 1995, 1996). Samples collected from nearby borings as part of 2008 sampling (FS-26 and FS-27) did not identify the presence of TPH-D in this location, and therefore the area is considered to be more limited than previously thought.

4.3.5 Pettit Oil

Soil quality over a large portion of the former Chevron Bulk Fuel Plant (Pettit Oil; located at 638 Marine Drive) is different in character than contamination identified elsewhere at the MTA Site, as it is characterized by residual diesel product and associated elevated TPH-D concentrations. LNAPL as a separate phase product is present in MW-3, MW-8, MW-9, and RZ-2, and sheen has been measured in MW-2. Product thicknesses measured in May 2007 ranged from 1.4 feet in MW-8 to 0.33 feet in MW-3 (Gettler-Ryan Inc. 2005, 2007). Monitoring Wells MW-8 and MW-9 were installed in December 2004 to characterize conditions at the downgradient edge of the property. Based on the product thicknesses that accumulated in these monitoring wells, the separate-phase diesel may extend a short distance downgradient beneath Marine Drive.

Gasoline-range contamination in soil is limited to a handful of detections at concentrations considerably less than 1,000 mg/kg, and so does not appear to be significant contaminant. Older data indicates an isolated “hot spot” of TPH-G at MW-5 (2,700 mg/kg) on the property adjacent to Pettit Oil and outside the boundaries of the MTA Site. This area of contamination appears to be bounded to the east and west, as soil samples collected from P1 and P2 are non-detect for TPH-G.

4.3.6 K Ply (Former and Current PenPly)

4.3.6.1 TPH-G/Benzene

TPH-G- and/or BTEX-contaminated soil is present beneath the K Ply mill (now PenPly) in two areas: the northern end of the facility, where gasoline is commingled with a release of separate-phase hydraulic oil present at the water table and smear zone, and the southern end of the facility, where soil contamination has been detected over a broad area.

Limited data are available to characterize the TPH-G in soil co-located with the hydraulic oil release beneath the northern end of the facility, which is being cleaned up by Rayonier under a separate Agreed Order between Rayonier and Ecology. Based on 1988 soil samples (Landau 1988), TPH-G is present in soil in this area at concentrations up to 2,400 mg/kg. The source of this gasoline has not been identified.

The 2009 Landau investigation beneath the southern portion of the K Ply Mill identified a broad area of moderate level TPH-G and BTEX soil contamination, which extends from the southwest corner of the mill, covered by a concrete slab (B16), to approximately 200 feet to the east (B21 and B18). Concentrations ranged from 1,300 to 4,300 mg/kg TPH-G. Along with the TPH-G contamination, the soil in this area includes substantially higher concentrations of benzene (up to 24 mg/kg) than has been detected elsewhere at the site. Toluene, ethylbenzene, and xylenes concentrations in soil are co-located with benzene, though benzene is considered the primary risk-driver constituent (refer to Section 5.1).

The general extent of this TPH-G and benzene contamination in soil is bounded to the south by B17 (8 mg/kg), to the east near the machine shop at location PZ-7 (10 mg/kg) and to the west by PZ-2 (non-detect) in Cedar Street. The presence and extent of contamination under the mid-section of the mill building is not well defined due to minimal data in this area.

The contamination beneath the mill includes soil from the vadose zone. For example, significant BTEX contamination was detected in soil at B16 at a depth of 1 to 2 feet bgs, and at PZ-6 at 4 to 5 feet bgs. TPH-G was detected at concentrations greater than 1,000 mg/kg and benzene was a significant component of the BTEX fraction in these samples. TPH-G was also detected at 200 mg/kg at 2 to 3 feet bgs at B20. Field observations of moderate to strong hydrocarbon odors and elevated PID readings (approximately 100 to 800 ppm) were observed in shallow soil in several other borings beneath the mill building (B20, B21, B18, and PZ-8) as well.

Several potential scenarios may have resulted in the release or releases that provide the source area for the Cedar Street Plume. Based on the widespread distribution of soil contamination and the presence of soil contamination at vadose zone depths in multiple locations, however, one or more surface spills of gasoline within the mill building footprint is considered the most likely source of the Cedar Street Plume. Very shallow vadose zone soil contamination at B16 is unlikely to be associated with a leak from Pipeline 8, which is situated approximately 5 feet deeper than the shallow contamination. Elevated vadose zone contamination detected at PZ-6 is located approximately 60 feet east of Pipeline 8, over 100 feet from the abandoned storm sewer, and about 40 feet north of the raised concrete slab beneath the southern end of the building. Based on these findings, the release(s) that resulted in the Cedar Street Plume appear to be associated with mill or pre-mill operations in this area and not migration of contaminants from nearby bulk petroleum storage facilities or pipelines. The former USTs and paint shed adjacent to the mill on the west have been ruled out based on the analytical results.

In addition to the contamination beneath the building, an additional area of TPH-G soil contamination at K Ply was identified outside the mill building through RI soil borings. Petroleum-contaminated soil was identified north of K Ply, close to the K Ply Bulkhead in Soil Boring 210, in which TPH-G was detected at 791 mg/kg in soil above the water table.

4.3.6.2 TPH-D

Diesel range and heavier hydrocarbons have been detected in multiple locations under and outside of the K Ply Mill Building. The largest of these areas of contamination is the release of hydraulic oil under three plywood presses under the northern portion of the mill. As indicated above, the hydraulic oil release is being remediated by Rayonier under a separate Agreed Order between Rayonier and Ecology. Available data indicate that separate-phase hydraulic oil does not extend to the bulkhead north of K Ply, which is consistent with the low mobility of hydraulic oil. As noted above, the hydraulic oil is commingled with gasoline and benzene, which appear to contribute to groundwater contamination in this area (refer to Section 4.4).

Concerning the presence of TPH-D in the southern portion of the mill, no indications of diesel-range hydrocarbons were observed in any of the multiple soil cores; however, TPH-D contamination was identified in two samples at low levels (B18 at 320 mg/kg and PZ-6 at 150 mg/k) collected by Landau in 2009.

Outside of the mill, more elevated TPH-D is present near the former form oil USTs between K Ply and Cedar Street based on location 217, where TPH-D was detected at 2,580 mg/kg. The sample was collected from above the water table at a depth of 6 to 7 feet bgs. TPH-D contamination appears to be confined to this area and is well constrained, as samples in close proximity to PZ-9 are non-detect, including B23, PZ-3 and P15.

Low-level TPH-D contamination is also present near the K Ply Bulkhead, based on the detection of 530 mg/kg TPH-D at soil boring 210, and the vicinity of Well PP-7, which is upgradient of the K Ply building.

4.4 GROUNDWATER QUALITY

There are a number of areas throughout the MTA Site where spills or leaks of petroleum products have impacted soil. In turn, these soil areas may be sources of toxic petroleum constituents (e.g., benzene) to groundwater. The plumes emanating from these multiple source areas cover broad areas of the MTA Site and in many cases have commingled.

Groundwater sampling data indicate three distinct plumes in groundwater at the MTA Site (refer to Figures 4.5, 4.6, and 4.7 and Tables 4.3 and 4.4). Benzene, as a major constituent of gasoline, generally occurs with TPH-G in site groundwater, and it is useful to consider these contaminants together as they have a common source and extent. In contrast, plumes that contain TPH-D may or may not contain TPH-G/benzene. As noted above, toluene, ethylbenzene, and xylenes are commonly co-located with benzene, but are not COCs (refer to Section 5.1).

The three major groundwater plumes and their primary constituents are:

- **MTA Plume**: TPH-G/benzene, with low-level TPH-D near the MTA Bulkhead
- **K Ply/Cedar Street Plume**: TPH-G/benzene, with TPH-D and TPH-G south of K Ply
- **Pettit Oil Plume**: TPH-D, with low-level TPH-G/benzene

Each plume is discussed separately below.

4.4.1 Marine Trades Area Plume

The MTA Plume consists of elevated TPH-G and benzene in the upper 10 feet of groundwater that covers most of the western half of the MTA Site from the Pettit Oil bulk plant northward to the MTA Bulkhead. The upgradient end of the MTA Plume is located at the former ARCO Bulk Plant, where concentrations of TPH-G and benzene are more elevated and widespread than at Pettit Oil across Marine Drive. The MTA Plume is primarily associated with releases from the former ARCO Bulk Plant and the former Standard Oil Dock Bulk Plant, based on the presence of significant gasoline contamination in subsurface soils beneath the footprint of these facilities.

The plume extends downgradient at elevated concentrations to the former Standard Oil Dock Bulk Plant and to monitoring wells located at the MTA Bulkhead. It is bounded to the west by Tumwater Creek and to the east by non-detect results in monitoring wells and probe points that extend through the central portion of the MTA Site.

At the downgradient end of the plume at the MTA Bulkhead, benzene is present at elevated concentrations (up to 184 µg/L) in monitoring wells along approximately 300 lineal feet of the bulkhead. TPH-G concentrations in groundwater in monitoring wells along the bulkhead (up to 5,400 µg/L) are generally higher than benzene. The northwest corner of the plume in the vicinity of MW-29 and FS-4 appears to be a hotspot of TPH-G and benzene contamination. A hotspot of both TPH-G and benzene is also present in the general vicinity of MW-32 and FS-29, where vadose zone soil contamination indicates a potential lingering source area. The data also suggest a hotspot of benzene and TPH-G at the northern edge of the Westport Marine building, in the vicinity of MW-25 and FS-26. There are no seeps along the bulkhead so the actual concentrations of contaminant releases to surface water are not known.

Up-to-date characterization of the middle section of the plume is made difficult due to the lack of data underneath the Westport Marine Structure. However, older groundwater data indicate significant concentrations were present in this area as recently as 2003 (FSM 2003a). Current TPH-G and benzene concentrations are expected to be similar in concentration.

Based on monitoring well results, the thickness of the plume is limited to the upper 10 feet of groundwater. Monitoring well sampling from well pairs MW-20A/B and MW-21A/B did not result in detections of TPH-G or benzene in the deeper wells, which are screened from 20 to 25 feet bgs or approximately 10 to 15 feet beneath the water table surface.

4.4.2 K Ply/Cedar Street Plume

The K Ply Plume and Cedar Street Plume, previously considered distinct areas of groundwater contamination (Floyd|Snider 2007), are now considered so commingled that they are better described as one plume with multiple sources, based on older data and Landau’s 2009 investigation of the area beneath the K Ply mill.

The K Ply/Cedar Street Plume consists of elevated benzene and TPH-G in the upper 10 feet of groundwater over a large area that includes the majority of the footprint of the K Ply Mill Building. Other typical gasoline constituents, including toluene, ethylbenzene, xylenes, trimethylbenzene, etc., have also been detected in the plume, but at significantly lower concentrations.

The contoured concentrations (Figure 4.6) of benzene in groundwater beneath the K Ply mill and extending northward beneath Cedar Street illustrate a large, elongated groundwater plume migrating in the direction of groundwater flow. The plume has two downgradient lobes, a western lobe beneath Cedar Street and an eastern lobe beneath K Ply. Geoprobe samples and wells confirm that the western lobe does not extend to the MTA Bulkhead area; rather it extends to within approximately 100 feet from the MTA Bulkhead near the Port’s office building. In contrast, the eastern lobe extends to the K Ply Bulkhead. The data indicate that no hydraulic oil extends to the K Ply Bulkhead, either as dissolved constituents or as separate-phase product.

The source of the eastern lobe appears to be the commingled hydraulic oil/gasoline contamination area beneath the northern end of the K Ply mill (being remediated for a hydraulic oil release under a separate Agreed Order between Ecology and Rayonier). It is also possible that the more recent and better defined area of gasoline in soil farther upgradient, under the southern portion of the mill is a contributing source.

The middle section of the plume extends from west of Cedar Street to nearly the eastern edge of the K Ply mill. Of note, the elevated benzene concentrations in the portion of the benzene plume under Cedar Street between K Ply and Platypus Marine were identified unexpectedly as part of 2005 RI investigative activities because earlier work in the mid-1990s detected only trace to non-detect levels of benzene in this area. The discovery triggered a series of investigations, as described in Section 3.2, the results of which are presented in this RI/FS.

The southern portion of the plume, which includes the most elevated TPH-G and benzene concentrations in groundwater and soil (refer to Section 4.3.6), is largely beneath the K Ply Mill Building. The contaminated soil in this area is the likely source area for most of the plume. The highest concentration of TPH-G in groundwater at the MTA Site, 53,000 µg/L, was detected in groundwater from boring location PZ-6, beneath the K Ply mill, and the highest concentration of benzene, 11,000 µg/L, was detected at PZ-6, also located beneath the mill building. These concentrations, and results from other nearby borings, are elevated enough to indicate proximity to a source area under the mill as supported by elevated concentrations of TPH-G/benzene detected in soil samples from PZ-6 and B16. Refer to Section 4.3.6 above for discussion of the source area soils.

Stormwater collected from the roof of the K Ply Mill Building that is channeled to and infiltrating through soil beneath the mill may also contribute to the leaching of COCs from soil into groundwater in the K Ply/Cedar Street Plume.

The K Ply/Cedar Street Plume is present in the upper 10 feet though it is concentrated within the upper 5 feet of the aquifer based on samples collected from Soil Boring 68 in October 2005 that showed benzene at 5.5 µg/L in the deeper groundwater sample (16 to 20 feet bgs) compared to benzene at 915 µg/L in the upper 5 feet of groundwater sampled.

A small area of the southern portion of the plume consists primarily of TPH-D and TPH-G, with limited benzene. This portion of the plume is located in the area between the former Peninsula Fuel Company, the K Ply mill, and Platypus Marine. The results from Well PP-7 and several nearby soil probe groundwater sampling locations (SB-86, SB-90, SB-91, SB-92, SB-93, SB-96, and SB-97) indicate the presence of TPH-G in groundwater throughout this area along with more localized detections of relatively low-concentration benzene (up to 32.5 µg/L detected historically in MW-8) and TPH-D. Elevated TPH-G concentrations extend across the alley from the southern portion of the K Ply/Cedar Street Plume to the southern boundary of the MTA Site at Peninsula Fuels.

The limited and low concentration occurrence of benzene in this area is not substantial enough to suggest any connection with the significantly higher and more widespread concentrations of benzene in the K Ply/Cedar Street Benzene Plume further downgradient.

The occurrence of TPH-D in groundwater in this area also includes the intermittent measurement of separate-phase diesel product in PP-7. Though free product was not measured in PP-7 in May 2007, approximately 0.02 feet of product was measured prior to sampling on January 30, 2007 and has been historically noted in this well.[6]

The available evidence indicates that the source of this area of the plume is primarily residual gasoline and diesel contamination in subsurface soils near Pipeline 5 and Pipeline 8, which were historically operated by Peninsula Fuel, and in the area of the former D&D Distributors/Phillips 66 Bulk Plant. Refer to the illustration of pipeline locations in Figure 2.3.

4.4.3 Pettit Oil Plume

The primary contaminant in groundwater at Pettit Oil is TPH-D with minor amounts of TPH-G and benzene. The Pettit Oil Plume also includes areas of separate-phase diesel product (apparently formerly released at Pettit Oil), which provide an ongoing source of diesel-range organic compounds to groundwater, resulting in a localized TPH-D plume in groundwater. Figure 4.8 shows the wells containing free product and the limits of the dissolved diesel plume.

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[6] Free product appears to have contaminated the January 30 sample, resulting in an anomalously elevated detection of 36,000 µg/L TPH-D in this sample.

The groundwater quality downgradient of Pettit Oil, however, suggests little or no migration of free product or TPH-D beneath Marine Drive.

Minor amounts of TPH-G (up to 1,100 µg/L in recent sampling) and benzene (up to 24 µg/L in recent sampling) have also been detected in groundwater at Pettit Oil. These areas of the Pettit Oil Plume are included within the boundaries of the larger MTA Plume (refer to Figure 4.6).

4.5 SURFACE WATER QUALITY

There are two surface water bodies at the MTA Site: Tumwater Creek and the marine waters of Port Angeles Harbor.

4.5.1 Tumwater Creek

Surface water samples were collected from three locations along Tumwater Creek in 1995 (Shannon & Wilson 1996). The samples were tested for TPH-D, TPH-G, and BTEX with no detections reported. The lack of detections in the creek is consistent with the site hydrogeology. The creek, which flows through a man-made channel in the fill beneath the MTA Site, was previously found to be a hydraulic barrier and a “losing” stream (Shannon & Wilson 1993, 1996). This hydrologic condition, where surface water generally discharges to groundwater, is consistent with the artificial nature of the creek, which was cut into site fill. The losing nature of the creek was confirmed by a survey of the creek bottom and measurements of the creek stage height in May 2007 (refer to Table 4.1 and Figure 4.1). As shown in this figure, the creek stage elevation is over 1 foot higher than the nearby water table at upgradient location RP-2. At RP-1, the creek stage elevation was measured to be close to the elevation of groundwater in Well MW-12. The creek elevation at measuring point RP-1 is located closer to the shoreline, however, and so is far more subject to tidal variation.[7] The potentiometric contours “V” downstream as expected with losing creeks, indicating that the creek recharges groundwater in its vicinity (Figure 4.1). These data support the conclusion that Tumwater Creek acts as a hydraulic barrier along the western edge of the MTA Site, which is consistent with analytical sampling results that demonstrate no site COCs west of the creek.

4.5.2 Port Angeles Harbor

The intertidal zone in front of the MTA Bulkhead was examined on several occasions during low tides for evidence of groundwater seeps. No evidence of seeps was observed in the sandy intertidal deposits in front of the riprap shoreline in this area.

Groundwater monitoring in wells located adjacent to the MTA Bulkhead suggests that elevated benzene, TPH-G, and TPH-D may be discharging to Port Angeles harbor from shallow groundwater through the bulkhead when the tidal elevation drops below the potentiometric surface elevation (approximately 5 feet NAVD88). Monitoring wells adjacent to the bulkhead are sampled at the daily lowest low tide to more accurately characterize groundwater by minimizing the presence of saline waters that may mix with fresher shallow groundwater at high tides. Groundwater sampled from shallow monitoring wells adjacent to the bulkhead at the daily lowest low tide is considered to have the highest potential concentration of COCs potentially discharging to Port Angeles Harbor. Gradient reversals at high tide, however, are thought to

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[7] The measurement at RP-1 was collected at approximately 9:14 AM, when the tidal elevation was near its daily midpoint (1.8 feet NAVD 88) and falling.

dilute contaminated groundwater. As noted above, it is not possible to establish directly whether Port of Port Angeles waters are being impacted due to the lack of seeps and presence of rip-rap which prevents sampling of marine waters on the shoreward side of the bulkhead during low tides when discharge of contaminated groundwater would be greatest. The effects of tidal variation on contaminant transport are discussed in the following section.

Monitoring of deeper groundwater (approximately 20 to 25 feet bgs or -5 to -10 NAVD88) adjacent to the MTA Bulkhead, however, indicates that contamination is below detection in deeper groundwater. Thus, it appears that deeper groundwater is not a pathway for contaminant discharges to Port Angeles Harbor.

4.6 SEDIMENT QUALITY

Sediments in Port Angeles Harbor have the potential to receive contaminated groundwater discharge from the MTA Site. However, available sediment results provide no indications that site COCs, primarily volatile organic compounds derived from gasoline, are partitioning into sediments, as described below. For this reason, and based on the Tumwater Creek Delta and Port Angeles Harbor data indicating little to no TPH present in sediments in the vicinity of the MTA Site, sediment is not considered a potentially affected media.

4.6.1 Tumwater Creek Delta

Surface sediment samples were collected from six Port Angeles Harbor locations in the delta at the mouth of Tumwater Creek in 1997 by Port of Port Angeles as a component of a Tumwater Creek dredging project. Three of the locations were located adjacent to the northwest corner of the MTA Bulkhead near the former Standard Oil Dock, where soil and groundwater contamination are present. Tumwater Creek delta sampling results and a location map are included in Appendix E. The six locations were combined by the laboratory into two composite samples for analysis. The sediment samples were tested for VOCs (including BTEX), SVOCs, and metals. No detections were reported for VOCs or SVOCs. Naturally occurring metals arsenic, barium, and chromium were detected at low concentrations below available criteria including Sediment Management Standards Sediment Quality Standards (SMS SQS) and MTCA Method A (arsenic and chromium) and MTCA Method B (barium).

4.6.2 Port Angeles Harbor

In February 2012, a draft of the Port Angeles Harbor Sediment Characterization Report was released by Ecology (Ecology 2012). The Port of Port Angeles will be working with Ecology on issues related to the Port Angeles Harbor Sediment Characterization study and its findings. The report presents data for surface sediment grab samples (0-10 cm) and subsurface sediment core samples (maximum 12 feet) throughout the Harbor. Two of these samples were located in the vicinity of the MTA Site: surface samples BL03 and BLO4. BL03 was collected adjacent to or underneath the Terminal 3 pier structure, and BLO4 was collected adjacent to the Terminal 1 pier structure approximately 500 feet from the shoreline. Additionally, surface sample BLO1 and subsurface core BLO2 were collected in the shoreline sediments west of Tumwater Creek. All surface samples were analyzed for a broad suite of contaminants including site COC TPH-D. The motor oil fraction of TPH was also reported for all samples, but site COCs benzene and TPH-G were not analyzed. Subsurface samples from BLO2 were not analyzed for TPH.

Generally, surface concentrations of TPH-D were low in sediments in the vicinity of the MTA Site. Detected concentrations were 83 ppm, 66 ppm, 50 ppm, and 14 ppm in locations BLO1 through BL04 respectively. The lowest concentrations from these four locations were from the two samples located closest to the MTA Site shoreline. TPH motor oil was also detected in low concentrations in sediments. Detected concentrations were 320 ppm, 280 ppm, 150 ppm, and 39 ppm in locations BLO1 through BL04. Although there are no cleanup criteria available for comparison for TPH in sediments, these concentrations are well below MTCA Method A soil cleanup criteria. These concentrations are consistent with other detections of TPH-D throughout Port Angeles Harbor sediment, including locations far from potential petroleum sources.

Both the Tumwater Creek and Port Angeles Harbor sediment results are consistent with the understanding that the volatile COCs do not partition to sediment organic matter, as they are too soluble and have a low affinity for organic matter. The detected TPH concentrations are unlikely to have resulted from groundwater discharge from the MTA Site, as they are consistent with concentrations found elsewhere in Port Angeles Harbor.

4.7 TIDAL INFLUENCE ON CONTAMINANT FATE AND TRANSPORT

In this section, the effects of tidal variation on contaminant fate and transport in soil and groundwater near the shoreline are described. A general description of the physical effect of tides upon groundwater was presented in Section 4.2.

4.7.1 Expanded Soil Smear Zone

One effect of tides on contaminants near the shoreline is the potential for an expanded soil smear zone thickness due to greater groundwater fluctuations. Soil data and logging observations from shoreline Soil Borings 74 and 76 indicate that petroleum-contaminated soil at the water table is present across a 5 foot smear zone, which is consistent with the range of tidal variation, and thicker than the 2-to-3-foot smear zone observed further inland at the MTA Site.

4.7.2 Shallow Groundwater

Tidal influence dilutes and slows the discharge of contaminants from shallow groundwater (approximately the upper 5 to 10 feet) through the bulkhead, but does not materially affect contaminant transport driven by the net flow of shallow groundwater. Figure 4.9 displays a conceptual cross section of the interaction between the tidal waters of Port Angeles Harbor and the benzene plume at the MTA Bulkhead. This cross section, based on the representative bulkhead well pair MW-20A/MW-20B, illustrates that TPH-G and benzene are at an elevation at which groundwater discharges primarily to intertidal waters, likely through the seams in the wooden bulkhead and then through the riprap that armors the shoreline and supports the bulkhead.

Temporary gradient reversals were observed during high tides that cause a back-and-forth “pulse” effect in discharging groundwater and contribute to mixing of marine waters with shallow groundwater in the upper reaches of the aquifer. Under these conditions, the concentration of COCs has occasionally been observed to be more dilute near the bulkhead. Mixing of marine waters with shallow groundwater not only causes dilution of contaminant concentrations, but temporarily slows or reverses the advective transport of contaminants near the shoreline (Figure 4.8). Regardless of the temporary slowing of contaminants, overall, the net transport of dissolved contaminants remains northward toward the harbor. According to a prior study, the average gradient (corrected for tidal fluctuations) is between 0.002 and 0.006 (Shannon & Wilson 1996).

4.7.3 Deeper Groundwater

No COCs are present in groundwater below the upper 10 feet of the saturated zone. The presence of a low-permeability silt layer at the contact between fill and native in parts of the site is consistent with preventing migration of COCs below about the upper 5 feet of the saturated zone.

The mixing of marine waters with shallow groundwater does not extend below the upper 5 feet of the saturated zone, based on the results of the specific conductivity and TDS measurements collected during discrete-depth groundwater sampling at Locations SB-70 through SB-72 (refer to Table 4.5). Indications of higher conductivity and TDS in deeper groundwater (evidence of saline mixing) were not observed below the uppermost (5-foot) interval of the aquifer.

As is commonly observed in tidally-influenced groundwater, tides exerted greater influence on groundwater measured by deeper wells of pairs than on groundwater measured by wells screened at shallower elevation. As noted in Section 4.5, however, groundwater quality results indicate that this greater relative flux in deeper water than shallow water at low tide is not resulting in contaminants being transported downward in the aquifer, or discharging to surface water through deeper groundwater. The absence of contaminants in the groundwater in the deeper wells (screened below the upper 10 feet of the saturated zone) of the two shoreline well pairs, MW-20A/B and MW-21A/B, indicates that significant downward mixing of contaminants from the shallow part of the aquifer is not occurring.

These findings indicate that only the uppermost 10 feet of the saturated zone site-wide, including near the bulkhead, is impacted by groundwater contamination above cleanup levels.

4.8 CONCLUSION

This remedial investigation report fully complies with requirements under the 2005 Agreed Order and provides sufficient data and information necessary to adequately characterize the west side of the MTA Site for the purpose of developing and evaluating cleanup action alternatives in accordance with WAC 173-340-350.

5.0 Conceptual Site Model

A conceptual site model (CSM) was developed for the MTA Site to provide a useful summary of site conditions and exposure pathways which are fundamental to the development of cleanup levels. The CSM identifies how the COCs were released into the environment, how they migrate through various environmental media, and what receptor populations (human and ecological) are at risk. The CSM, as described below, is based on new and pre-existing chemical data, current land use, and established contaminant fate and transport processes. A summary of the CSM is presented in Figure 5.1.

5.1 ORIGINAL RELEASE MECHANISM AND PRIMARY CONTAMINATED MEDIA

The original release mechanisms consisted of both documented and undocumented spills and fuel leaks from ASTs and petroleum piping from the various former bulk plants that were located within the MTA Site boundaries. These releases contaminated the surface and subsurface soil at many areas of the MTA Site. In some places, the releases to subsurface soil are continuous over large areas, in other places, the releases are localized. Due to the extensive redevelopment of the MTA Site following the era of the bulk plants, original surface soils that may have once been impacted by spills have been extensively reworked and/or capped and are no longer considered an environmental media of concern.

The soil quality and separate-phase product in the apparent source areas for each of the three groundwater plumes (and release mechanisms, where known) are discussed in Section 4.3 and summarized here:

- **MTA Plume**: Gasoline-contaminated soils throughout the western portion of the MTA Site have contributed to this plume of TPH-G and benzene. The highest soil source concentrations, and areas of most significant apparent releases, are found at the former ARCO Bulk Plant and at the former Standard Oil Dock Bulk Plant. Contaminated soils are predominantly located in the smear zone (approximately 8 to 12 feet bgs), with scattered areas of vadose zone (approximately 2 to 10 feet bgs) contamination.
- **K Ply/Cedar Street Plume**: Available evidence indicates surface spills of gasoline beneath the K Ply mill are the probable source for the benzene and TPH-G plume extending from the southern area of K Ply. Diesel- and gasoline-contaminated soils at the southern site boundary with Peninsula Fuel and an occasionally-apparent thin layer of free diesel product in the alley between Peninsula Fuel and K Ply are also contributing TPH-G and TPH-D to this plume. Gasoline associated with the hydraulic oil release (being cleaned up separately) is a contributing source of COCs to groundwater beneath the northern section of K Ply. Contaminated soils are predominantly located in the smear zone (approximately 8 to 12 feet bgs), with scattered areas of vadose zone (approximately 2 to 10 feet bgs) contamination.
- **Pettit Oil Plume**: The free diesel product in the subsurface in this area remains a source of TPH-D to groundwater. Free diesel product is located at the water table (approximately 10 feet bgs), at measured thicknesses up to 1.4 feet. Contaminated soils are predominantly located in the smear zone (approximately 8 to 12 feet bgs), with scattered areas of vadose zone (approximately 2 to 10 feet bgs) contamination. In addition, localized areas of gasoline releases to soil have been identified.

5.2 SECONDARY RELEASE MECHANISMS

Diesel and gasoline product, once released to the soil, have been further transported from surface and subsurface soil by secondary mechanisms, primarily infiltration of groundwater and gravity drainage of petroleum product. COCs may also have been historically released from surface soil by direct volatilization, but this pathway has been eliminated by the reworking and capping of surface soils and by recent construction activities. Volatile COCs in subsurface soil that could potentially continue to migrate into overlying building spaces, as discussed in Section 5.2.5.

Diesel-range and heavier-range gasoline hydrocarbons that are non-volatile tend to be adsorbed to organic matter in soil as they infiltrate downward into the subsurface. Prior to the reworking and capping of surface soil, hydrocarbons may have been dispersed by wind (via dust) and water (via stormwater runoff). Contaminant transport by stormwater is not considered a pathway, however, due to the current lack of contaminants in surface soils, as surface soil (approximately the upper 2 feet) has been removed, reworked, and/or covered with several feet of imported fill as various industrial concerns have redeveloped the MTA Site following cessation of the bulk plants and preceding site uses. Stormwater runoff in contact with surface soils generally infiltrates into the subsurface. Stormwater directed to storm sewers that discharge into Tumwater Creek and Port Angeles Harbor is primarily from paved surfaces that are blocked from contact with soil. Infiltration of stormwater collected from the roof of the K Ply Mill Building and channeled beneath the mill may have once contributed to the leaching of COCs into groundwater in the K Ply/Cedar Street Plume.

In certain areas, these petroleum compounds infiltrated the subsurface soil and contacted groundwater, resulting in all three of the groundwater plumes identified. Where the release was significant enough (e.g., at Pettit Oil), the petroleum accumulated as free product on the shallow water table. The soluble constituents (e.g., benzene) have dissolved or are dissolving into groundwater and are migrating (by advection) toward Port Angeles Harbor:

- **MTA Plume**: TPH-G and benzene have dissolved into groundwater from soil source areas at the former ARCO Bulk Plant and the former Standard Oil/Chevron Bulk Fuel Plant. The plume of elevated TPH-G and benzene is limited to the upper 10 feet of the saturated zone, and may be discharging to surface water based on the elevated concentrations in monitoring wells located at the bulkhead. Volatile organic compounds in groundwater, chiefly benzene, have the potential to migrate via the soil vapor pathway into future buildings that may be constructed over the plume. The office portion of the existing building located over the MTA Plume, Westport Marine, was constructed with a sub-slab vapor barrier to block the vapor intrusion pathway.
- **K Ply/Cedar Street Plume**: Elevated benzene, TPH-G, and TPH-D concentrations from beneath K Ply, and elevated TPH-G and TPH-D concentrations from the area south of K Ply are migrating with groundwater flow toward the bulkhead along Cedar Street and beneath the K Ply building. These contaminants comprise a plume limited to the upper 10 feet of the saturated zone. Discharge of roof stormwater from K Ply contributes to the leaching of contaminants. TPH-G and very low levels of benzene in groundwater may be discharging to surface water based on the elevated concentrations in geoprobe groundwater samples located at the bulkhead north of K Ply. Hydraulic oil and associated TPH-D (being cleaned up separately) does not appear to be migrating from the area of the release. Volatile organic compounds in soil, chiefly benzene, have the potential to migrate through the soil vapor pathway

into the overlying K Ply Mill Building, or any future construction located over the plume.

- **Pettit Oil Plume**: Diesel product at Pettit Oil appears to have had limited mobility as a soluble constituent in groundwater, and has not resulted in significant diesel contamination in groundwater north of the source area.

The source areas with high contaminant concentrations are present as a smear zone resulting from fluctuations in groundwater levels due to seasonal and tidal variation. The contamination remaining in the smear zone (e.g., as residual saturation) acts as a reservoir for continued release of contaminants in groundwater and will continue to do so until the COCs are completely dissolved out, volatilized, or biologically degraded. Such attenuation processes may take years to decades.

The smear zone appears to be most significant in the downgradient reaches of the MTA Plume, where tidal influence results in greater groundwater fluctuation. Substantial smear zone contamination is also present beneath the K Ply mill and Pettit Oil.

5.3 POTENTIALLY CONTAMINATED MEDIA

The results of the transport mechanism analysis summarized above identify the main media and pathways through which the COCs are transported. The affected media are subsurface soil, groundwater, and soil vapor/indoor air. Port Angeles Harbor surface water is considered a potentially affected medium for site contaminants due to the potential discharge of contaminated groundwater into marine waters through gaps in the bulkhead. As described in Section 4.5, sampling of shallow monitoring wells adjacent to the bulkhead at low tide shows elevated concentrations of TPH-G, TPH-D, and benzene. It is not possible, however, to establish directly whether marine waters are impacted, however, due to the lack of seeps and presence of rip-rap which prevents sampling marine waters on the shoreward side of the bulkhead during low tides when discharge of contaminated groundwater would be greatest. In addition, the magnitude of dilution of COC concentrations from temporary gradient reversals at high tide is unknown.

Harbor sediment is not considered a potentially affected medium based on available data (refer to Section 4.6) and because site COCs do not partition to sediment organic matter. In addition, state and federal standards do not provide criteria for cleanup of site COCs in marine sediments. Sediment quality in Port Angeles Harbor is undergoing scrutiny as part of the Puget Sound Initiative due to other concerns unrelated to site conditions.

Tumwater Creek is not considered a potentially affected medium as past testing of water in the creek did not detect TPH or BTEX and the creek appears to be a losing creek (refer to Section 4.5) along this stretch. Additionally, seeps and persistent sheens have not been reported in the creek.

Exposure scenarios associated with the potential risks to humans and marine ecological receptors from these media are discussed in Section 5. 6. Evaluation of the vapor pathway and the risk to terrestrial ecological receptors are presented in Sections 5.4 and Section 5.5 below.

5.4 VAPOR PATHWAY AND REGULATORY FRAMEWORK FOR AIR

Evaluation of the vapor pathway, and potential for contaminants to migrate to indoor air from either a contaminated soil zone or groundwater plume is required under MTCA for the MTA Site due to the presence of volatile COCs, including benzene, in both soil and groundwater. Modeling was used to develop screening levels for soils and groundwater protective of indoor air quality. The following sections describe past and current modeling activities conducted for the MTA Site. These include modeling conducted prior to construction of the Westport Marine facility, and as part of this RI/FS for the other existing structures on the MTA Site situated above contaminated groundwater (K Ply mill, the northern Platypus Marine structure) to determine the potential for inhalation risk associated with site contaminants. Modeling of vapor intrusion from groundwater indicates no potential risk of exposure through inhalation in the K Ply and Platypus structures. Elevated benzene concentrations in soils beneath K Ply have the potential to impact indoor air quality. Based on these analyses, direct measurement of benzene concentrations in air inside K Ply followed by mitigation as needed are proposed as part of the preferred remedial action (refer to Section 10.0).

5.4.1 2003 Vapor Pathway Analysis at Westport Marine

Vapor intrusion modeling was conducted in 2003 prior to construction of the Westport Marine facility (FSM 2002, 2003a). During this investigation, soil gas samples were collected from the shallow subsurface in numerous locations across the footprint of the proposed Westport Marine facility. Detected benzene concentrations were then input into a mass balance equation to calculate the resulting indoor air concentration of benzene expected given the proposed Westport Marine building construction. The Johnson & Ettinger Vapor Intrusion Model (J&E Model) was used to develop a site-specific mass balance equation to determine the benzene concentration in soil gas below the proposed facility that would be protective of indoor air quality. This evaluation was appropriate for the planned construction, as site-specific shallow soil vapor data was collected, and details regarding building construction were available for modeling. Results of the mass balance modeling indicated no risk to human health exists from soil vapor intrusion given the existing soil gas concentrations and building parameters. As a precautionary measure, however, the Westport Marine facility was constructed with a sub-slab vapor barrier to seal the office area of the building from vapor intrusion. This was a conservative measure, as modeling indicated no action was required.

5.4.2 Vapor Pathway Analysis for K Ply/Cedar Street Plume

Two separate vapor pathway analyses were conducted, one for groundwater sources and one for soil sources.

5.4.2.1 Groundwater Sources

Benzene in groundwater in the Cedar Street/K Ply Plume was evaluated first to determine its potential for migration to indoor air at both the K Ply mill and Platypus Marine facilities. Modeling indicated that existing concentrations of benzene in groundwater were less than the calculated conservative screening level protective of an indoor air concentration set equal to the MTCA Method C Industrial cleanup level.

The analysis was conducted using a groundwater flux model (GFM), a different model than used for the Westport Marine facility, which relied on site-specific vapor data that was not available for the K Ply and Platypus Marine facilities. The J&E Model, which is commonly used to determine soil and groundwater concentrations protective of indoor air quality or health risk associated with a given subsurface concentration, was not appropriate for the K Ply facility. The building construction did not fit the fixed parameters of the model, and building construction has a substantial impact on the calculations and result of the J&E Model[8]. The GFM evaluated the potential for contaminants in groundwater to diffuse through the unsaturated soil zone, and enter an enclosed space located above the plume. The GFM considers the mass balance between the groundwater and vapor phase, and evaluates the maximum degree of contaminant diffusion and dispersion from the groundwater phase to the vapor phase that can occur during the groundwater plume's retention time beneath a given structure. The model assumes an infinite source of contaminants in the groundwater plume. The other conservative assumptions in the model evaluation include: no impedance to vapor migration through the unsaturated soil zone, all vapor volatilized beneath the structure enters the enclosed space, and building construction does not limit migration of contaminants. This allows for a conservative analysis that more accurately represents the maximum vapor intrusion potential for a given structure, given site conditions, including groundwater velocity, building construction, and maximum permissible indoor air concentrations.

Refer to Appendix F for a detailed explanation of the GFM, and the calculated results for both the K Ply and Platypus Marine facilities. Based on the results of the vapor intrusion evaluation, the exposure pathway of inhalation resulting from soil vapor intrusion to indoor air from groundwater contamination is not considered a potential risk.

5.4.2.2 Soil Sources

The identification of shallow vadose zone soil contamination during the 2009 investigation necessitated further evaluation of the vapor pathway to K Ply indoor air from underlying soil sources.

Elevated benzene concentrations were detected in vadose zone soils across a broad area beneath the K Ply mill at concentrations up to 24 mg/kg below the raised concrete slab (B16), and 18 mg/kg beneath the crawl space (B21). Concentrations of toluene, ethylbenzene, and xylenes greater than MTCA A cleanup standards were also detected in this area, at the same sampling locations as benzene. Benzene is the contaminant of most concern for cleanup due to its known carcinogenic effects. These concentrations are sufficiently elevated, and present in shallow enough soil, to have the potential to migrate from the subsurface into enclosed building spaces, potentially resulting in impacts to indoor air quality. Due to the construction type of the K Ply mill structure, and the limitations of the J&E Model for non-standard construction, the J&E model is not applicable to model conditions at the K Ply mil. The GFM method discussed above is applicable to groundwater contamination only.

Due to these modeling limitations, empirical air sampling is proposed to determine the potential for vapor intrusion resulting from shallow soil contamination. The results of air sampling will provide more accurate evaluation of the soil to indoor air migration pathway. Until indoor air data are available, the remedial alternatives evaluated in this RI/FS will therefore conservatively assume an indoor air pathway exists for the K Ply Mill Building and include in the preferred remedial alternative contingency measures for protection of indoor air.

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[8] The J&E Model was developed for evaluation of buildings with concrete foundations either subgrade, or slab-on-grade. The K-Ply facility is wood plank construction, with an unpaved crawl space beneath the occupied space, and a section of raised concrete slab foundation unsuitable for J&E Models.

5.5 TERRESTRIAL ECOLOGICAL EVALUATION

The purpose of a terrestrial ecological evaluation (TEE) is to determine if a release of contaminants to the soils at a site pose adverse effects to terrestrial receptors. The TEE may be concluded if land use at the MTA Site and surrounding area makes substantial wildlife exposure unlikely (WAC 173-340-7492). In accordance with MTCA requirements, a simplified TEE was conducted for the MTA Site (refer to Appendix G). The evaluation found the MTA Site does not pose a substantial potential risk to terrestrial receptors due to its industrial nature and lack of habitat. No further terrestrial evaluation is necessary.

5.6 POTENTIAL EXPOSURE SCENARIOS AND RECEPTORS

Potential exposure pathways, receptors, and exposure scenarios are illustrated on Figure 5.1. Based on current and expected future land use, it is most appropriate to use an industrial exposure scenario for the upland portion of the MTA Site given that the site and surrounding land has for decades been developed for industrial use and there are no expectations that this will change in the future. Thus, on-site occupational and construction workers are the only potential human receptors for the following exposure scenarios: (1) direct contact with contaminated subsurface soil, and (2) inhalation of vapors in buildings.

Based on its proximity to the harbor and its tidal influence, site groundwater has been determined to be non-potable in this setting, with the highest beneficial use being discharge to the marine waters of Port Angeles Harbor.

The potential ecological receptors are the aquatic species living or feeding in the harbor, including fish and birds that may contact or ingest contaminants from groundwater at its point of discharge into marine waters. People who consume seafood are the human receptors in Port Angeles Harbor who may become exposed to contaminated groundwater via ingestion of aquatic organisms.

Based on the results of vapor pathway analysis and modeling (refer to Section 5.2.4), there is a potential completed pathway for a vapor inhalation exposure scenario from soil to indoor air in the K Ply Mill Building. The analysis indicates that there is currently no inhalation exposure scenario from groundwater contaminant concentrations to any existing buildings on the MTA Site. Future construction of buildings at the MTA Site over either vadose zone soil contamination, or the groundwater plume, could result in additional potential receptors through the vapor to indoor air pathway, and should be evaluated prior to construction. There are currently no plans to construct additional buildings at the MTA Site. A quantitative evaluation for additional buildings is not currently feasible because evaluation of potential exposure risks to indoor occupants due to vapor intrusion is dependent on the specific building design, use, and location.

Based on the results of the simplified TEE (refer to Section 5.5) and given the current and future industrial use of the MTA Site and its highly developed setting, there is no terrestrial ecological exposure scenario.

The specific potential exposure scenarios and receptors for each subsurface soil area and groundwater plume are the following:

- **MTA Plume (TPH-G, and benzene in groundwater; TPH-G, TPH-D and BTEX in soil)**

    - Construction worker direct contact with subsurface soil
    - Ingestion of contaminants in groundwater discharging to Port Angeles Harbor by aquatic species that live or feed in the harbor
    - Ingestion of contaminated aquatic organisms by humans who consume seafood
    - Inhalation of indoor air to office workers in the Westport Marine (currently blocked by geomembrane vapor barrier)
- **K Ply/Cedar Street Benzene Plume (TPH-G, TPH-D, and benzene in groundwater: TPH-G, TPH-D, and BTEX in soil)**
    - Construction worker direct contact with subsurface soil
    - Ingestion of contaminants in groundwater discharging to Port Angeles Harbor by aquatic species that live or feed in the harbor
    - Ingestion of contaminated aquatic organisms by humans who consume seafood
    - Inhalation of indoor air to occupational workers in the K Ply mill (Note- analytical testing is required to confirm this pathway).
- **Pettit Oil Plume (TPH-D)**
    - Construction worker direct contact with subsurface soil.

Cleanup standards for each of the above COCs relative to each of the identified exposure scenarios are developed in Section 6.0.

6.0 Regulatory Requirements, Remedial Action Objectives, Cleanup Standards, and Cleanup Areas

In this section, MTCA and other applicable or relevant and appropriate requirements (ARARs) are considered in the development of remedial action objectives (RAOs) and cleanup standards. Based on the distinct RAOs and corresponding cleanup approaches for different areas, the MTA Site is divided into three Cleanup Areas.

6.1 APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

Remedial alternatives must be in compliance with MTCA cleanup regulations (WAC 173-340). A threshold requirement under MTCA is compliance with ARARs which must be met by all proposed remedial alternatives. Under WAC 173-340-350 and WAC 173-340-710, the term “applicable requirements” refers to regulatory cleanup standards, standards of control, and other environmental requirements, criteria, or limitations established under state or federal law that specifically address a COC, remedial action, location, or other circumstance at the facility. The “relevant and appropriate” requirements are regulatory requirements or guidance that do not apply to the facility under law, but have been determined to be appropriate for use by Ecology.

As outlined in MTCA 173-340-710, all cleanup actions proposed for the MTA Site must meet the substantive requirements of all applicable state, and federal regulations. Remedial actions conducted under a consent decree with Ecology must comply with the substantive requirements of the ARARs, but are exempt from their procedural requirements, such as permitting and approval requirements (WAC 173-340-710(9)). This exemption applies to permitting requirements under the Washington State Water Pollution Control Act, the Solid Waste Management Act, the Hazardous Waste Management Act, the Clean Air Act, the State Fisheries Code, the Shoreline Management Act, and local laws requiring permitting.

A review of the ARARs applicable to the MTA Site was conducted to ensure that the remediation alternatives considered the most current and applicable federal, state, and local requirements. The results of this review have been applied to the preferred remedial alternative (refer to Section 10.0).

6.2 REMEDIAL ACTION OBJECTIVES AND CLEANUP STANDARDS

RAOs are substantive goals for a cleanup action that address the overall MTCA cleanup process. RAOs are used in conjunction with the division of the MTA Site into Cleanup Areas to provide a structure for the alternatives evaluation based on the CSM; site geography, development and other conditions; and the applicable cleanup standards.

Protection of human health and the environment site-wide can be achieved through achievement of the following RAOs:

1. Prevent COCs in groundwater from discharging to surface water at concentrations greater than groundwater CULs protective of surface water.
2. Prevent direct contact exposure by workers to subsurface soils with COC concentrations greater than CULs protective of the direct contact pathway.
3. Prevent inhalation exposure in buildings with underlying benzene soil contamination to indoor air with benzene concentrations greater than CULs. *Note: this RAO has*

already been met under the Westport Marine building following installation of the geomembrane vapor barrier in 2003.

4. Remove, to the extent practicable, LNAPL accumulations on the water table.

6.3 CLEANUP STANDARDS

Cleanup standards under MTCA consist of cleanup levels based on all applicable regulatory requirements and the point(s) of compliance where these cleanup levels must be met. The following site-specific information has been relied upon in the development of cleanup standards for the MTA Site:

- The MTA Site is zoned heavy industrial and has been used for industry since the turn of the twentieth century. Future use and redevelopment are expected to remain heavy industrial. For these reasons, standard MTCA industrial land use exposure assumptions are applicable when considering soil and vapor exposure scenarios.
- The MTA Site is presently covered with impervious and semi-pervious surfaces, such as buildings, pavement, or compacted fill. Surface soil (approximately the upper 2 feet) has been moved, reworked, and covered with several feet of clean fill as various industrial concerns have occupied the MTA Site following cessation of the bulk plants and preceding site uses. Currently, surface soil is considered uncontaminated or a “blocked” pathway in areas that are paved or covered by buildings.
- The groundwater at the MTA Site has been determined to be non-potable in accordance with MTCA requirements (WAC 173-340-720 (2)). Groundwater is considered non-potable because it occurs in former aquatic tidelands that were filled by dredge sands. Shallow groundwater that currently discharges into the waters of Port Angeles Harbor occurs in this fill material, and mixes with marine waters during temporary gradient reversals. Groundwater at the MTA Site is not a current or potential future source of drinking water based on the observed concentrations of total dissolved solids ranging up to 19,000 mg/L (refer to Table 4.2).
- The maximum beneficial use of water in the harbor is for the protection of aquatic life.

6.3.1 Soil

6.3.1.1 Soil Cleanup Levels

Proposed CULs for soil, presented in Table 6.1, were evaluated for BTEX, TPH-D, and TPH-G based on direct contact, soil-to-ground water pathway, and indoor air, based on the exposure pathways described in the CSM presented in Section 5.0 and MTCA requirements.

For the protection of groundwater, the Method A soil cleanup levels for BTEX are proposed, because they are protective of the soil-to-groundwater pathway. For TPH-D and TPH-G, default MTCA A values are proposed. This was done for several reasons: (1) the MTCA A TPH soil cleanup concentrations are conservative and protective of all pathways, and (2) the MTCA A values consider the cumulative risk for all the individual substances such as BTEX and SVOCs present in petroleum.

For the direct contact (ingestion) worker exposure pathway, BTEX constituents have established Method C industrial cleanup levels. The highest detected benzene, toluene, ethylbenzene, and xylenes concentrations at the MTA Site in the RI (24 mg/kg, 57 mg/kg, 99 mg/kg, and 370 mg/kg, respectively) are substantially less than the Method C industrial land use value for direct contact cleanup levels.

Soil cleanup levels were not calculated for protection of indoor air quality. Inhalation risk will be addressed empirically through indoor air sampling, followed by mitigation as necessary to protect workers from exposure to benzene from inhalation of indoor air.

6.3.1.2 Point of Compliance for Soil

The point of compliance for soil to protect groundwater is throughout the MTA Site. For protection of the soil vapor pathway, the point of compliance is from the surface to the uppermost ground water table (approximately 10 feet bgs at the MTA Site). For soil cleanup levels based on direct contact, the point of compliance is from ground surface to a depth of 15 feet bgs. The overall appropriate point of compliance for soil, therefore, is throughout the MTA Site based on protection of groundwater. .

6.3.2 Groundwater

6.3.2.1 Groundwater Cleanup Levels

Groundwater cleanup levels were derived in accordance with WAC 173-340-720, as summarized below. Per WAC 173-340-720(1)(a), groundwater cleanup levels are based on the highest beneficial use of groundwater and the reasonable maximum exposure expected to occur under current and future site use conditions. The maximum beneficial use of groundwater beneath the MTA Site is discharge to the surface waters of Port Angeles Harbor. The reasonable maximum exposure scenario expected to occur is based on the discharge to surface water of the highest detected concentration of site COCs (refer to Table 6.2), and ingestion of aquatic organisms affected by COCs. As noted above, site groundwater meets the requirements for non-potable groundwater under WAC 173-340-720(2). Groundwater cleanup levels were therefore developed consistent with the requirements of WAC 173-340-720(6)(b), including the MTCA Method B site-specific risk assessment elements described in WAC 173-340-720(6)(c)(i) and consistent with WAC 173-340-702 and WAC 173-340-708.

In accordance with WAC 173-340-720(6)(c)(i), potential groundwater exposure pathways and groundwater uses were considered (refer to Figure 5.1). At approximately 10 feet below ground, exposure to groundwater during site development or utility excavation is not considered an applicable exposure pathway. Exposure to groundwater seeping through the bulkhead at low tide is not considered an applicable pathway due to the presence of rip rap armoring and inaccessibility of the slope. There is no reasonable scenario under which groundwater would be consumed as drinking water. The potential pathway of concern is discharge of groundwater to Port Angeles Harbor surface water at the MTA and K Ply bulkheads. Cleanup levels for groundwater are based on protection of the beneficial uses of this surface water body for all users, including recreational users. COC concentrations in groundwater must be protective of surface water and must meet surface water standards at the point at which groundwater discharges into surface water.

According to WAC 173-340-730 (3)(b), surface water cleanup levels under MTCA Method B should be at least as stringent as applicable state and federal laws including the Water Quality Standards for the State of Washington, Clean Water Act, National Recommended Water Quality Criteria (NRWQC), and the National Toxics Rule.

Refer to Table 6.2 for proposed groundwater cleanup levels. For compounds for which the federal criteria are available (e.g., benzene), the standard Method B CULs are based on the most protective of the federally-promulgated, human-health based criteria protective of surface water. For benzene, this value is 51 µg/L, a value promulgated under the NRWQC considering human ingestion of aquatic organisms[9] and protection of aquatic life. This concentration for benzene has been approved for use as a cleanup and/or screening level at other MTCA sites being addressed as part of the Puget Sound Initiatives, including the Everett North Marina West End Site. Federal or state water quality criteria do not exist for TPH-G or TPH-D. According to WAC 173-340-730(3)(C), Method A concentrations for TPH are appropriate to be used for protection of surface water. Currently, benzene is the “risk-driver” as it is the only carcinogenic COC in groundwater and its concentration in shoreline wells exceeds the applicable most protective surface water cleanup level as listed in Table 6.2.

These cleanup levels meet the other requirements of WAC 173-340-720(6)(c)(i) (A) through (F) as follows:

(A) Groundwater cleanup levels meet the applicable state and federal laws for protection of surface water as described above.

(B) The cleanup levels will result in no significant acute or chronic toxic effects on human health. The calculated hazard quotient for benzene through the fish exposure pathway at 51 µg/L is 0.008.[10] MTCA Method A CULs for TPH-G and TPH-D are highly conservative relative to a hazard quotient of 1 for all pathways including ingestion of aquatic organisms; therefore, the total hazard index from is less than 1.

(C) The cleanup levels will result in an upper bound on the estimated excess cancer risk that is less than or equal to 10^{-6} for individual hazardous substances. The cleanup level for benzene is derived from a 10^{-6} human health cancer risk based on ingestion of aquatic organisms. The sole carcinogenic component of TPH-G is benzene. MTCA Method A CULs for TPH-G when benzene is present and TPH-D are therefore highly conservative relative to the 10^{-6} human health cancer risk for all pathways including ingestion of aquatic organisms; therefore, the cumulative cancer risk is based solely on benzene and is 10^{-6} (and meets the 10^{-5} cumulative standard).

(D) The cleanup levels are low enough that they will not result in nonaqueous phase liquid being present in or on groundwater and comply with the limitation on free product in 173-340-720(7)(d).

(E) and (F) The cleanup levels will not exceed the surface water cleanup levels derived under WAC 173-340-730.

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[9] For benzene, this is based on the same human health cancer risk (10^{-6}) and oral slope factor range as the MTCA Method B number.

[10] Hazard index was calculated based on the following inputs, which include the same inputs used in the NRWQC where applicable: bioconcentration factor = 5.2 L/kg; fish consumption rate = 17.5 g/day; fish diet fraction = 0.5 unitless; exposure duration = 30 years; non-cancer oral reference dose =0.004 mg/kg-day; average body weight = 70 kg; averaging time = 30 years.

6.3.2.2 Groundwater Point of Compliance

MTCA states that standard point of compliance (POC) for groundwater cleanup levels is throughout the site to the outer boundary of the plume. However, Ecology may approve a conditional point of compliance where it can be demonstrated that it is not practical to meet the cleanup level within a reasonable restoration time frame. This condition of impracticability holds for the MTA Site given the very large mass of source area soil that extends under existing buildings. The conditional point of compliance must be located as close as possible to the source but not exceeding the property boundary and as close as technically possible to the point or points where groundwater flows into the surface water (WAC 173-340-720(8)(c)). In addition, the person responsible for undertaking the cleanup action shall demonstrate that all practicable methods of treatment are to be used in the site cleanup.

There is no exposure to site groundwater through drinking water. The highest beneficial use of groundwater at the MTA Site is discharge to surface water. Therefore, a groundwater conditional point of compliance is proposed for the MTA Site within the property boundary along the bulkhead, the closest monitoring location to the point of discharge to surface water.

6.3.3 Indoor Air

6.3.3.1 Indoor Air Cleanup Levels

The proposed CUL for benzene in air is 3.2 µg/m^3, which is the Method C Carcinogen Standard Formula Value.[11] No other site COCs are a risk to indoor air quality due to volatility, or concentrations existing in site soil and groundwater.

6.3.3.2 Indoor Air Point of Compliance

The point of compliance for air is site-wide; however, vapor intrusion from subsurface contaminants occurs only in enclosed spaces and structures. Compliance with air cleanup levels will be measured within the K Ply Mill Building to assess if there is a completed exposure pathway from soil to indoor air in this location, and empirically assess whether the BTEX concentrations in soil beneath the K Ply mill are protective of indoor air. Modeling or previous data collection has addressed potential exposure at all other existing on-site structures. Current conditions do not pose an unacceptable risk of exposure through the indoor air pathway; refer to Section 5.4.

6.4 CLEANUP AREAS

The MTA Site has been divided into three Cleanup Areas, illustrated on Figure 5.2: the Bulkhead, Upgradient, and Pettit Oil Cleanup Areas. The Cleanup Areas correspond generally to distinct physical areas but because they are defined by RAOs, there is overlap between Cleanup Areas. Remedial alternatives are developed and evaluated for each cleanup area in this RI/FS. The preferred alternatives for each Cleanup Area together form a comprehensive overall remedy. These Cleanup Areas are described below.

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[11] This cleanup level is based on equation 750-2 in the MTCA that incorporates a 24-hour exposure assumption. Because industrial exposure should be calculated based on an 8-hour exposure, it is anticipated that this cleanup level may be revisited in consultation with Ecology.

6.4.1 Bulkhead Cleanup Area

Remediation of the Bulkhead Cleanup Area will address RAO 1, preventing the presumed discharge of COCs in groundwater to surface water at concentrations greater than cleanup levels.

The Bulkhead Cleanup Area is operationally defined as a groundwater zone encompassing the conditional point of compliance adjacent to Port Angeles Harbor, stretching from Tumwater Creek in the west to the eastern site boundary north of K Ply in the east (the MTA and K Ply Bulkheads). The Bulkhead Cleanup Area extends inland into the MTA Site a distance suitable for implementing a remedial measure capable of protecting Port Angeles Harbor surface water (approximately 100 feet from the shoreline with overlap into the Upgradient Cleanup Area (see below)). Two groundwater plumes, the MTA Plume and the K Ply/Cedar Street Plume, currently extend to the bulkheads in this Cleanup Area.

6.4.2 Upgradient Cleanup Area

The Upgradient Cleanup Area consists of the entire site area, including overlap with the Bulkhead Cleanup Area and Pettit Oil Cleanup Area (described below). This Cleanup Area is characterized by widespread scattered areas of residual subsurface soil contamination that are likely to continue to act as sources of groundwater contamination but are covered in large part by existing buildings with active operations. Remediation of the Upgradient Cleanup Area will address the following RAOs: (1) preventing the presumed discharge of COCs in groundwater to surface water at concentrations greater than cleanup levels, (2) preventing direct contact by occupational and site workers with subsurface soil, and (3) of preventing potential vapor to indoor air exposures in the K Ply Mill Building and any future buildings constructed over the MTA Plume.

6.4.3 Pettit Oil Cleanup Area

The Pettit Oil Cleanup Area addresses remediation of LNAPL that is the basis for RAO 4. Residual soil contamination associated with LNAPL is also considered part of the Upgradient Cleanup Area. The Pettit Oil Cleanup Area consists of free diesel LNAPL at the groundwater surface at Pettit Oil. For purposes of this RI, it also includes the small area of free diesel product intermittently observed in monitoring well PP-7. The hydraulic oil release beneath K Ply is being cleaned up under a separate Agreed Order and is not included in this Cleanup Area.

Under WAC 173-340-360(2)(c)(ii)(A), the minimum requirements for non-permanent groundwater cleanup actions, “treatment or removal of the source of the release shall be conducted for liquid wastes. This includes removal [sic] free product consisting of petroleum and other LNAPL from the ground water using normally-accepted engineering practices.”

6.5 MTCA ALTERNATIVE EVALUATION CRITERIA

6.5.1 MTCA Threshold Requirements

The RAOs and cleanup standards presented above provide the basis for identifying remedial technologies and developing remedial alternatives for evaluation, and the recommending of a preferred alternative for the final cleanup action.

As required by WAC 173-340-350(8)(c)(i)(G), the remedial alternatives are evaluated relative to criteria set forth in WAC 173-340-360. A preliminary screening of potential technologies, presented in Section 7.0, was conducted to eliminate those alternatives that do not meet the threshold requirements (presented below), or are technically infeasible at the MTA Site. For each of the Cleanup Areas, remedial technologies that pass a preliminary screening are assembled into alternatives that represent the range of technological approaches that meet the RAOs and MTCA cleanup requirements.

The four threshold criteria that all cleanup actions must satisfy as specified in WAC 173-340-360(2) were used as part of the preliminary screening (refer to Section 7.0). Potentially applicable technologies were eliminated if they were technically unable to achieve a given RAO or meet all of the following criteria:

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

To allow selection from among alternatives that meet the threshold requirements, WAC 173-340-360(3) specifies three other criteria that alternatives must achieve:

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

To determine whether the cleanup action utilizes a permanent solution to the maximum extent practicable, MTCA requires that a disproportionate cost analysis be conducted as part of the alternatives evaluation, as described below and presented in Section 8.0.

6.5.2 MTCA Selection Criteria and Disproportionate Cost Analysis

Technologies that meet the threshold requirements listed above and pass the initial screening presented in Section 7.0 are assembled into alternatives and subjected to a more detailed analysis to select the alternative that “uses permanent solutions to the maximum extent practicable.” The detailed analysis, presented in Section 9.0, makes use of a “disproportionate cost” analysis in addition to MTCA selection criteria, to determine whether costs are disproportionate to benefits by examining whether the incremental costs of the most permanent alternative over that of a lower cost alternative exceed the degree of benefit achieved by the most permanent alternative over that of the lower cost alternative. In the disproportionate cost analysis, the following criteria are evaluated (WAC 173-340-360(3)(e) through (f)):

- Overall protectiveness
- Permanence
- Cost
- Effectiveness over the long term, which includes reductions in toxicity, mobility, and volume
- Management of short-term risks

- Technical and administrative implementability
- Consideration of public concerns

In addition to these criteria, the restoration time frame must be considered when choosing between alternatives.

MTCA also sets forth requirements specifically for groundwater cleanups. Cleanup actions for groundwater must be permanent, or, if non-permanent must contain and either treat or remove the source of any release that cannot be reliably contained.

7.0 Identification and Screening of Remedial Technologies

The RAOs and cleanup standards presented above provide the basis for identifying remedial technologies and developing remedial alternatives for evaluation. In this section, potentially applicable remedial technologies are identified and screened for applicability based on site-specific considerations and whether they can meet MTCA threshold criteria.

7.1 POTENTIALLY APPLICABLE TECHNOLOGIES

The relatively common occurrence of petroleum contamination nationwide has resulted in accumulated experience in remediating petroleum contamination in soil and groundwater and recovery of separate-phase product.

7.1.1 Soil

Common treatment approaches for petroleum hydrocarbons in soil range from monitored natural attenuation to excavation and disposal, and include both in-situ and ex-situ treatment technologies. In-situ technologies include enhanced biodegradation, bioventing and soil vapor extraction (SVE). Once excavated, soil may be treated by a variety of technologies as alternatives to off-site disposal. These technologies, which include ex-situ biological treatment (land farming), and off-site treatment by low temperature thermal desorption, are considered variations on the excavation/disposal alternative, which is considered more representative and cost-effective at this site. Less commonly used but potentially applicable in-situ technologies considered include chemical oxidation, electrokinetic separation, soil flushing, solidification/stabilization, thermally enhanced SVE, and phytoremediation. This section briefly describes the soil treatment technologies evaluated during the preliminary screening process.

Monitored Natural Attenuation. Regular soil and/or groundwater sampling to monitor the results of one or more physical, chemical, or biological processes that reduce the mass, toxicity, volume, or concentration of contaminants in soil. These in-situ processes include biodegradation and volatilization.

Excavation. Excavation of areas of highly contaminated soil using standard construction equipment and transport to appropriate landfill or thermal treatment facility or on-site land farming cell. Excavated areas would be subjected to confirmational soil sampling prior to backfill, compaction, and regrading.

Enhanced Biodegradation. The activity of naturally occurring microorganisms (e.g., fungi, bacteria) is stimulated by circulating water-based solutions through contaminated soils to enhance in-situ biological degradation (metabolism) of organic contaminants. Nutrients, oxygen, or other amendments may be used to enhance bioremediation and contaminant desorption from subsurface materials. In the presence of sufficient oxygen (aerobic conditions), microorganisms will ultimately convert many organic contaminants to carbon dioxide, water, and microbial cell mass. In the absence of oxygen (anaerobic conditions), the contaminants will be ultimately metabolized to methane. In-situ bioremediation of soil typically involves the percolation or injection of ground water containing dissolved oxygen and nutrients through saturated zone soils only.

Bioventing. Bioventing, a remedy for unsaturated zone petroleum-contaminated soils, stimulates the natural in-situ biodegradation of aerobically degradable compounds in soil by providing oxygen to existing soil microorganisms. In contrast to soil vapor vacuum extraction, bioventing uses low air flow rates to provide only enough oxygen to sustain microbial activity. Oxygen is most commonly supplied through direct air injection into residual contamination in soil. In addition to degradation of adsorbed fuel residuals, volatile compounds are biodegraded as vapors move slowly through biologically active soil. Primarily used to remediate jet fuel and diesel range hydrocarbons.

Soil Vapor Extraction. Unsaturated zone soil remediation technology in which a vacuum is applied through extraction wells to the soil to induce the controlled flow of air and remove mostly volatile contaminants from the soil. The vapor stream is treated to recover or destroy the contaminants. May be enhanced with thermal treatment or air sparging.

Phytoremediation. Phytoremediation uses plants to remove, transfer, stabilize, and destroy contaminants in soil and sediment. The mechanisms of phytoremediation include enhanced rhizosphere biodegradation, phyto-extraction (also called phyto-accumulation), phyto-degradation, and phyto-stabilization.

Chemical Oxidation. Injection of oxidizing agents such as ozone, hydrogen peroxide, or permanganate to rapidly destroy organic contaminants including TPH in both saturated and unsaturated zones.

Surfactant Soil Flushing. Water, or water containing an additive to enhance contaminant solubility, is applied to the soil or injected into the ground water to raise the water table into the contaminated soil zone. Contaminants are leached into the ground water, which is then extracted and treated.

Thermally Enhanced Soil Vapor Extraction. Thermally enhanced SVE uses electrical resistance or hot-air/steam injection to heat the unsaturated zone soil, increase the volatilization rate of contaminants and facilitate extraction in the vapor phase. The process is otherwise similar to standard SVE but requires heat resistant extraction wells.

Capping. Capping consists of placement of an impervious cover over contaminated soil, thereby preventing infiltration of rainwater and creating a barrier to direct contact with the underlying contaminated soil. Institutional controls are typically required to maintain the cap.

7.1.2 Groundwater

Commonly used groundwater technologies include monitored natural attenuation, enhanced bioremediation, air sparging, pump and treat, in-well air stripping, dual phase extraction, and bioslurping. Once extracted, groundwater may be treated by a variety of ex-situ groundwater treatment technologies. These technologies, such as liquid phase carbon adsorption, column air stripping, or discharge to the local publicly-owned treatment works (POTW) or Port of Port Angeles treatment system are considered variations on the pump-and-treat alternative and appropriate for evaluation in detail during the design stage. One exception is the ex-situ treatment alternative of a constructed wetlands, which offers a significantly different approach from other ex-situ treatment technologies. Other less common in-situ technologies considered include phytoremediation, chemical oxidation, and permeable reactive barriers (PRBs).

Monitored Natural Attenuation. Regular groundwater sampling to monitor the results of one or more physical, chemical, or biological processes that reduce the mass, toxicity, volume, or concentration of contaminants in soil or groundwater. These in-situ processes include biodegradation; dispersion; dilution; sorption; volatilization; and chemical or biological stabilization, transformation, or destruction of contaminants.

Enhanced Biodegradation. Acceleration of the natural biodegradation process by providing nutrients, electron acceptors, and competent degrading microorganisms to degrade (metabolize) organic contaminants in groundwater. Typical enhancements include oxygen, nitrates, or solid phase peroxide products such as Oxygen Release Compound.

Air Sparging. Air is injected through a contaminated aquifer, where it passes horizontally and vertically through channels in the soil column, creating an underground stripper that removes contaminants by volatilization. This injected air helps to flush the contaminants up into the unsaturated zone where a vapor extraction system is usually implemented in conjunction with air sparging to remove the generated vapor phase contamination. This technology is designed to operate at high flow rates to maintain increased contact between ground water and soil and strip more ground water by sparging.

In-well Air Stripping. Air is injected into a double screened well, lifting the water in the well and forcing it out the upper screen. Simultaneously, additional water is drawn in through the lower screen. Once in the well, some of the VOCs in the contaminated ground water are transferred from the dissolved phase to the vapor phase by air bubbles. The contaminated air rises in the well to the water surface where vapors are drawn off and treated by a soil vapor extraction system.

Pump and Treat. Groundwater is pumped from extraction wells or recovery trenches to one of a variety of potential ex-situ treatment processes such as liquid phase carbon adsorption or column air stripping or discharge to the local POTW.

Dual-phase Extraction. Generally, a high vacuum system is used to remove simultaneous various combinations of contaminated ground water, separate-phase petroleum product, and hydrocarbon vapor from unsaturated soils. Extracted liquids and vapor are treated and/or collected for disposal.

Bioslurping. Bioslurping utilizes elements of both bioventing and free product recovery to simultaneously recover free product and bioremediate vadose zone soils. Bioslurping can improve free-product recovery efficiency without extracting large quantities of ground water. Vacuum-enhanced pumping allows LNAPL to be lifted off the water table and released from the capillary fringe. This minimizes changes in the water table elevation, which minimizes the creation of a smear zone. Bioventing of vadose zone soils is achieved by withdrawing soil gas via the vacuum applied to each recovery well. When free-product removal activities are completed, the bioslurping system is easily converted to a conventional bioventing system to complete the remediation.

Constructed Wetlands. The constructed wetlands-based treatment technology uses natural geochemical and biological processes inherent in an artificial wetland ecosystem to accumulate and remove contaminants from influent waters. The process can use a filtration or degradation process. Microbial activity breaks down benzene and TPH that is filtered by organic soils, microbial fauna, algae, and vascular plants.

Phytoremediation. Plant-based processes to remove or destroy benzene and TPH that include enhanced rhizosphere biodegradation, hydraulic control, phyto-degradation and phyto-volatilization.

Chemical Oxidation. Injection of oxidizing agents such as ozone, hydrogen peroxide, or permanganate to rapidly destroy hydrocarbons.

Permeable Reactive Barrier (PRB; a.k.a. passive treatment wall). Reactive media promotes degradation of benzene/TPH in groundwater in-situ as it travels through the barrier. Commonly configured as a ‘funnel and gate’, with sections of impermeable barrier to channel groundwater into a smaller treatment zone. The treatment zone may utilize passive adsorption media such as peat or leaf compost, bone char, or granulated activated carbon.

Barrier Wall. A barrier wall effectively provides a physical barrier to groundwater flow by creating a zone of substantially lower hydraulic conductivity than the surrounding formation that impedes the transport of contaminants beyond the wall. The wall can be constructed of mixtures on-site soil, cement and/or bentonite (slurry wall), or consist of interlocking panels of plastic or steel driven into the ground (sheetpile). Barrier walls are often used in conjunction with groundwater extraction to maintain hydraulic control of the plume and prevent the migration of contaminants around or underneath the barrier.

7.1.3 Separate-Phase Product

Technologies that have been developed for the removal of LNAPL include two general categories: “passive” product recovery, in which the existing groundwater gradient is maintained, and more aggressive “active” product recovery, in which a gradient is induced to increase the rate and influence of recovery wells/locations. Passive remedial systems utilize hand bailers, absorbents, a series of skimming wells, or collection of product through a trench. Active recovery systems include depressing the water table to produce a potentiometric gradient via a vacuum and/or pumping system, to increase the rate and area of influence of the LNAPL extraction equipment. Separate skimmers can be set in each well withdraw the LNAPL that is brought in by the applied gradient. The following paragraphs briefly introduce the technologies evaluated as part of the preliminary screening process.

Skimming Wells. Multiple skimming wells recover product using a variety of means (floating skimmers, pneumatic pumps, mechanical belt skimmers, hand bailing, collection canisters, and passive absorbent inserts.

Trench Skimming. Product is recovered from wells contained within a trench constructed of coarser material and located to intercept groundwater and product flow.

Barrier Wall with Skimming System. A barrier wall is installed to contain product or funnel it toward skimming system at recovery outlets.

Water Table Depression. A cone of depression is created to induce a product gradient toward an extraction well, where both product and groundwater are recovered, using single- (combined) or dual-pump (separate) systems. Extracted liquids are treated and collected for disposal.

Vacuum-enhanced Recovery. Vacuum enhanced recovery (VER) applies a vacuum to skimmer wells or induced water table gradient recovery wells to induce a larger potential gradient toward the recovery well through negative pressure, while minimizing the physical movement of the oil water interface. Extracts volatile hydrocarbons from the unsaturated zone and minimizes smearing from the cone of depression. Extracted liquids and vapor are treated and collected for disposal.

Bioslurping. Similar to VER but uses only vacuum applied via a drop tube to recover vapor, oil, and water, from the water table and the capillary fringe, allowing for removal of product with minimal depression of the water table. Vapor recovery enhances bioremediation of soils in the unsaturated zone. Extracted liquids and vapor are treated and collected for disposal.

7.2 RETAINED TECHNOLOGIES

A preliminary screening of the potentially applicable technologies for each Cleanup Area and RAO was conducted and is summarized in Table 7.1. The technologies retained for further evaluation following the screening process in Table 7.1 are listed in this section.

7.2.1 Bulkhead Cleanup Area

To address RAO 1, preventing benzene- and TPH-contaminated groundwater from discharging to Port Angeles Harbor at concentrations greater than cleanup levels protective of surface water, and comply with MTCA, the following remedial approaches and corresponding technologies are retained:

- In-situ groundwater treatment at the bulkhead, using air sparging
- Groundwater recovery at the bulkhead with treatment or discharge to POTW, using one of the following technologies:
  - Interceptor trench
  - Groundwater extraction wells
  - Dual-phase extraction wells
- Containment of groundwater at the bulkhead, in conjunction with groundwater extraction or in-situ treatment, using one of the following technologies:
  - Slurry wall
  - Sheetpile

7.2.2 Upgradient Cleanup Area

In order to assist in achieving RAO 1, remedial technologies were evaluated that would reduce the concentrations of COCs in soil that are sources of continuing groundwater contamination. The following approaches are retained:

- Source removal (in accessible areas)
- Capping unpaved areas of contaminated soil with impervious surfacing to reduce infiltration and leaching of vadose zone soil contaminants to groundwater

To address RAO 2, preventing direct contact to petroleum-contaminated subsurface soil by workers, the following approaches were retained:

- Institutional controls

To address RAO 3, preventing exposure to BTEX in indoor air in the K Ply mill and any future buildings constructed over areas of contaminated soil, the following approaches were retained:

- Vapor barrier (for potential future buildings only)
- Sub-slab vapor capture (for potential future buildings only)
- Mitigation measures, such as improved ventilation, for the K Ply Mill Building

As discussed previously in Section 5.4.2, indoor air monitoring will be conducted in the K Ply mill to establish if mitigation measures such as improved ventilation or other methods will be required at that facility. Indoor air monitoring and associated contingencies are included in the preferred alternative (refer to Section 10.0).

7.2.3 Pettit Oil Cleanup Area

To address RAO 5, removal of separate-phase product from the water table to the extent practicable, the following approaches were retained:

- "Active" (induced gradient) product recovery utilizing one of the following technologies:
    - Water table depression
    - Vacuum-enhanced recovery
    - Bioslurping
- Source removal in accessible areas
- Product bailing and/or passive recovery inserts are retained only for the small area of LNAPL intermittently measured near PP-7

Representative retained technologies are assembled into remedial alternatives in Section 8.0 for evaluation in Section 9.0.

8.0 Description of Cleanup Action Alternatives

In this section, the retained technologies are assembled into representative alternatives for each Cleanup Area. A no action alternative is included for comparison as a baseline for each Cleanup Area. Alternatives are subjected to a detailed analysis relative to the MTCA evaluation criteria and disproportionate cost criteria in Section 9.0.

8.1 BULKHEAD CLEANUP AREA

As described in Section 3.2.1, the Bulkhead Cleanup Area is defined as encompassing the zone of the proposed conditional point of compliance for contaminated groundwater along the current bulkhead, stretching from Tumwater Creek in the west to the eastern site boundary north of K Ply in the east. The Bulkhead Cleanup Area extends into the MTA Site a distance suitable for implementing a remedial measure capable of protecting Port Angeles Harbor surface water. Remediation of soil within this area to improve the effectiveness, restoration time frame, or permanence of the bulkhead groundwater remedial alternative, is also considered in the alternatives for the Upgradient Cleanup Area. Alternatives for this Cleanup Area are numbered B1 to B4 to differentiate them from alternatives for the Upgradient and Pettit Oil Cleanup Areas. Refer to Figures 8.1 and 8.2 for conceptual illustrations of these alternatives.

8.1.1 Alternative B1: No Action

The baseline alternative would involve no additional action at the Bulkhead Cleanup Area. This alternative would leave in place the status quo conditions, in which groundwater with elevated COC concentrations may be discharging to Port Angeles Harbor surface water.

8.1.2 Alternative B2: Groundwater Recovery Wells and Ex-situ Treatment

This alternative consists of extracting shallow groundwater as a means of preventing the potential discharge of groundwater with elevated COC concentrations. A system of groundwater recovery wells would extract and convey contaminated groundwater for treatment and discharge before it discharges to Port Angeles Harbor.

The system would be designed to achieve the remedial goal of preventing discharge of contaminated groundwater, without excessively drawing the plumes forward by the induced gradient, and without extracting excessive seawater mixed into groundwater. Based on available information, the groundwater recovery well system would consist of a single row of groundwater recovery wells connected to a shallow utility trench oriented approximately parallel to the shoreline and perpendicular to the direction of groundwater flow. The wells would be completed in below-grade vaults, with collection piping, power, and controls entering the vault from a utility trench. Wells would be located as necessary to produce a capture zone that recovers contaminated groundwater, mostly from upgradient, while minimizing the capture of marine waters from downgradient. The system is likely to consist of two sections that target the MTA and K Ply/Cedar Street Plumes, and in doing so would cover approximately 700 to 800 linear feet of shoreline. The recovery system would be designed to capture the upper 10 feet of groundwater where the contaminants are located.

Accommodating tidal variation would be an important factor in the design of the system to maximize the recovery of contaminated site groundwater, while minimizing the recovery of saltwater from Port Angeles Harbor (which regularly mixes with groundwater during high tidal cycles). If not effectively mitigated, gradient reversals during high tide could result in extraction of seawater, adding otherwise unnecessary volume for hydraulic capture and increasing treatment costs. In addition to the additional volume, the increased ionic strength of marine-influenced water may add cost by decreasing the efficiency of the ex-situ treatment system, or resulting in the need for increased maintenance. To accommodate tidal variation, it is expected that the groundwater extraction system would provide for sufficient controls to adjust to changing gradients. It is expected that recovery wells would utilize electric submersible pumps with variable speed to allow fine control of pumping rates from each well. If appropriate to maintain the capture zone in response to tidal and seasonal variation, pumps may be controlled by a programmable logic controller (PLC) that utilizes pressure transducer readings from monitoring wells or piezometers to monitor groundwater gradient and adjusts the pumping rates accordingly.

As a contingency, the groundwater recovery system may be designed to include a “hanging” subsurface containment barrier, such as a slurry wall or sheetpile wall, to dampen tidal influence. The barrier would be “hanging,” meaning that it would not be keyed into an underlying confining unit, and would allow groundwater to flow beneath it to discharge to surface water. Since the need for a barrier wall to mitigate tidal effects from extraction wells would likely be determined following the initial operation of the remedial action, this option is not included in Alternative B2. To provide for a comparison of the full range of potential remedial approaches, a barrier wall is included in Alternative B4 (refer to Section 8.1.4 below).

Recovered groundwater would be conveyed to either a new, on-site groundwater treatment facility or depending on water quality, sent directly to the local sanitary sewer for treatment at the Port Angeles POTW. On-site treatment would likely involve the construction of a small building or shed, or conversion of an existing building, to house one of the established ex-situ remedial technologies for petroleum hydrocarbons, such as carbon adsorption, air stripping, or catalytic oxidation. In addition to maintaining the piping, pumps, and other hardware from iron fouling and general wear, each ex-situ approach involves different operations and maintenance needs, such as disposal and replacement of spent carbon, air emissions monitoring, etc. Groundwater treated on-site would then either be discharged under a NPDES permit to Port Angeles Harbor, or discharged to the sanitary sewer under an industrial wastewater discharge permit. Discharge to the sanitary sewer, with or without on-site treatment, would involve a connection fee and ongoing discharge fees.

The effectiveness of groundwater recovery in protecting the waters of Port Angeles Harbor may also be enhanced initially by excavation of accessible soil near the MTA Bulkhead (refer to Figure 4.3). After an initial disruption following excavation, removing contaminated soil from the Bulkhead Cleanup Area may temporarily decrease the contaminant concentration in recovered groundwater. The large mass of contaminated soil beneath buildings upgradient of the accessible source soils at the MTA Bulkhead, however, would continue to leach COCs to groundwater over time, minimizing any short-term advantage to excavation near the bulkhead. Refer to the evaluation of remedial alternatives for the Upgradient Cleanup Area in Section 9.2.

8.1.3 Alternative B3: Air Sparge Curtain

This alternative would use air sparging to treat petroleum hydrocarbons in groundwater by stripping volatiles from the compounds and enhancing bioremediation. Because of its long history of use and continued refinement, air sparging is considered a presumptive remedy for remediating dissolved plumes from petroleum hydrocarbon impacts.

The geology of the area north of Westport Marine, including the MTA bulkhead where an air sparge curtain would be located, is consistent with this remedial technology. The dredge fill that makes up the upper saturated zone, where soil and groundwater contamination are present, is generally a fine to medium, well-graded sand with silt and gravel, and the underlying beach deposits include well-graded and poorly-graded fine to coarse sand with areas of silty sand and silty gravel present. These units have a horizontal hydraulic conductivity of approximately 10^{-3} cm/sec, which is consistent with effective distribution of air in the subsurface. Heterogeneities such as thin, discontinuous silt lenses were observed in the shallow saturated zone in soil borings, but none significant enough to interfere with air sparging. A relatively continuous silt layer was observed at approximately 15 feet below ground at the MTA bulkhead, which is below the impacted soil and groundwater. Air sparging can be effective even in silty soils, which often have sufficient permeability to transmit air, and which often have discontinuities or secondary permeability channels that allow vertical flow of air. Even if the silt limits the vertical flow of air and thus the vertical depth of air sparge wells, the silt deposit is located sufficiently below the smear zone to allow successful air sparging above the silt. The potentially smaller radius of influence of smaller air sparge wells can be addressed through engineering design.

Based on available information, the system is likely to consist primarily of a treatment zone or “curtain” oriented approximately parallel to the shoreline and perpendicular to the direction of groundwater flow. The curtain component of the system is likely to be constructed as close to the bulkhead as feasible but wide enough to allow sufficient distance for the treatment to be effective prior to discharge. Similar to Alternatives B1 and B2, it is expected that the air sparge curtain system would consist of sections that target the downgradient ends of the MTA and K Ply/Cedar Street Plumes, and span approximately 700 to 800 feet of shoreline. The system would be designed to treat the upper 5 to 10 feet of groundwater where the contaminants are located.

Air sparging is expected to remediate soil within its radius of influence, further minimizing any short-term enhancements to the remedy that excavation of accessible soils near the bulkhead may provide.

It is expected that an SVE system would be integrated into the air sparge system to address safety issues associated with the potential for increased VOC-impacted vapor migration. The increased rate of contaminant volatilization in the subsurface typically requires recovery to avoid migration of VOC-impacted vapors into buildings or accumulation at unsafe concentrations beneath asphalt or foundations. The SVE system would be operated as necessary to avoid these or other problems with soil vapors. It may be possible to phase out the use of the SVE system over time as concentrations of extracted vapors decrease.

Tidal variation, including the chemical effects of shallow saline mixing from Port Angeles Harbor into fresh groundwater, is not expected to be a significant factor in the engineering of the air sparge curtain. The air sparge system would not promote additional mixing of marine waters because the groundwater mounding in response to air sparging is expected to steepen the hydraulic gradient toward Port Angeles Harbor. . Additionally, seawater salinity and alkalinity are not expected to interfere with the physical process of stripping volatiles from the dissolved phase or bioremediation of petroleum hydrocarbons. If necessary, a hanging barrier wall could be added as a contingency should seawater interference be detrimental to system performance.

A hanging barrier wall is currently not considered necessary for the air sparging system to achieve cleanup levels at the point of compliance. If the performance of the air sparging system is below expectations, however, it is expected that a hanging barrier wall would be installed following system optimization, a thorough performance review, and after consideration of other possible modifications to improve performance.

Due to the relative simplicity of the components, the operation and maintenance requirements of air sparging are less than for alternatives that include groundwater extraction, even with the inclusion of an SVE treatment system.

The air sparge curtain alternative may require collection of additional design data prior to implementation for system optimization. For greater flexibility, the system may be designed to allow shutdown in areas where cleanup levels have been demonstrated to have been met. Once installed, compliance monitoring of groundwater inside and downgradient from the treatment area would be maintained.

8.1.4 Alternative B4: Barrier Wall with Active Groundwater Interceptor Trench and Ex-situ Treatment

This alternative consists of a subsurface groundwater containment barrier, such as a slurry or sheet pile wall, in combination with a trench to intercept, actively recover, and treat groundwater prior to discharging to Port Angeles Harbor. Interceptor trenches are very effective in intercepting contaminants in groundwater flowing into the trench and are typically easier to operate than groundwater recovery wells. An interceptor trench in this setting would require installation of a barrier wall downgradient of the interceptor trench to stop tidal waters from flowing into the trench and potentially overwhelming the system. The trench would generally be expected to operate independently of the tidal variation, because the barrier wall will dampen tidal effects, and because the trench design will intercept shallow groundwater and not draw water from beneath the barrier wall. The combination of the barrier wall with the interceptor trench will allow the trench to serve as a flexible control that has the potential to recover and treat less water than would be expected with groundwater recovery wells.

The barrier wall with active groundwater interceptor trench would be oriented approximately parallel to the shoreline and perpendicular to the direction of groundwater flow, be constructed as close to the bulkhead as feasible, and would span approximately 700 to 800 feet of shoreline downgradient of the MTA and K Ply/Cedar Street Plumes.

As with Alternative B2, extracted groundwater would then be conveyed to either a new, on-site groundwater treatment facility or to a discharge point to the local sanitary sewer for treatment at the Port Angeles POTW. Groundwater treated on-site would then either be discharged under a NPDES permit to Port Angeles Harbor, or discharged to the sanitary sewer under an industrial wastewater discharge permit.

The construction of the barrier wall with interceptor trench would require excavation of a substantial volume (estimated to be approximately 1,600 tons) of soil along the bulkhead as part of construction of the interceptor trench, much of which is known to be contaminated. The effectiveness of the barrier wall with interceptor trench in protecting the waters of Port Angeles Harbor may be initially enhanced by excavation of nearby contaminated soil source areas. As previously noted, however, the large mass of contaminated soil that will remain in place beneath buildings upgradient from this area will continue to leach COCs to groundwater.

Operation and maintenance of the barrier wall and active interceptor trench system would include maintaining the pumps, plumbing and electrical components of the active recovery trench, and operation of the on-site treatment system, if applicable. As described for Alternative B2, ex-situ treatment technologies each involve different operations and maintenance needs, such as disposal and replacement of spent carbon, air emissions monitoring, etc.

The alternative would include compliance monitoring of both the groundwater downgradient of the barrier wall system and the extracted water in the treatment train, including the discharge point to Port Angeles Harbor if applicable.

8.2 UPGRADIENT CLEANUP AREA

The Upgradient Cleanup Area, which encompasses the entire site area, is characterized by widespread scattered areas of residual soil contamination that are likely to continue to act as sources of groundwater contamination but are covered in large part by buildings. Alternatives for this Cleanup Area are numbered U1 to U3 to differentiate them from alternatives for the Bulkhead and Pettit Oil Cleanup Areas. Refer to Figure 8.3 for conceptual illustrations of these alternatives.

Regardless of which of the following remedial alternatives is selected, a large volume of contaminated soil is expected to remain in place beneath existing buildings. This soil will continue to leach COCs to groundwater no matter what remedial alternatives are implemented for soil in accessible areas; this situation is addressed by protection of surface water through a remedy in the Bulkhead Cleanup Area at the conditional POC.

Monitoring and institutional controls will be included in the preferred comprehensive site remedy (refer to the description of the preferred remedy in Section 10.0) to prevent direct contact with contaminated subsurface soil. The institutional controls are expected to consist of information provided to contractors or utility workers about subsurface contaminants and soil handling protocols prior to trenching or other subsurface work. Capped areas would also need to undergo routine inspection and repair. An environmental covenant describing the institutional controls would also be required per WAC 173-340-440 (8).

As previously discussed, air sampling in the K Ply mill, and any subsequent potential mitigation efforts such as improved ventilation, will be implemented as part of the preferred alternative regardless of which alternative is selected for the Upgradient Cleanup Area (refer to Section 10.1). For this reason, this component is omitted from the evaluation in the next several sections. In addition, minor modifications to the stormwater routing from the roof of the K Ply mill structure to decrease the leaching of COCs from soil beneath the mill building are expected to be implemented as part of the preferred alternative and are not evaluated in the sections below.

8.2.1 Alternative U1: No Action

The baseline alternative would involve no additional action at the Upgradient Cleanup Area. This alternative would leave in place the status quo conditions, in which potential exposure risks to site development and utility workers exist from subsurface soil and widespread scattered areas of contaminated subsurface soil may be continuing to leach petroleum hydrocarbons into groundwater.

8.2.2 Alternative U2: Capping, Monitoring, and Institutional Controls

This alternative would include maintenance of existing asphalt in areas with underlying soil contamination and construction of an impervious (asphalt or similar) cap over the soil contamination north of Westport Marine which is currently the only major unpaved or uncovered area of the MTA Site with underlying soil with TPH exceedances greater than cleanup levels. This alternative would also include modifications to the stormwater conveyances from the roof of the K Ply Mill as needed to prevent leaching associated with discharge of stormwater to the ground beneath K Ply.

Alternative U2 would leave in place the scattered and often inaccessible areas of subsurface contaminated soil. Groundwater would be monitored to track the leaching of COCs to groundwater over time. As part of this alternative, capping and monitoring would be implemented as a remedy for the Upgradient Cleanup Area in conjunction with a remedy for groundwater that protects surface water at the bulkhead conditional POC.

A component of this alternative is to monitor groundwater COC concentrations to assess whether concentrations are decreasing over time. The alternative is likely to involve the installation of a small number of additional groundwater monitoring wells to ensure thorough site coverage.

Capping would cause a temporary but substantial interference with the operations of Westport Marine, by blocking access to the large bay on the north side of the structure for a short period of time.

8.2.3 Alternative U3: Accessible Source Removal, Monitoring, and Institutional Controls

In addition to stormwater modifications to K Ply, groundwater monitoring and institutional controls, this alternative would involve removal of contaminated soil from the entire area accessible for excavation north of the Westport Marine building. Soils removed from the MTA Site would be transported to a licensed disposal facility for off-site treatment and/or disposal. This approach is the most permanent remedial alternative considered practicable at the MTA Site when compared to the other alternatives as part of the disproportionate cost analysis (refer to Section 9.0). Even this relatively large-scale removal, however, would not result in a highly permanent remedy due to the presence of substantial contaminated soil beneath existing buildings and would substantially disrupt operations at the site.

The goal of this approach is to reduce leaching of COCs from TPH-G and BTEX contaminated soil to groundwater to the extent feasible by removing soil with concentrations greater than cleanup levels that is not currently covered by buildings. The small areas of accessible contaminated soil north of Peninsula Fuel and east of Westport Marine are not considered in this alternative as these areas are located upgradient from substantial source areas beneath the K Ply Mill Building and Westport Marine buildings, respectively. Excavation of the accessible soil in these areas is therefore not expected to have a material effect on the leaching of COCs to groundwater relative to other sources contributing to the K Ply/Cedar Street Plume and MTA Plume.

Excavation would be conducted using standard construction equipment to remove contaminated soils from the subsurface. Soil would be stockpiled on-site, or loaded directly into trucks or barges for transport to a recycling or disposal facility. Utilities disrupted during soil removal activities must be relocated or replaced. Shoring may be used to provide excavation stability; nevertheless, setbacks from structures, including the bulkhead, are expected to be necessary. The groundwater table fluctuates seasonally, and tidally, and would limit the depth of excavation to a few feet below the water table. Excavation dewatering may be conducted to allow for excavation below the water table, and would generate a waste stream of extracted groundwater that would likely require treatment prior to disposal either at an off-site facility or to the POTW.

By removing the area of contaminated soil between Westport Marine and the bulkhead, this alternative would clean up virtually all soil within approximately 300 feet of the bulkhead north of Westport Marine. While it may have an initial effect on the concentrations of COCs in groundwater that are to be remediated in the Bulkhead Cleanup Area, this alternative is not expected to reduce the overall restoration time frame of the Bulkhead Cleanup Area remedy because a more substantial amount of contaminated soil would remain in place beneath the Westport Marine building and K Ply mill and continue to leach into groundwater.

Based on the assumption that only the four feet at the smear zone would be excavated within an approximately 2-acre area, the volume of contaminated soil to be excavated is estimated to be approximately 11,000 cubic yards out of a total of 31,000 cubic yards of contaminated soil estimated to be located at the MTA Site.[12] The volume of contaminated soil that would remain in place further upgradient beneath existing buildings and structures is estimated to be a minimum of 7,000 cubic yards from the smear zone beneath Westport Marine, 4,200 cubic yards from beneath the southern portion of K Ply, 2,000 cubic yards from the area south of K Ply, and 2,000 cubic yards of TPH-G contaminated soil at the hydraulic oil release beneath the north portion of K Ply. With vadose zone contamination included, the total volume of contaminated soil from these areas that would remain in place is estimated to be approximately 20,000 cubic yards.

In addition, the scale of the excavation of accessible soil would substantially affect the operations of the Port and its tenants. The excavation would dramatically disrupt the transfer of logs from west of Tumwater Creek to cargo vessels docked at Terminal 3 north of the bulkhead. At the current capacity, approximately two to three ships are loaded with logs for export each month, each requiring approximately 1,200 truckloads across the bulkhead entrance to Terminal 3. In addition, the excavation would prevent Westport Marine from moving watercraft in and out of the facility through the large bay at the north side of the building for several months. This activity is central to the operations at Westport Marine. Thus, the excavation may drastically limit production at Westport Marine or result in a temporary shutdown. The excavation would also temporarily eliminate the employee parking lot. Additionally, the staging area and substantial truck traffic required would likely interfere with Platypus Marine's ability to transport watercraft between the waterfront and the repair facility.

8.3 PETTIT OIL CLEANUP AREA

The Pettit Oil Cleanup Area is defined as the area occupied by the free diesel LNAPL at the groundwater surface at Pettit Oil. Given that the LNAPL at Pettit Oil is not a source of an off-site groundwater plume, this Cleanup Area is narrowly defined to focus efforts on remediating the LNAPL. Alternatives for this Cleanup Area are numbered P1 to P3.

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[12] To reach the contaminated soil at the smear zone, however, approximately 20,000 cubic yards of overburden would have to be excavated, stockpiled, and re-used for backfill. The estimated total of contaminated soil does not include contaminated soil at Pettit Oil.

8.3.1 Alternative P1: No Action

The baseline alternative would involve no additional action at the Pettit Oil Cleanup Area. This alternative would leave in place the status quo conditions, in which a large area of free diesel product is present at the groundwater surface (refer to Figure 8.4).

8.3.2 Alternative P2: Active Product Recovery

This alternative would involve implementing one of the three technologies that utilize an induced gradient for removal of relatively non-viscous LNAPL such as the diesel product at the Pettit Oil Cleanup Area. These include one or a combination of water table depression, VER, and/or bioslurping. Since these technologies overlap in large part, the exact engineering details of the product recovery system will be decided as part of the design stage. The alternative is likely to consist of limited additional delineation of the LNAPL, installation of extraction wells, and installation of a product recovery tank, groundwater treatment system (if applicable), vapor recovery system (if applicable) and associated piping and electrical connections. In addition to maintaining the system components, the recovered free product will be periodically transported off-site for disposal or recycling. Depending on the influent concentrations, the extracted groundwater may be treated on-site and then discharged to the sanitary sewer or discharged directly to the sanitary sewer for treatment at the POTW.

The system will be operated until LNAPL is recovered to the extent practical, as determined by an appropriately designed monitoring plan. The thickness of product at the water table will be monitored, the volume of free product recovered will be measured, and the downgradient edge of the product lense will be monitored to track any migration of the product lense.

Residual contaminated soil remaining following the removal of free product will be subject to institutional controls to limit exposure to underlying soil. The alternative may include the installation of a small number of additional groundwater monitoring wells, as well as quarterly or semi-annual groundwater monitoring events and reporting.

As indicated previously, product bailing or use of passive recovery inserts is considered an appropriate remedial approach for the limited area of LNAPL in the vicinity of PP-7.

8.3.3 Alternative P3: Source Removal

This alternative consists of the excavation and disposal of LNAPL to the extent practicable, and the excavation of contaminated soil impacted with LNAPL. Because Pettit Oil is an active facility with contamination located beneath buildings and the central paved lot, it is expected that the excavation would be implemented in two phases. The initial phase would consist of excavating accessible LNAPL-impacted soil from the southern edge of the property, beneath the former ASTs, and prior to the redevelopment of this area. This area to be excavated constitutes approximately 5,000 square feet. Depending on the thickness of contaminated soil, this area is estimated to include between 1,000 tons (4-foot thickness) and 3,000 tons (12-foot thickness) of contaminated soil accessible for excavation and disposal during the initial phase.

During the initial phase, LNAPL and LNAPL-impacted soil currently under or close to buildings, structures, or the central paved area necessary for operations would not be removed. A second phase of excavation would be implemented at a future time to complete the removal of LNAPL and LNAPL-impacted soil. The second phase of excavation would proceed at a time and in a manner that does not interfere with operations, such as a relocation of the Pettit Oil business and demolition of site structures, or in conjunction with other future land use changes or redevelopment. In the interim period, institutional controls including a restrictive covenant would be utilized to prevent exposure to COCs by direct contact. Based on the available information, the area to be excavated during the second phase would total approximately 10,000 square feet. Depending on the thickness of contaminated soil, this area is estimated to include between 2,000 tons (4-foot thickness) and 6,000 tons (12-foot thickness) of contaminated soil accessible for excavation and disposal during the second phase.

In the interim period between phases, vacuum-enhanced recovery (VER) would be performed using Ecology-approved surfactants to mobilize LNAPL. VER would be implemented at Recovery Wells MW-8, MW-9, and MW-10 using a portable vacuum truck in regular, discrete events. Product thickness would continue to be monitored.

For both phases, excavation would be conducted using standard construction equipment. Free product, once exposed at the water table, may be removed using a vacuum recovery truck. Contaminated soil and free product would be transported off-site for disposal or recycling. Following confirmation of the removal of the free product, the excavations would be backfilled with clean imported fill, compacted, and re-graded/repaved to return the area to its former condition.

Since the RAO for the Pettit Oil Cleanup Area is the removal of free product, and all complete exposure pathways will be addressed through remedies for the Bulkhead and Upgradient Cleanup Areas, it is expected that excavation would not proceed significantly below the water table. The alternative may include the installation of a small number of additional groundwater monitoring wells to ensure no reaccumulation of LNAPL, as well as groundwater monitoring events and reporting.

9.0 Detailed Analysis of Alternatives

In this section, alternatives for each Cleanup Area are evaluated relative to each other using the MTCA evaluation and disproportionate cost criteria. Estimated costs used in this evaluation include remedy components the east side of the MTA Site (refer to Appendix H). The detailed comparison for each Cleanup Area is presented in Tables 9.1 through 9.3. A summary of the overall evaluation for all three Cleanup Areas is presented in Table 9.4. A description of the evaluation for each Cleanup Area is presented below and forms the basis for selection of preferred remedial alternative components.

9.1 BULKHEAD CLEANUP AREA ALTERNATIVES EVALUATION AND DISPROPORTIONATE COST ANALYSIS

Three remedial alternatives and the no-action alternative were evaluated to determine how they are expected to perform in meeting RAO 1 preventing COCs in groundwater from discharging to surface water at concentrations greater than groundwater CULs protective of surface water. The no-action alternative, included as a baseline alternative for comparison, does not meet the RAO and is not considered further in this discussion.

The remedial alternatives and variant options are presented below:

- B2: Groundwater Recovery Wells and Ex-situ Treatment
- B3: Air Sparge Curtain
- B4 Combination Barrier Wall and Interceptor Trench

Underlying this evaluation is the impracticality of remediating all of the contaminated soil at the site. A large volume of the contaminated soil located beneath existing buildings will continue to contaminate groundwater for many years before naturally degrading, even if the accessible soil is removed from the area adjacent to the shoreline. The focus of this evaluation, therefore, is to assess the best approach to attain cleanup levels in groundwater at the conditional POC.

With respect to overall protectiveness, the three alternatives are approximately equal in rank. All are capable of achieving RAO 1, preventing COCs in groundwater from discharging to surface water at concentrations greater than groundwater CULs protective of surface water. Each alternative would achieve this RAO soon after implementation and would, therefore, provide approximately the same degree of risk reduction, within approximately the same time frame.

All three options would require a relatively long period of time to achieve restoration. Due to the substantial volume of contaminated soil that will remain beneath buildings, the areas upgradient from the Bulkhead Cleanup Area will continue to be a long-term source of groundwater contamination. All of the options require continued operation for many years to prevent discharge of contaminated groundwater to surface water. Alternative B3 would result in a greater reduction of contaminant volume by remediating impacted soil over time within the radius of influence of the air sparge curtain, and establishing a zone favorable to bioremediation.

Greater long-term effectiveness is attributed to Alternative B3 than either Alternative B2 or B4 based several factors. Air sparging is considered a presumptive remedy for petroleum hydrocarbons in groundwater because of its well-documented record of success over the long term. One reason that air sparging is more effective over time is that air sparge components are simpler and less prone to failure than those of groundwater extraction (e.g., recovery wells [B2] or an interceptor trench [B4]). Air sparging piping and manifold components convey compressed air into the subsurface (and in the case of SVE, convey soil vapor to the treatment system) and do not have the operational issues associated with conveying water (e.g. iron fouling). The ex-situ groundwater treatment for Alternatives B4 and B2 would require more complex and active operations and maintenance than Alternative B3, including maintaining pumps, keeping pipes free of fouling, and continuous discharge of treated effluent water.

A second factor is that, while groundwater recovery is widely recognized as effective at hydraulic containment (which supports attainment of RAO 1), groundwater recovery has been considered generally ineffective as a long-term remediation strategy for groundwater by USEPA since the 1990s, because long-term rebound from diffusion-controlled pore spaces is common (USEPA 1996). The CSM for the Bulkhead Cleanup Area indicates that long-term rebound from contaminated vadose zone soil is likely to occur in response to groundwater recovery. Through a combination of physical and biological means, air sparging typically remediates impacted soil within its radius of influence, decreasing the available source material and controlling rebound in groundwater concentrations. Air sparging is therefore more consistent with long-term effectiveness than continued diffusion-controlled rebound.

Thirdly, air sparging is considerably more flexible over the long term than either groundwater recovery option under consideration. The larger number of sparge points would allow partial shutdown of treatment in areas that are in compliance. Groundwater recovery wells are typically located precisely to provide a specific capture zone with far less flexibility; and interceptor trench sections are not usually able to be selectively shut down. Alternative B4 is considered slightly more effective than Alternative B2 over the long term due to its inclusion of a permanent physical barrier in addition to groundwater recovery.

Short-term risk management provides little distinction between alternatives in this case. The risks to human health and the environment associated with construction of all the alternatives are low and the controls in place to manage these short-term risks are effective. Alternative B4 includes slightly higher short-term risks due to the relative complexity of the deep trenching and barrier wall construction when compared to Alternatives B2 and B3.

All the alternatives are considered technically implementable. While Alternative B4 is more complex to construct, the technical obstacles are expected to be manageable using standard methods. Administrative implementability provides additional selection considerations. All of the alternatives will interfere to some degree with operations at the waterfront, including log export at Terminal 3 and ship-building activities at Westport Marine. The type of construction and its duration will determine the level of administrative implementability. Alternative B4, which includes a long, deep section of trenching with pipe placement and a barrier wall, is notably less implementable because of the substantial impact from this kind of construction. Deep trenching of this kind can be slow due to shoring requirements and may require a large excavation area depending on sidewall slopes. Based on current Port and Westport Marine operations, construction of Alternative B4 would result in a substantial interference with log export activity and ship construction business. Construction is expected to last months for this alternative and to block off access to the bulkhead area, including the Port's use of Terminal 3 and Westport Marine's ability to move ships between its facility and the waterfront. In contrast, Alternatives B2 and B3 are ranked higher for administrative implementability than B4. Alternatives B2 and B3 include a barrier wall only as a contingency in response to inadequate performance, and do not require deep trenching. These alternatives consist primarily of well drilling and shallow trenching, which could likely be completed within weeks and may not require closing off such a large area as Alternative B4. While conventional barrier wall (e.g. soil-bentonite slurry wall) installation techniques may require a large area for mixing slurry, sidewalls are vertical and installation often proceed rapidly in sandy soils such as those at the Site.

Since the ability to achieve permanence within a reasonable restoration time frame is similar among the alternatives, they are ranked in approximate order from most to least protective and effective over the long term as part of the disproportionate cost analysis. Most effective over the long term is Alternative B3 ($2.4 million[13]), followed by Alternative B4 ($3.35 million), and then Alternative B2 ($2.57 million).

Greater protectiveness and effectiveness are attributed to Alternative B3 over Alternatives B4 or B2 based on the following:

- The ability for air sparging to remediate saturated zone soil over time
- The effectiveness of air sparging remediation in groundwater mixed with saltwater and subject to tidal fluctuation
- The greater operational flexibility of the air sparge curtain in response to changing contaminant concentrations over time
- The greater long-term reliability due to the lower intensity of air sparge operations and maintenance relative to groundwater recovery options.

This evaluation indicates that the higher cost alternatives do not provide incremental benefits over the lowest cost alternative. The alternative that clearly provides the best combination of protectiveness, long-term effectiveness, and cost, therefore, is Alternative B3: Air Sparge Curtain.

9.2 UPGRADIENT CLEANUP AREA ALTERNATIVES EVALUATION AND DISPROPORTIONATE COST ANALYSIS

Two remedial alternatives, and the no-action alternative, were evaluated to determine how they are expected to perform in achieving the three RAOs for the Upgradient Cleanup Area:

1. Prevent COCs in groundwater from discharging to surface water at concentrations greater than groundwater CULs protective of surface water.
2. Prevent direct contact exposure by workers to subsurface soils with COC concentrations greater than CULs protective of the direct contact pathway.
3. Prevent inhalation exposure in buildings with underlying BTEX soil contamination to indoor air with BTEX concentrations greater than CULs[14].

The no-action alternative, included as a baseline alternative for comparison, does not address the RAO and is not considered further.

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[13] For evaluation purposes, this cost includes an SVE and treatment system, because it is expected that an SVE system will be constructed in conjunction with the air sparge curtain, and operated if necessary (refer to Section 8.1.3).

[14] The indoor air pathway is blocked for the west side of the MTA Site due to a vapor barrier beneath the Westport Marine offices.

The two alternatives considered are presented below:

- U2: Capping, Monitoring, and Institutional Controls
- U3: Accessible Source Removal, Monitoring, and Institutional Controls

As noted previously, a key assumption behind this evaluation is that remediating all of the contaminated soil at the site is infeasible due to the large volume of the contaminated soil located beneath existing buildings with active operations. Because this material will continue to contaminate groundwater for many years before naturally degrading, overall site remediation is focused on groundwater at a conditional POC at the bulkhead. For both of the alternatives considered, the inhalation pathway will be addressed through indoor air sampling with follow-up mitigation (e.g., ventilation improvements) as necessary; the direct contact pathway for subsurface soil will be addressed using institutional controls for worker protection. The primary focus of the Upgradient Cleanup Area comparative evaluation and disproportionate cost analysis, therefore, is on the protection of surface water and cost-effectiveness of these alternatives in enhancing the overall site remedy including remediation of groundwater at a conditional POC at the bulkhead.

The two alternatives provide a similar level of long-term effectiveness and protection of surface water. Capping would prevent leaching from currently unpaved vadose zone contaminated soils in the area adjacent to the MTA Bulkhead for Alternative U2. Capping would not be necessary for Alternative U3, which would remove the contaminated soil from this area. Alternative U3 would also reduce the leaching of COCs from smear zone soil through permanent removal of contaminated soil from the single large accessible area of the MTA Site. Even Alternative U3, however, would remediate only about a third of the contaminated soil at the MTA Site (approximately 11,000 out of 31,000 estimated total cubic yards). As indicated in Section 8.2.3 COCs will continue to leach from inaccessible areas of contaminated soil upgradient of the areas to be excavated and require remediation of groundwater at the bulkhead for an extended time.

Short-term risk management provides some distinction between U2 and U3. Alternative U3,scores lower for short-term risk than U2, due to the risk of contact with contaminated soil and groundwater, increased exposure to potential vapor from exposed soil and groundwater in the excavation, physical hazards associated with an open excavation on an active site, and handling, and transport of contaminated material from the MTA Site. Health and safety planning and procedures that would be used to manage these short-term risks are effective.

For technical and administrative implementability, Alternative U2 scores higher than U3. Alternative U2 is highly implementable, with no apparent technical or administrative obstacles. Alternative U3 involves substantial disruption to site operations from excavation, stockpiling, and waste loading, potential dewatering, and possible administrative obstacles associated with the large number of trucks that would be required to haul the contaminated soil off-site by road. Refer to Section 8.2.3 for additional details.

The results of this scoring process indicate that Alternative U3 with provides little or no additional protectiveness or effectiveness over the long term than Alternative U2. Instead, Alternative U3 would generate greater short-term risk and would be substantially more disruptive to the operations at the Port. The estimated total costs for Alternative U3 is $5.4 million and for Alternative U2 is $900,000.

The additional cost to implement Alternative U3 is disproportionate to its benefits because the active excavation approach in the uplands area does not substantially increase the effectiveness of remediating groundwater to protect surface water. Even if, under Alternative U3, contaminated soil from the area adjacent to the MTA Bulkhead is removed, the groundwater remedy at the bulkhead would still need to be operated for the same period of time to remediate contaminated groundwater migrating from upgradient of the Bulkhead Cleanup Area. The incremental costs of the higher cost alternative (U3) over the lower cost alternative (U2) substantially exceed the incremental degree of benefits achieved by Alternative U3 over Alternative U2. The alternative that provides the best balance of permanence and cost, therefore, is Alternative U2: Capping, Monitoring, and Institutional Controls.

9.3 PETTIT OIL CLEANUP AREA ALTERNATIVES EVALUATION AND DISPROPORTIONATE COST ANALYSIS

Two remedial alternatives and the no-action alternative were evaluated to determine how they are expected to perform in meeting the RAO, for the Pettit Oil Cleanup Area, removal, to the extent practicable, LNAPL accumulations on the water table. The no-action alternative, included as a baseline alternative for comparison, does not address the RAO and is not considered further.

The two alternatives considered are presented below:

- P2: Active Product Recovery
- P3: Source Removal

For both alternatives under consideration, passive recovery well inserts or equivalent will be utilized for the small, intermittent area of LNAPL near PP-7. The primary focus of the comparative evaluation and disproportionate cost analysis is on the cost-effectiveness of these alternatives in providing permanence in LNAPL recovery at Pettit Oil.

For overall protectiveness, Alternative P3 scores higher than Alternative P2 because source removal would remove a greater volume of LNAPL and LNAPL-impacted soil. (Refer to Table 6.1), providing greater risk reduction and improvement in overall environmental quality than active product recovery. Active product recovery would not fully remediate soil and would leave residual LNAPL. Because the timing of the second phase of active product recovery is unknown, it is not possible to compare precisely the restoration time frames of the two options. Active product recovery would require an estimated 10 years of operation to remove the majority of product. Source removal would rapidly remove a large fraction of the LNAPL immediately and leave virtually no soil containing residual LNAPL. Alternative P3 would remove the remainder of LNAPL and LNAPL-impacted soil at a future date. Though this date may or may not occur sooner than the estimated 10 year restoration time frame of Alternative P2, during the interim period, exposure risks would be addressed through institutional controls and LNAPL would be controlled with regular VER events.

Alternative P3 scores substantially higher than Alternative P2 with respect to permanence, because source removal is the most permanent option, and would leave virtually no residually-saturated soil in the Pettit Oil area.

Alternative P3 is also expected to be considerably more effective in achieving the RAO over the long term, because it carries a much higher degree of certainty for removing the majority of the LNAPL, and would leave a lower residual risk from soil containing residual LNAPL.

Alternative P3 scores slightly lower for short-term risk than Alternative P2 because of the risks associated with the excavation and transport of petroleum-contaminated soil and LNAPL, which are considered greater than those associated with construction and operation of an LNAPL recovery system. Short-term risk management provides only a minor distinction between Alternatives P2 and P3. Risks to human health and the environment associated with construction of both Alternatives P2 and P3 are generally low and the standard health and safety controls used to manage these short-term risks are effective.

Technical and administrative implementability provides little reason to prefer one alternative over another. Both alternatives are highly implementable, with technical and administrative challenges that are expected to be able to be overcome. Alternative P3 uses two phases to overcome a substantial administrative obstacle to implementing source removal. Active product recovery would insert physical features and maintenance activities into the small area of the Pettit Oil facility for approximately 10 years, which would interfere with site operations but not prevent implementation.

The overall results of this scoring process indicate that Alternative P3, source removal, ranks higher than Alternative P2, active product recovery, due to the significant permanence and protectiveness benefits of source removal. Alternative P3 includes some uncertainty regarding the restoration time frame, though this is mitigated by institutional controls and vacuum recovery events in the interim, and is greatly outweighed by the benefits of Alternative P3 over Alternative P2.

For the disproportionate cost analysis, the alternatives in approximate order of most to least permanent, and estimated total 10-year present value costs are Alternative P3 ($1.5 million[15]), then Alternative P2 ($1,59 million). This evaluation indicates that, despite similar overall costs, Alternative P3 provides substantial benefits over Alternative P2. The alternative that provides the best combination of permanence and cost, therefore, is Alternative P3: Source Removal.

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[15] For evaluation purposes, this cost includes both phases of excavation in 2011 dollars. This cost would be lower if the second phase of excavation were discounted as a future cost.

10.0 Preferred Cleanup Action

In this section, the preferred remedial components are combined into a comprehensive remedy for the west side of the MTA Site. The compliance of this remedy with MTCA and other ARARs is described, along with the estimated cleanup costs for the west side of the MTCA Site. Refer to Figure 10.1 and Table 10.1 for a summary of the Preferred Cleanup Action.

10.1 DESCRIPTION OF THE PREFERRED CLEANUP ACTION

The preferred remedy for the west side of the MTA Site is comprised of individual remedy components for each of the three Cleanup Areas that together form a comprehensive site remedy. The primary component of the remedial strategy utilizes groundwater remediation at a conditional point of compliance to protect surface water. However, the presence of substantial contaminated soil in inaccessible areas beneath buildings will require an extended time frame (i.e*.,* at least 30 years) to achieve a fully permanent remedy.

The following combination of remedy components best balances MTCA criteria for permanence, protectiveness, restoration time frame, and cost. Specific details of certain remedy components can only be established following engineering design based on an approved cleanup action plan. The preferred remedy is comprised of Alternatives B3, U2, and P3, and includes the following:

1. Installation of an air sparge curtain in-situ treatment system for groundwater COC plumes that may be discharging to surface water at concentrations greater than cleanup levels or approaching the point of discharge. The air sparge system will include a SVE system, which will be operated as necessary to manage volatile compounds transferred from groundwater to the vadose zone.
2. Long-term operation and maintenance of the air sparge and SVE treatment systems. These systems are expected to be operated until upgradient source areas undergo sufficient attenuation, estimated to be at least 30 years. Portions of the systems may be shut down over time as groundwater attains compliance with cleanup levels on a location-specific basis.
3. Impervious capping of the unpaved area north of Westport Marine to reduce leaching of COCs from vadose zone soil contamination to groundwater.
4. An initial phase of excavating the accessible LNAPL-impacted soil from the southern edge of Pettit Oil, beneath the former ASTs. Excavation would proceed until soil from this area was in compliance with MTCA requirements for the removal of LNAPL.
5. Semiannual VER events at Pettit Oil Wells MW-8, MW-9, and MW-10 using surfactants to mobilize LNAPL and removal using a portable vacuum truck.
6. A second phase of excavation at Pettit Oil to complete the removal of LNAPL and LNAPL-impacted soil at a future time to avoid interference with current operations.
7. Site-wide institutional controls to prevent direct contact to contaminated soil and LNAPL in the subsurface and to maintain impervious capping.
8. Long-term monitoring of groundwater at the conditional POC in the site interior and in LNAPL areas.

These components are illustrated in Figure 10.1. A further description of the overall remedy by Cleanup Area is provided, below.

10.1.1 Bulkhead Cleanup Area

The preferred cleanup action components at the Bulkhead Cleanup Area would achieve RAO 1, protection of surface water, by in-situ treatment of groundwater using air sparging immediately upgradient of the point of discharge, as described below (refer to Figures 10.1 and 10.2):

- The air sparge curtain is likely to consist of two rows of air injection wells, connected to a central shed or trailer with air injection lines in shallow trenches. Wells may be installed at multiple depths to maximize air distribution. The system will be designed for pulsed operation, and for area control to allow partial shutdown as groundwater attains compliance in selected locations. SVE pipes or wells will be integrated into air sparge trenches to the extent feasible. If necessary to manage volatiles transferred from groundwater to the vadose zone, extracted soil vapor will be treated and emissions monitored under an Olympic Region Clean Air Agency (ORCAA) permit.
- If necessary, based on initial performance, a hanging barrier wall will be installed to augment the air sparge curtain with physical containment. A hanging barrier wall is considered unlikely to be necessary, and would only be installed following system optimization, a thorough performance review, and after consideration of other possible modifications to improve performance. Under this contingency, contaminated groundwater flowing into the air sparge curtain would be treated and discharged to Port Angeles Harbor beneath the hanging barrier wall. The barrier wall would be one of several technologies that decrease hydraulic conductivity by orders of magnitude, effectively blocking flow and redirecting groundwater flow paths. The barrier wall is anticipated to be either a slurry wall (e.g., a soil-bentonite mixture) or interlocking sheet piles, installed to a depth of approximately 20 feet below ground surface. The blockage of shallow groundwater would cause the potentiometric surface to mound slightly behind the barrier wall. The increased head would drive groundwater flow downward, such that treated groundwater will discharge to Port Angeles Harbor at a greater depth.
- A monitoring well network will be established and a monitoring program will be implemented to ensure that the system achieves cleanup levels. This will include installing conditional POC monitoring wells at the bulkhead to monitor groundwater as close as practicable to the point of discharge to surface water. Monitoring may also include hydraulic measurements to track changes in potentiometric head as necessary.
- The air sparge and SVE systems will require active operation and regular maintenance. It is expected that the system will be largely automatic, with inspections and adjustments conducted by on-site Port staff, and periodic maintenance events conducted by qualified technicians. System operation and maintenance would be necessary until groundwater is no longer entering the treatment zone at concentrations greater than CULs as a result of the weathering and attenuation of COCs in upgradient soil and groundwater, which is expected to take several decades. It is expected that the system design will allow partial shut down for areas along the bulkhead where CULs have been achieved. This approach will lower operation and maintenance costs over time and focus efforts on any recalcitrant areas.

10.1.2 Upgradient Cleanup Area

The preferred cleanup action components for the Upgradient Cleanup Area include a variety of actions designed to address RAOs 1 (protection of surface water), 2 (prevention of direct contact in subsurface soils), and 3 (the inhalation pathway). As indicated in Section 9.0, the preferred cleanup action components for the Upgradient Cleanup Area support the Bulkhead Cleanup Area in achieving protection of surface water. However, the preferred alternative does not include remediation of all upland sources of groundwater contamination because substantial source material cannot be practicably removed from or treated beneath buildings (refer to Figure 10.1). The components of the preferred alternative would include:

- Impervious capping, such as asphalt, will be installed over contaminated vadose zone soils lying under the unpaved area between Westport Marine and the perimeter roadway adjacent to the bulkhead. This action will improve the quality of groundwater flowing toward the Bulkhead Cleanup Area treatment system by reducing surface water infiltration. Additional stormwater catch basins and pipes will be installed as necessary to route stormwater from this area into the existing stormwater system for the MTA Site.
- In conjunction with groundwater monitoring at the conditional point of compliance, long-term monitoring of groundwater is expected to be conducted at selected locations within the site interior. The goals of this sampling would be to monitor trends in COC concentrations to assess ongoing attenuation of COCs so that the treatment system can eventually be decommissioned.
- Institutional controls will be implemented to inform contractors or utility workers about subsurface contaminants and soil handling protocols prior to trenching or other subsurface work. This action would address RAO 2, preventing direct contact with subsurface contaminated soils, and LNAPL, in the case of Pettit Oil. Capped areas would also need to undergo routine inspection and repair. An environmental covenant describing the nature of the contamination left in place, a prohibition on withdrawals of site groundwater, and the monitoring and maintenance requirements of the institutional controls would also be required to be recorded on all affected properties per WAC 173-340-440(8).

10.1.3 Pettit Oil Cleanup Area

The preferred cleanup action components for the Pettit Oil Cleanup Area are focused on achieving RAO 4, the MTCA requirement for removal of LNAPL accumulations to the extent practicable. Refer to Figure 10.1. Specifically, the components would include the following:

- A focused, direct-push investigation would be conducted to delineate the extent of LNAPL and support the design of the excavation.
- An initial phase of excavating the accessible LNAPL-impacted soil from the southern edge of Pettit Oil, beneath the former ASTs. Excavation would proceed until soil from this area was in compliance with MTCA requirements for removal of LNAPL. This area to be excavated is estimated to be approximately 5,000 square feet, and to include between 1,000 tons (4-foot thickness) and 3,000 tons (12-foot thickness) of contaminated soil that will be removed for off-site disposal or recycling.
- Semiannual vacuum-enhanced recovery (VER) events at Pettit Oil Wells MW-8, MW-9, and MW-10 using Ecology-approved surfactants to mobilize LNAPL and

removal using a portable vacuum truck. VER events and product thickness monitoring would continue until product recovery is no longer feasible or until the second phase of excavation at Pettit Oil.

- A second phase of excavation at Pettit Oil at a future time to complete the removal of LNAPL and LNAPL-impacted soil. The second phase of excavation would be ideally occur during a relocation of the Pettit Oil business and demolition of site structures, or in conjunction with other future land use changes or redevelopment, to avoid interference with operations. The area to be excavated during the second phase is estimated to total approximately 10,000 square feet, and include between 2,000 tons (4-foot thickness) and 6,000 tons (12-foot thickness) of contaminated soil that will be removed for off-site disposal or recycling.

10.2 COMPLIANCE WITH THE MODEL TOXICS CONTROL ACT

The preferred remedy meets MTCA requirements for Selection of Cleanup Actions (Chapter 173-340-360 WAC) as follows.

The proposed remedy meets the following threshold requirements:

I. **Protect Human Health and the Environment.** The preferred remedy will protect human health and the environment in both the short and long term. The remedy will reduce the risks presently posed by groundwater to aquatic receptors through a combination of in-situ air sparge treatment at the downgradient edge of plume, impervious capping to reduce infiltration, and implementation of a long-term groundwater monitoring program to ensure the remedy is protective. Risks to workers by underlying contaminated soil will be addressed by land use restrictions.

    a. **Comply with Cleanup Standards.** The preferred remedy will comply with CULs for groundwater and soil. The proposed point of compliance for groundwater is a conditional point of compliance at the existing bulkhead across the entire MTA Site. Groundwater discharging to surface water will be treated with all known, available, and reasonable methods prior to release.

        i. **Comply with ARARs.** The preferred remedy is expected to fully comply with all action-, chemical-, and location-specific ARARs, as described below.

        ii. **Provide for Compliance Monitoring.** The preferred remedy will continue to provide for compliance monitoring. A long-term O&M plan will be developed for the MTA Site for groundwater to assess effectiveness and permanence of the remedy. The monitoring is expected to be more intensive for the initial 5 to 10 years following remedy implementation, with less frequent monitoring in the future.

The preferred remedy also meets the other selection criteria of MTCA:

1. **Providing for reasonable restoration time frame.** The preferred remedy can be designed, permitted, and installed in as little as two years after the Cleanup Action Plan (CAP) for the MTA Site is adopted. The restoration time frame for these actions to achieve groundwater CULs at the conditional point of compliance is expected to be within one year of construction and system startup, with substantial decreases in COC concentrations occurring within weeks. Operation is expected to continue until

sufficient attenuation of COCs in upgradient groundwater and soil has occurred, which is estimated to take up to 30 years.

2. **Using Permanent Solutions to the Maximum Extent Practicable.** The preferred remedy utilizes permanent solutions to the degree practical, based on a balance between permanence and cost as determined by disproportionate cost analysis. The majority of contaminated soil at the MTA Site lies under existing buildings with active operations and is impractical to excavate. Excavation of soil in the accessible areas of the MTA Site was considered but was determined to provide no increased permanence or other environmental benefit proportionate with the cost with the exception of excavation at Pettit Oil.
3. **Considering Public Concerns.** This document will be presented to the public and stakeholders through a public comment process. A public meeting will be held if sufficient requests are received. Ecology will prepare a responsiveness summary as part of the CAP that documents how each of the public comments were considered and addressed.

Additionally, the remedy meets MTCA requirements for groundwater actions specified in Chapter 173-340-360 (2)(c) for non-permanent groundwater cleanup actions, including removal of LNAPL using normally accepted engineering practices, and use of groundwater containment measures, in conjunction with treatment, to avoid expansion of the volume of groundwater affected.

As discussed in Section 6.4.2.2, the remedy meets the MTCA requirements for a conditional POC at the bulkhead point of discharge of groundwater to surface water, as measured in monitoring wells adjacent to the bulkhead. These conditions were met based on the impracticality of achieving compliance in site-wide groundwater within a reasonable restoration time frame, the highest beneficial use of groundwater at the MTA Site of discharge to surface water, and the lack of an exposure pathway to site groundwater through drinking water. In addition, the remedy meets the other conditions necessary to be eligible for a conditional POC:

- Groundwater discharge into surface water will be treated with all known, available, and reasonable methods prior to release.
- Groundwater discharge into surface water will not result in violations of sediment quality standards.
- Groundwater monitoring shall be performed to assess long-term performance and address potential bioaccumulation issues.
- Achievement of cleanup levels will not rely on a dilution zone in order to meet surface water standards.

10.3 OWNERSHIP, ACCESS, AND INSTITUTIONAL CONTROLS

Apart from the lots owned by Pettit Oil and Westport Marine, the MTA Site is entirely owned by the Port. This includes the land along the bulkhead where the CPOC is being proposed. Access agreements will be arranged as necessary to allow implementation of the cleanup action and monitoring and recording of necessary environmental covenants.

Implementation of institutional controls will be required on those portions of affected properties where soil and groundwater exceed cleanup levels. Institutional controls in the form of an environmental covenant will likely include the following:

- Restriction on withdrawal of groundwater from the MTA Site for drinking purposes.
- Requirement that the MTA Site be maintained for industrial use only in the manner consistent with zoning requirements.
- Requirement for long-term monitoring.
- Requirement that the pavement be maintained as an impervious surface to prevent infiltration.

10.4 SUMMARY OF THE ESTIMATED REMEDY COSTS

The estimated total 30-year present value cost for the preferred remedy is $4,684,000 as summarized in the table below. Cost estimate worksheets are presented in Appendix H. The long-term monitoring costs are based on a 30-year time frame, based on the expectation that this is the approximate time frame for natural attenuation of COCs in site soil and groundwater such that operation of the in-situ treatment system is no longer necessary. The regular VER events and LNAPL monitoring costs at Pettit Oil are estimated based on a 10-year time frame.

Estimated Cost for the Preferred Remedy[1]

Remedy Element	Capital Cost	30 Percent Contingency	Annual O&M Cost with 30% Contingency	Estimated O&M Duration	Present Value O&M (5% Net Discount Rate)	Total
Bulkhead Air Sparge Construction	$540,000	$162,000	--	--	--	$702,000
Bulkhead Air Sparge Operations and Maintenance[2]			$62,000[2]	30 years	$960,000	$960,000
Capping at Westport Marine, Institutional Controls, K Ply Stormwater Modification	$690,000	$207,000	--	--	--	$900,000
Pettit Oil Source Removal Phase 1 and 2 Excavations	$1,109,000	$333,000	--	--	--	$1,442,000
Semiannual VER Events and LNAPL Monitoring	--	--	$10,000	10 years	$80,000	$80,000

Estimated Cost for the Preferred Remedy[1]

Remedy Element	Capital Cost	30 Percent Contingency	Annual O&M Cost with 30% Contingency	Estimated O&M Duration	Present Value O&M (5% Net Discount Rate)	Total
Site-wide Groundwater Compliance Monitoring	–	--	\$33,000	30 years	\$500,000	\$500,000
Ecology 5-year Review[3]			\$7,000[3]	30 years	\$100,000	\$100,000
Subtotals	***\$2,339,000***	***\$702,000***	***\$112,000*** ***(years 1–10)*** ***\$102,000*** ***(years 11–20)***	–	***\$1,640,000***	
					Preferred Remedy Present Value TOTAL	**\$4,684,000**

Notes:

1 Estimate does not include costs associated with completion of a Cleanup Action Plan, or regulatory agency coordination outside of the 5-year review process. All costs are in 2011 dollars. Refer to Appendix H for additional cost information associated with the Preferred Remedial Alternative.

2 Estimate includes costs associated with System O&M, electricity, and annualized equipment replacement costs as presented in Appendix GH, Alternative B3 – *West Side Only*. Annual Site-Wide Groundwater Compliance Monitoring is presented as a separate line in this table. A 30% contingency on annual O&M costs has been included in the estimate for the preferred remedy.

3 Five-year review cost assumes \$25,000 Ecology and consulting costs every 5 years for 30 years, plus 30% contingency.

10.5 APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

The preferred alternative complies with the ARARs under WAC 173-340-710 described below. Legally applicable requirements to be considered are those that specifically address a hazardous substance, cleanup action, location or other circumstances at the MTA Site.

10.5.1 Chemical-specific Applicable or Relevant and Appropriate Requirements

The preferred alternative is predicted to attain concentration-based cleanup levels developed under MTCA for the COCs in applicable media at the MTA Site. Please refer to Section 6.4 for a detailed discussion of how cleanup levels were identified.

10.5.1.1 Sediment Management Standards (WAC 173-204)

Sediment Management Standards are not applicable at the MTA Site because none of the COCs currently discharging to surface water at concentrations greater than applicable cleanup standards have established cleanup criteria under the Sediment Management Standards.

10.5.1.2 Water Quality Standards for Washington Surface Waters (WAC 173-201A)

The preferred alternative will comply with Washington State Surface Water Standards that apply to stormwater discharges during remedial construction.

While there are no promulgated surface water standards for the site COCs, standards that control discharge of other pollutants to stormwater generated during construction would be applicable.

10.5.1.3 National Toxics Rule

This rule sets numeric criteria for several priority toxic pollutants in marine surface waters, including several VOCs. The National Toxics Rule was used to develop cleanup levels. Subpart D, Federally promulgated water quality standards, is applicable. These standards are referenced in MTCA (WAC 173-340-730 (3)(b)) as applicable federal laws and are based on human health. Of the site COCs, criteria are listed for benzene only.

10.5.1.4 National Recommended Water Quality Standards

These federally-promulgated water quality standards are applicable. These standards are referenced in MTCA (WAC 173-340-730 (3)(b)) as applicable federal laws and are based on human health. Of the site COCs, criteria are listed for benzene only.

10.5.1.5 Controls for New Sources of Toxic Air Pollutants (WAC 173-460)

Pursuant to Chapter 70.94 RCW, Washington Clean Air Act, the purpose of this regulation is to establish controls for new or modified sources emitting toxic air pollutants (TAPs) in order to prevent air pollution, reduce emissions to the extent reasonably possible, and maintain such levels of air quality as will protect human health and safety. Operation of an SVE system as part of the preferred remedy would establish a new potential source of benzene, ethylbenzene, and toluene, which are regulated as toxic air pollutants listed in WAC 173-460-150. The air emissions from the vapor treatment system would require a permit, monitoring, and reporting administered by ORCAA.

10.5.2 Location-specific Applicable or Relevant and Appropriate Requirements

The following location-specific ARARs would apply to the preferred remedy.

10.5.2.1 Native American Graves Protection and Repatriation Act (25 USC 3001 through 3113; 43 CFR Part 10) and Washington's Indian Graves and Records Law (RCW 27.44)

These statutes, or local variations, prohibit the destruction or removal of Native American cultural items and require written notification of inadvertent discovery to the appropriate agencies and Native American tribe. Because the general waterfront area has been occupied, or otherwise used, by Native American tribes, remediation activities could uncover artifacts. A Cultural Resources Plan must be developed and submitted to the City of Port Angeles when significant ground disturbing activities are implemented. The plan typically requires oversight by an archeologist to examine disturbed soil for evidence of artifacts.

10.5.2.2 Archaeological Resources Protection Act (16 USC 470aa et seq.; 43 CFR part 7)

This program, or similar local variations, sets forth requirements that are triggered when archaeological resources are discovered. These requirements only apply if archaeological items are discovered during implementation of the selected remedy.

10.5.2.3 Washington State Shoreline Management Act (WAC 173-16-040(4) and City of Port Angeles Shoreline Master Program

The Washington Shoreline Management Act, authorized under the federal Coastal Zone Management Act, and implemented through the City of Port Angeles' Shoreline Master Program, establishes requirements for substantial development occurring within the waters of the State of Washington or within 200 feet of a shoreline. The preferred remedy will comply with the applicable substantive requirements under the City of Port Angeles' Shoreline Management Act Program.

10.5.3 Action-specific Applicable or Relevant and Appropriate Requirements

Action-specific ARARs are requirements that define acceptable management practices and are usually specific to certain kinds of activities that occur or are specific to the technologies that are used during the implementation of cleanup actions. The preferred alternative will comply with the following requirements.

10.5.3.1 Washington Dangerous Waste Regulations (WAC 173-303)

These requirements potentially apply to the identification, generation, accumulation, and transport of hazardous/dangerous wastes at the MTA Site during remediation. These standards are applicable to any soil wastes that are taken off-site for disposal. However, it is unlikely that any of the soil cutting or excavation material will be classified as dangerous waste.

10.5.3.2 Washington Solid Waste Handling Standards (WAC 173-350)

These requirements establish minimum standards for handling and disposal of solid waste. They are applicable for alternatives that generate solid waste, the definition of which includes wastes that are likely to be generated as a result of MTA Site remediation, including contaminated soils, construction and demolition wastes, and garbage. The standards require that solid waste be handled in a manner that does not pose a threat to human health or the environment, and comply with local solid waste management rules and applicable water and air pollution controls.

10.5.3.3 Water Quality Standards for Surface Waters of the State of Washington (RCW 90.48 and 90.54; WAC 173-201A)

The preferred alternative will comply with surface water quality standards such as turbidity and pH that apply to certain construction elements (e.g., during excavation activities). The area of construction and equipment staging will likely be greater than one acre, and so will require a National Pollution Discharge Elimination System (NPDES) Stormwater Construction Permit, administered by Ecology to control discharge of pollutants from the construction activities.

10.5.3.4 State Environmental Policy Act

State Environmental Policy Act (SEPA) review should be conducted in conjunction with design and permitting to evaluate SEPA/National Environmental Policy compliance.

10.5.3.5 Federal and State of Washington Worker Safety Regulations

The safety of workers implementing remedies at hazardous waste sites are covered by the following regulations:

- Health and Safety for Hazardous Waste Operations and Emergency Response (HAZWOPER), WAC 296-62 and Health and Safety 29 CAR 1901.120
- Occupational Safety and Health Act (OSHA)
- Washington Industrial Safety and Health Act (WISHA), WAC 296-62, WAC 296-155, RCW 49.1

The HAZWOPER regulates health and safety operations for hazardous waste sites. The health and safety regulations describe federal requirements for health and safety training for workers at hazardous waste sites.

OSHA provides employee health and safety regulations for construction activities and general construction standards, as well as regulations for fire protection, materials handling, hazardous materials, personal protective equipment, and general environmental controls. Hazardous waste site work requires employees to be trained prior to participation in site activities, medical monitoring, monitoring to protect employees from excessive exposure to hazardous substances, and decontamination of personnel and equipment.

Washington State adopted the standards that govern the conditions of employment in all work places under its WISHA regulations. The regulations encourage efforts to reduce safety and health hazards in the work place and set standards for safe work practices for dangerous areas such as trenches, excavations, and hazardous waste sites.

10.5.3.6 Underground Injection Well Registration

The Underground Injection Control Program (UIC) protects groundwater quality by regulating discharges to UIC wells. UIC wells are manmade structures used to discharge fluids into the subsurface. Introducing surfactants would require registration with the UIC Program. Injection wells utilized for purposes of environmental cleanup under MTCA are rule-authorized, provided they meet the non-endangerment standard. It is expected that introduction of surfactants would meet this standard.

10.6 CONCLUSION

This feasibility study fully complies with requirements under the 2005 Agreed Order and provides sufficient information on cleanup action alternatives to enable a cleanup action to be selected for the west side of the MTA Site in accordance with WAC 173-340-350.

11.0 References

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Marine Trades Area Site
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Final
Remedial Investigation/ Feasibility Study

Tables

Table 3.1
Monitoring Well Information

Monitoring Well	**Screened Interval (feet bgs)**	**Measuring Point Elevation (feet NAVD 88)[1]**	**Northing**	**Easting**
Marine Trades Area Monitoring Wells				
MW-3	6–20	16.107	420315.4750'	1002724.1400'
MW-4	5–15	15.632	420478.4920'	1002466.0660'
MW-6	6–16	16.330	420514.6370'	1002409.6830'
MW-8	5–20	17.873	420359.3030'	1002924.1500'
MW-9	5–20	15.560	420924.9470'	1002963.7610'
MW-10	5–20	15.056	420903.6760'	1002756.0200'
MW-12	5–20	14.287	420875.9510'	1002585.9150'
MW-13	5–20	13.527	420854.0230'	1002518.6320'
MW-14	5–20	16.158	420364.7500'	1002621.6070'
MW-20A[2]	5–15	14.548	420963.2480'	1002720.6730'
MW-20B[2]	20–25	14.414	420965.8040'	1002731.2570'
MW-21A[2]	5–15	14.089	420995.871’	1002947.960’
MW-21B[2]	20–25	14.340	420997.2090'	1002958.4150'
MW-22[2]	5–15	15.305	421040.0040'	1003161.4380'
MW-23[2]	5–15	16.606	420272.8100'	1002922.3250'
MW-24[2]	5–15	15.378	420755.0000'	1002936.0790'
MW-25[2]	5–15	15.575	420728.7770'	1002677.0530'
MW-26[2]	5–15	14.75	420782.538’	1002585.65’
MW-27[2]	5–20	14.76	420840.927’	1002688.779
MW-28[2]	5–15	15.62	420799.679	1002843.84’
MW-29[2]	5–15	13.96	420925.699’	1002617.713’
MW-30[2]	5–15	14.18	420974.166	1002801.73’
MW-31[2]	5–15	13.92	420994.181’	1002876.827’
MW-32[2]	5–15	14.64	420880.17’	1002799.57’
MW-33[2]	5–17	17.07	420475.105’	1002803.052’
K-Ply Monitoring Wells				
PP-7	8–13.2	16.552	420315.8610'	1002981.5120'
PP-9	NA	17.043	420103.0260'	1003332.2600'
PP-13	10–15	16.622	420733.1690'	1003172.1820'

Monitoring Well	Screened Interval (feet bgs)	Measuring Point Elevation (feet NAVD 88)[1]	Northing	Easting
K-Ply Monitoring Wells (continued)				
PP-15	7.5–12.5	NA	NA	NA
Pettit Oil Monitoring Wells				
MW-1	2.5–7.5	13.798	420250.0950'	1002408.5300'
MW-2	1.5–6.5	14.061	420236.6160'	1002467.6300'
MW-3	2.5–7.5	13.540	420304.6870'	1002398.8100'
MW-4	1.5–7.5	14.048	420323.3480'	1002344.9900'
MW-5	3.5–19.5	16.406	420334.9450'	1002454.1300'
MW-6	4–19	16.646	420360.6980'	1002425.4200'
MW-8[2]	4.5–20	16.572	420396.8180'	1002423.3300'
MW-9[2]	4.5–20	16.548	420364.7230'	1002471.8000'
MW-10[2]	4.5–20	16.198	420341.6000'	1002500.8700'
RZ-1	NA	14.670	420267.2850'	1002463.0380'
RZ-2	NA	15.189	420270.1800'	1002375.8100'
RZ-3	NA	15.585	420304.2750'	1002325.9300'

Notes:

1 Measuring point elevations for monitoring wells from survey of top of PVC well casing by Northwestern Territories, Inc., January 30 through February 1, 2007 and February 8, 2008.

2 Wells installed during RI/FS activities.

Abbreviations:

bgs	Below ground surface
NA	Not available
NAVD	North American Vertical Datum of 1988

Table 4.1
Potentiometric Elevations—January 31 and May 8–10, 2007

Monitoring Well	Measuring Point Elevation (feet NAVD 88)[1]	Depth to Water January 31, 2007 (feet)	Water Table Elevation January 31, 2007 (feet NAVD)	Depth to Water May 8–10, 2007[2] (feet)	Water Table Elevation May 8–10, 2007[2] (feet NAVD)
Marine Trades Area Monitoring Wells					
MW-3	16.107	9.57	6.54	10.16	5.95
MW-4	15.632	9.16	6.47	9.69	5.94
MW-6	16.330	10.03	6.30	10.37	5.96
MW-8	17.873	11.68	6.19	12.11	5.76
MW-9	15.560	10.25	5.31	11.04	4.52
MW-10	15.056	9.37	5.69	10.14	4.92
MW-12	14.287	8.50	5.79	9.16	5.13
MW-13	13.527	7.83	5.70	8.45	5.08
MW-14	16.158	9.62	6.54	10.1	6.06
MW-20A	14.548	8.69	5.86	9.5	5.05
MW-20B	14.414	8.55	5.86	9.83	4.58
MW-21A	14.089	9.01	5.08	9.92	4.17
MW-21B	14.340	9.04	5.30	10.09	4.25
MW-22	15.305	10.00	5.31	12.04	3.27
MW-23	16.606	10.53	6.08	10.98	5.63
MW-24	15.378	9.46	5.92	9.93	5.45
MW-25	15.575	9.62	5.96	10.17	5.41
K-Ply Monitoring Wells					
PP-7	16.550	9.97[2]	6.58[2]	10.42[3]	6.13[2]
PP-9	17.040	9.74	7.30	10.45	6.59
PP-13	16.622	10.69	5.93	11.21	5.41
Pettit Oil Monitoring Wells					
MW-1	13.798	NA	NA	6.25	7.55
MW-2	14.061	NA	NA	6.98	7.08
MW-3	13.540	NA	NA	6.42	7.12[4]
MW-4	14.048	NA	NA	6.32	7.73

Monitoring Well	Measuring Point Elevation (feet NAVD 88)[1]	Depth to Water January 31, 2007 (feet)	Water Table Elevation January 31, 2007 (feet NAVD)	Depth to Water May 8–10, 2007[2] (feet)	Water Table Elevation May 8–10, 2007[2] (feet NAVD)
Pettit Oil Monitoring Wells (continued)					
MW-5	16.406	NA	NA	9.74	6.67
MW-6	16.646	NA	NA	9.76	6.89
MW-8	16.572	NA	NA	NA	NA
MW-9	16.548	NA	NA	NA	NA
MW-10	16.198	NA	NA	NA	NA
RZ-1	14.670	NA	NA	NA	NA
RZ-2	15.189	NA	NA	7.60	7.59
RZ-3	15.585	NA	NA	7.59	8.00
Tumwater Creek Measurement Stations					
RP-1	13.8	NA	NA	9.0	4.8
RP-2	14.1	NA	NA	7.2	6.9

Notes:

1 Measuring point elevations for selected monitoring wells from survey by NTI, January 30 through February 1, 2007. Measuring point elevations for Tumwater Creek points (RP-1 and RP-2) from survey by Floyd|Snider, May 7, 2007.

2 Water level measurements for Pettit Oil Monitoring Wells were collected on May 10, 2007 (Gettler Ryan, 2007). All other measurements were collected on May 8, 2007.

3 Free product was not detected at the time of measurement, although 0.02 feet of product was detected on January 30, 2007.

4 Potentiometric elevation given for MW-3 has not been corrected for 0.33 feet of product measured in this well at the time of the measurement. This correction is not expected to significantly affect potentiometric contours shown on Figure 4.1.

Abbreviations:

NA Not available
NAVD North American Vertical Datum

Table 4.2
Soil Analytical Results

Date	Sample Location	Depth (feet)	TPH-G[1] (mg/kg)	TPH-D[2] (mg/kg)	TPH-Oil[2] (mg/kg)	Benzene[3] (mg/kg)	Toluene[3] (mg/kg)	Ethylbenzene[3] (mg/kg)	Total Xylenes[3] (mg/kg)
		MTCA Method A	**30**	**2,000**	**2,000**	**0.03**	**7**	**6**	**9**
Geoprobes—Floyd|Snider 2005 - 2007									
10/5/2007	SB-70	10–11	ND	ND	ND	ND	–	–	–
		11–12	ND	ND	ND	ND	–	–	–
10/6/2007	SB-72	10–11	ND	ND	ND	ND	–	–	–
		11–12	ND	ND	ND	ND	–	–	–
		14–16	ND	ND	ND	ND	–	–	–
10/6/2007	SB-74	6–8	ND	ND	ND	ND	–	–	–
		10–12	**1,700**	**5,300**	ND	ND	–	–	–
		10–12[4]	**1,250**	**2,710**	ND	**4.29**	–	–	–
		23–24	ND	ND	ND	ND	–	–	–
10/6/2007	SB-76	10–11	**759**	**4,910**	359	ND	–	–	–
		11–12	**1,020**	**3,900**	223	1.93	–	–	–
		15–16	ND	13.0	ND	ND	–	–	–
10/5/2007	SB-60	6–8	ND	29.2	ND	ND	–	–	–
		6–8[4]	**38.2**	309	ND	ND	–	–	–
		10–12	**2,710**	1,070	175	**9.88**	–	–	–
		14–16	12.5	ND	ND	**0.152**	–	–	–
		18–20	ND	ND	ND	ND	–	–	–
10/5/2005	SB-62	10–11	ND	ND	ND	ND	–	–	–
		11–12	ND	ND	ND	ND	–	–	–
10/5/2005	SB-80	10–11	ND	ND	ND	ND	–	–	–
		14–15	ND	ND	ND	ND	–	–	–
10/5/2005	SB-82	11–12	ND	28.5	489	ND	–	–	–
		14–15	ND	ND	ND	ND	–	–	–
10/5/2005	SB-84	10–11	ND	ND	ND	ND	–	–	–
		11–12	ND	ND	ND	ND	–	–	–
10/6/2005	SB-92	10–12	**2,110**	**11,800**	ND	**0.279 R**	–	–	–
11/30/2005	SB-101[5]	9–11	ND	–	–	ND	ND	ND	ND
11/30/2005	SB-102	11–14	ND	–	–	**0.236**	ND	ND	ND
11/30/2005	SB-103	13–15	ND	–	–	**0.0997**	ND	ND	ND
11/30/2005	SB-104	10–12	ND	–	–	ND	ND	ND	ND
11/30/2005	SB-105	13–15	ND	–	–	**0.622**	ND	ND	ND
11/30/2005	SB-106	10–12	ND	–	–	ND	ND	ND	ND
12/1/2005	SB-107	9–11	ND	–	–	ND	ND	ND	ND
12/1/2005	SB-108	10–12	ND	–	–	**0.676**	0.0394	0.0821	0.159
12/1/2005	SB-109	10–12	ND	–	–	**0.116**	ND	ND	ND
12/1/2005	SB 110	10–12	ND	–	–	**0.171**	ND	ND	ND
12/1/2005	SB-111	10–12	ND	–	–	ND	ND	ND	ND
12/1/2005	SB-112	10–12	ND	–	–	ND	ND	ND	ND
12/1/2005	SB-113	10–12	ND	–	–	ND	ND	ND	ND
12/2/2005	SB-114	10–12	ND	–	–	ND	ND	ND	ND
12/2/2005	SB-115	10–12	ND	–	–	ND	ND	ND	ND
12/2/2005	SB-116	10–12	ND	–	–	**0.188**	ND	ND	ND
12/2/2005	SB-117	10–12	ND	–	–	**0.154**	ND	0.113	ND
12/2/2005	SB-118	10–12	ND	–	–	ND	ND	ND	ND
5/31/2006	SB-210	6–8	**791**	530	–	< 0.05	< 0.08	< 0.08	< 2.0
5/31/2006	SB-215	6–7	19.4	46.7	–	< 0.04	< 0.07	< 0.07	< 0.1
5/31/2006	SB-217	6–7	< 7.8	**2,580**	–	< 0.05	< 0.08	< 0.08	< 0.2
5/31/2006	SB-217	9.5–11	< 4.8	1,670	–	< 0.03	< 0.05	< 0.05	< 0.1
Geoprobes—Floyd|Snider February 2008									
2/6/2008	FS-1	6–8	**371**	–	–	**0.458 J**	0.0196	2.27 J	0.23
		9–10	**7,260**	–	–	**11.8**	1.01	**75.4**	**16.7**
2/6/2008	FS-2	8–10	**1,020**	**11,900 E**	–	**0.0343 U**	0.171 U	0.171 U	0.514 U
		14–15	9.26 U	13 U	–	0.0229	0.00205	0.00348 U	0.0101
		17–18	**2,240**	**12,500 E**	–	0.0286 U	0.143 U	0.143 U	0.429 U
2/6/2008	FS-3	10–11	8.27 U	–	–	0.000942 U	0.000942 U	0.00251 U	0.00628 U
2/7/2008	FS-4A	2–3	**31.3**	–	–	**0.894 J**	0.00512	1.48 J	0.0794
2/7/2008	FS-4B	9–10	**2,620**	–	–	**8.8**	0.889	**12.8**	8.52
		15–16	7.88	–	–	0.0257 UJ	0.128 UJ	0.128 UJ	0.0282 UJ
2/6/2008	FS-5	2–3	29.2	–	–	0.0287	0.00273	0.00977	0.0243
		1–3	15.3	–	–	0.0166	0.00156	0.00554	0.016
		9–10	**736**	–	–	0.00207	0.00102 U	0.00272 U	0.00681 U
2/6/2008	FS-6	10–11	**207**	**5,940 E**	–	**0.137 UJ**	0.00491	1.53 J	0.0203
2/5/2008	FS-7	10–11	**1,550**	–	–	0.017	0.00405	**11.3 J**	0.051
		13–14	27	–	–	0.0114	0.00111 U	0.00295 U	0.00738 U
2/6/2008	FS-8	9.5–10.5	**4,600**	–	–	**1.21**	0.154	**50.5**	2.68
2/7/2008	FS-9	9–10	**783**	–	–	**0.117 J**	0.141 UJ	**7.79 J**	2 J
2/4/2008	FS-10	5–6	**236**	–	–	**0.0422**	0.176 U	0.232	0.527 U

Date	Sample Location	Depth (feet)	TPH-G[1] (mg/kg)	TPH-D[2] (mg/kg)	TPH-Oil[2] (mg/kg)	Benzene[3] (mg/kg)	Toluene[3] (mg/kg)	Ethylbenzene[3] (mg/kg)	Total Xylenes[3] (mg/kg)
MTCA Method A			**30**	**2,000**	**2,000**	**0.03**	**7**	**6**	**9**
Geoprobes—Floyd|Snider July 2009 (continued)									
2/4/2008	2/4/2008	9–10	**4,000**	–	–	0.0259 U	0.129 U	4.27	0.746
2/5/2008	FS-11	10–11	**87.1**	–	–	0.00111 U	0.00111 U	0.00746	0.0116
2/5/2008	FS-12	8–10	**1,960**	–	–	**0.296 J**	0.191 J	**13.4 J**	**19.8 J**
2/5/2008	FS-13	9	**7,440**	–	–	**0.748**	0.19	**60.9**	**21.5**
2/6/2008	FS-14	10–11	–	11 U	–	–	–	–	–
2/7/2008	FS-15	9–10	**781**	–	–	0.000846 U	0.000846 U	0.00226 U	0.0112
2/4/2008	FS-16	9.5–10.5	**435**	–	–	**0.0715**	0.174 U	0.174 U	0.523 U
2/5/2008	FS-17	4–6	**6,260**	–	–	**2.32**	1.9	**44.2**	**246**
		10–11	**254**	–	–	0.00163	0.00175	2.2 J	0.108
		16–18	8.45	–	–	0.00183	0.000951	0.00233 U	0.00595
2/7/2008	FS-18	4–6	**131**	–	–	0.00233	0.00125	0.118 UJ	0.026 UJ
		10–11	**106**	944	–	0.014	0.00128	0.683 J	0.84 J
2/6/2008	FS-19	9–10	6.07 U	–	–	0.000937 U	0.000937 U	0.0025 U	0.0062 U
2/4/2008	FS-20	10–12	17.9	–	–	0.0149	0.00253	0.00233 U	0.00657
		12–13	**80.9**	–	–	**0.279**	0.184 U	0.184 U	0.958
2/5/2008	FS-21	9–10	**640**	–	–	0.000853 I	0.000853 U	0.00227 U	0.00568 U
2/5/2008		13–14	**84.6**	–	–	**0.0469**	0.0101	0.0163	0.0362
2/7/2008	FS-22	8–9	**244**	–	–	0.000771 U	0.000771 U	0.00971	0.0258
2/7/2008		10–11	**1,620**	212	–	**0.127 UJ**	0.636 UJ	0.725 J	3.23 J
2/4/2008	FS-24	5–7	18.6	–	–	0.00171	0.00127 U	0.00339 U	0.00849 U
2/4/2008		8–11	20.8	–	–	0.00269	0.000786 U	0.00209 U	0.00524 U
2/4/2008		12–15	11.9	–	–	0.00224	0.00121	0.00261 U	0.0117
2/4/2008	FS-25	12–14	26.4	–	–	**0.343**	0.219 U	0.221	0.656 U
2/7/2008	FS-26	9–10	6.06 U	10.7 U	–	0.00118	0.00101 U	0.00269 U	0.00673 U
2/7/2008		14–16	–	13 U	–	–	–	–	–
2/7/2008	FS-27	13–14	6.55 U	11.6 U	–	0.000779 U	0.000779 U	0.00208 U	0.00519 U
2/7/2008	FS-28	9–10	**5,490**	541	–	**1.46**	1.05	**66.8**	**20.1**
2/5/2008	FS-29	2–3	**68.7**	11 U	–	0.0262	0.00109 U	0.0063	0.00725 U
		10–11	**85**	1,130	–	**0.453 J**	0.0244	1.54 J	0.115
2/8/2008	FS-30	9–10	**682**	–	–	0.000748 U	0.000748 U	0.00199 U	0.00499 U
2/6/2008	MW-26	10–11.5	**2,860**	–	–	0.028 U	0.14 U	0.171	0.442
2/5/2008	MW-27	5.5–6	**634**	–	–	0.00503	0.00322	0.948 UJ	0.201
		7.5–8.5	10.1	–	–	0.00097 U	0.00097 U	0.00536	0.018
2/6/2008	MW-28	10–11.5	7.32 U	–	–	0.000908 U	0.000908 U	0.00242 U	0.00605 U
2/5/2008	MW-29	10	**1,430**	–	–	**0.247 J**	0.0413	**8.44 J**	**9.72 J**
2/5/2008	MW-30	8–9	**31.4**	445	–	0.000948 U	0.000948 U	0.003	0.00632 U
		10	**1,030**	–	–	0.0225 U	0.112 U	0.162	0.337 U
		15	12.6	–	–	0.00675	0.000814 U	0.00217 U	0.00542 U
2/6/2008	MW-31	8–9	**5,380**	**4,450 E**	–	**0.227**	0.14 U	**11.6**	3.43
2/6/2008	MW-32	10–11.5	**868**	1,170	–	**0.447 J**	0.121 UJ	**8.85 J**	**11.1 J**
2/6/2008		16–16.5	**30.2**	11.2 U	–	**0.0436**	0.00202	0.00211 U	0.0111
2/7/2008	MW-33	6.5	8.78 U	12.5 U	–	0.00453	0.00215	0.00266 U	0.0172
		9	6.22 U	10.4 U	–	0.0249 U	0.124 U	0.124 U	0.373 U
		11.5	**475**	73.3	–	0.00381	0.0028	0.82 J	0.0255
		13	**137**	16	–	0.00873	0.00548	0.0921	0.0304
		18	6.4 U	11.5 U	–	0.000831 U	0.000831 U	0.00222 U	0.00554 U
Soil Borings Split Samples—Floyd|Snider April 2009									
1/14/2009	LAI-DP18	12–13	–	320	50 U	–	–	–	–
1/16/2009	LAI-PZ6	12.5–13.5	–	150	50 U	–	–	–	–
1/12/2009	LAI-DP8	11–12	–	33	50 U	–	–	–	–
1/14/2009	LAI-DP23	10.5–11.5	–	25 U	50 U	–	–	–	–
1/15/2009	LAI-PZ3	10.5–11.5	–	25 U	50 U	–	–	–	–
1/16/2009	LAI-PZ8	13–14	–	25 U	50 U	–	–	–	–
1/14/2009	LAI-PZ1	9–10	–	25 U	50 U	–	–	–	–
1/15/2009	LAI-PZ4	13.5–14.5	–	25 U	50 U	–	–	–	–
Test Pits and Shallow Investigation—Landau Associates, Inc. April 2009									
1/7/2009	TP1	5–6	3 U	–	–	0.03 U	0.06 U	0.06 U	0.2 U
1/7/2009	TP1	12.5–13	3(b)	–	–	**3.9**	0.1	0.3	0.2 U
1/7/2009	TP3	5–6	3 U	–	–	0.03 U	0.05 U	0.05 U	0.2 U
1/7/2009	TP3	13–13.5	3 U	–	–	**0.7**	0.05 U	0.05 U	0.2 U
1/7/2009	TP4	5–6	3 U	–	–	0.03 U	0.05 U	0.05 U	0.2 U
1/7/2009	TP4	11–12	3 U	–	–	**3**	0.07	0.06	0.2 U
1/7/2009	HB1	1.5–2	4(e)	–	–	0.03 U	0.05 U	0.05 U	0.2 U
1/7/2009	HB2	1.5–2	3 U	–	–	0.03 U	0.05 U	0.05 U	0.2 U
1/7/2009	HB3	0.5–1.5	16(c)	–	–	0.03 U	0.05 U	0.05 U	0.2 U
1/7/2009	HB3	1.5–2	3 U	–	–	0.03 U	0.05 U	0.05 U	0.2 U
1/7/2009	HB4	1.5–2	3 U	–	–	0.03 U	0.05 U	0.05 U	0.2 U
1/7/2009	Catch Basin	–	3 U	–	–	0.04 U	0.06 U	0.06 U	0.2 U
Geoprobes—Landau Associates, Inc. April 2009									
1/12/2009	B1	5–6	3 U	–	–	0.03 U	0.05 U	0.05 U	0.2 U

Date	Sample Location	Depth (feet)	TPH-G[1] (mg/kg)	TPH-D[2] (mg/kg)	TPH-Oil[2] (mg/kg)	Benzene[3] (mg/kg)	Toluene[3] (mg/kg)	Ethylbenzene[3] (mg/kg)	Total Xylenes[3] (mg/kg)
		MTCA Method A	**30**	**2,000**	**2,000**	**0.03**	**7**	**6**	**9**
Geoprobes—Landau Associates, Inc. April 2009 (continued)									
1/12/2009	B1	11.5–12.5	**2,200**(b)	–	–	0.03 U	6.7	**8.1**	8.7
1/12/2009	B2	5–6	3 U	–	–	0.03 U	0.05 U	0.05 U	0.2 U
1/12/2009	B2	11–12	**140 U**(i)	–	–	0.03 U	0.06	0.4	0.6
1/12/2009	B3	5–6	3 U	–	–	0.03 U	0.05 U	0.05 U	0.2 U
1/12/2009	B3	11–12	**330 U**(i)	–	–	0.03 U	0.9	3.2	3.5
1/12/2009	B4	5–6	3 U	–	–	0.03 U	0.05 U	0.05 U	0.2 U
1/12/2009	B4	11–12	**1,500**(b)	–	–	0.03 U	5 U	5 U	7.1
1/12/2009	B5	5–6	3 U	–	–	0.03 U	0.05 U	0.05 U	0.2 U
1/12/2009	B5	9–10	3 U	–	–	0.03 U	0.05 U	0.05 U	0.2 U
1/13/2009	B6	5–6	6(e)	–	–	0.03 U	0.05 U	0.05 U	0.2 U
1/13/2009	B6	11–12	3 U	–	–	0.03 U	0.05 U	0.05 U	0.2 U
1/12/2009	B7	5–6	3 U	–	–	0.03 U	0.05 U	0.05 U	0.2 U
1/12/2009	B7	11–12	6(b)	–	–	**0.04**	0.05 U	0.05 U	0.2 U
1/12/2009	B8	5–6	3 U	–	–	0.03 U	0.05 U	0.05 U	0.2 U
1/12/2009	B8	10–11	**830(b)**	–	–	**2.6 J**	3.6 J	5.1 J	3.9 J
1/12/2009	B8	11–12	5 U(i)	–	–	**1.2**	0.05 U	0.07	0.2 U
1/12/2009	B9	5–6	16(b)	–	–	**0.03**	0.05 U	0.1	0.2 U
1/12/2009	B9	10–11.5	**660**(d)	–	–	0.03 U	0.8	1.8	1.7
1/12/2009	B10	5–6	3(e)	–	–	0.03 U	0.05 U	0.05 U	0.2 U
1/12/2009	B10	10.5–11.5	3 U	–	–	0.03 U	0.05 U	0.05 U	0.2 U
1/13/2009	B11	5–6	12(g)	–	–	0.03 U	0.05 U	0.05 U	0.2 U
1/13/2009	B11	10–11	3 U	–	–	0.03 U	0.05 U	0.05 U	0.2 U
1/13/2009	B12	5–6	3 U	–	–	0.03 U	0.05 U	0.05 U	0.2 U
1/13/2009	B12	10.5–11.5	3 U	–	–	0.03 U	0.05 U	0.05 U	0.2 U
1/13/2009	B13	5–6	3 U	–	–	0.03 U	0.05 U	0.05 U	0.2 U
1/13/2009	B13	11.5–12.5	3 U	–	–	0.04 U	0.06 U	0.06 U	0.2 U
1/13/2009	B14	5–6	3 U	–	–	0.03 U	0.05 U	0.05 U	0.2 U
1/13/2009	B14	10.5–11.5	3 U	–	–	0.03 UJ	0.05 UJ	0.05 UJ	0.2 UJ
1/13/2009	B15	5.5–6.5(a)	3 U	–	–	0.03 U	0.05 U	0.05 U	0.2 U
1/13/2009	B15	12–13(a)	8(b)	–	–	0.06	0.05 U	0.4	0.2 U
1/13/2009	B16	5.5–6.5(a)	**1,300**(b),(h)	–	–	**24**	4.1	**6.9**	40
1/13/2009	B16	15.5–16.5(a)	**480**(b)	–	–	**17**	2.9	**9.1**	26
1/13/2009	B17	5.5–6.5(a)	8(b)	–	–	**0.5**	0.08	0.3	0.5
1/13/2009	B17	12–13(a)	3 U	–	–	**0.1**	0.05 U	0.1	0.2 U
1/14/2009	B18	5.5–6.5(a)	3 U	–	–	**0.04**	0.05 U	0.05	0.2 U
1/14/2009	B18	12–13(a)	**690**(b)	–	–	**2.6**	1.3	**17**	2.8
1/13/2009	B19	5–6	3 U	–	–	0.03 U	0.05 U	0.05 U	0.2 U
1/13/2009	B19	10.5–11.5	3 U	–	–	0.03 U	0.05 U	0.05 U	0.2 U
1/14/2009	B20	9–10(a)	**200**(b)	–	–	0.12 U	0.2 U	4.0	3.1
1/14/2009	B21	9–9.5(a)	3 U	–	–	0.03 U	0.06 U	0.06 U	0.2 U
1/14/2009	B21	14–14.5(a)	**2,000(b)**	–	–	**18**	5.9	**99**	**19**
1/15/2009	B22	5.5–6.5	3 U	–	–	0.03 U	0.05 U	0.05 U	0.2 U
1/15/2009	B22	10.5 – 11.5	3 U	–	–	0.03 U	0.05 U	0.05 U	0.2 U
1/14/2009	B23	11.5–12.5(a)	15(b)	–	–	**0.4**	0.2	0.8	0.8
1/14/2009	B24	7.5–8.5(a)	3 U	–	–	0.03 U	0.05 U	0.05 U	0.2 U
1/14/2009	B24	13.5–14.5(a)	3 U	–	–	0.03 U	0.05 U	0.06	0.2 U
1/13/2009	B25	5–6	3 U	–	–	0.03 U	0.05 U	0.05 U	0.2 U
1/13/2009	B25	10–10.25	3 U	–	–	0.03 U	0.05 U	0.05 U	0.2 U
1/13/2009	B26	5–6	3 U	–	–	0.03 U	0.05 U	0.05 U	0.2 U
1/13/2009	B26	10–11	3 U	–	–	0.03 U	0.05 U	0.05 U	0.2 U
1/14/2009	PZ-1	5–6	4 U	–	–	**0.09**	0.08 U	0.08 U	0.2 U
1/14/2009	PZ-1	9–10	3 U	–	–	0.03 U	0.05 U	0.05 U	0.2 U
1/14/2009	PZ-2	5–6	3 U	–	–	0.03 U	0.05 U	0.05 U	0.2 U
1/14/2009	PZ-2	8.5–9.5	3 U	–	–	0.03 U	0.05 U	0.05 U	0.2 U
1/15/2009	PZ-3	5–6	3 U	–	–	0.03 U	0.05 U	0.05 U	0.2 U
1/15/2009	PZ-3	10.5–11.5	3 U	–	–	**0.4**	0.05 U	0.05 U	0.2 U
1/15/2009	PZ-4	5–6(a)	7.5(f)	–	–	**0.7**	0.05	0.1	0.2 U
1/15/2009	PZ-4	13.5–14.5(a)	3.8(c)	–	–	**0.1**	0.05 U	0.05 U	0.2 U
1/16/2009	PZ-6	10–11(a)	**3,700**(b)	–	–	**9.3**	**57**	**63**	**370**
1/16/2009	PZ-6	12.5–13.5(a)	**150**(b)	–	–	**6.4**	2.7	3.8	**19**
1/15/2009	PZ-7	5.5–6.5(a)	3 U	–	–	0.03 U	0.05 U	0.05 U	0.2 U
1/15/2009	PZ-7	13.5–14.5(a)	10(b)	–	–	0.03 U	0.05	0.3	0.3
1/16/2009	PZ-8	9.5–10.5(a)	3 U	–	–	0.03 UJ	0.05 UJ	0.05 UJ	0.2 UJ
1/16/2009	PZ-8	13–14(a)	**400**(b)	–	–	**3.2**	**15**	**11**	**63**
1/15/2009	PZ-9	5–6	3 U	–	–	0.03 U	0.06 U	0.06 U	0.2 U
1/15/2009	PZ-9	10–11	3 U	–	–	**1.7**	0.05 U	0.05 U	0.2 U
1/15/2009	PZ-10	5–6	3 U	–	–	0.03 UJ	0.05 UJ	0.05 UJ	0.2 UJ
1/15/2009	PZ-10	10–11	3 U	–	–	0.03 U	0.05 U	0.05 U	0.2 U
1/15/2009	PZ-11	5–6	3 U	–	–	0.03 U	0.05 U	0.05 U	0.2 U
1/15/2009	PZ-11	9–10	3 U	–	–	0.03 U	0.05 U	0.05 U	0.2 U

Date	Sample Location	Depth (feet)	TPH-G[1] (mg/kg)	TPH-D[2] (mg/kg)	TPH-Oil[2] (mg/kg)	Benzene[3] (mg/kg)	Toluene[3] (mg/kg)	Ethylbenzene[3] (mg/kg)	Total Xylenes[3] (mg/kg)
		MTCA Method A	**30**	**2,000**	**2,000**	**0.03**	**7**	**6**	**9**
Geoprobes—Landau Associates, Inc. April 2009 (continued)									
1/15/2009	PZ-12	5–6	3 U	–	–	0.03 U	0.05 U	0.05 U	0.2 U
1/15/2009	PZ-12	9–10	3 U	–	–	**0.1**	0.05 U	0.05 U	0.2 U
1/15/2009	PZ-13	5–6	3 U	–	–	0.03 U	0.05 U	0.05 U	0.2 U
1/15/2009	PZ-13	9–10	3 U	–	–	0.03 U	0.05 U	0.05 U	0.2 U

Notes:

Samples analyzed for gasoline-range total petroleum hydrocarbons (TPH-G) by NWTPH-Gx and benzene, toluene, ethylbenzene, and xylenes (BTEX) by USEPA 8021B were collected using field preservation method USEPA 5030. Samples analyzed for diesel-range total petroleum hydrocarbons (TPH-D) by NWTPH-Dx were collected with silica gel cleanup.

– Not analyzed.
BOLD Value above MTCA Cleanup Criteria.
1 NWTPH-Gx.
2 NWTPH-Dx.
3 USEPA Method 8021B.
4 Unhomogenized blind field duplicate.
5 SB-101 collected from location of Boring SB-66 advanced in October 2005.
(a) Sample depth measured from elevated floor surface (approximately 4.5 feet higher than surrounding ground surface outside building).
(b) Chromatogram indicates sample contains product which is likely weathered gasoline.
(c) Chromatogram indicates sample contains product which is likely highly weathered gasoline.
(d) Chromatogram indicates sample contains product which is likely extremely weathered gasoline.
(e) Chromatogram indicates sample contains unidentified gasoline-range product.
(f) Chromatogram indicates sample contains product which is likely aviation gasoline-range product.
(g) Volatile range result due to individual peaks.
(h) Volatile range result biased high due to semivolatile-range overlap.
(i) TPH-G reporting limit raised due to semivolatile-range product overlap.

Abbreviation:
ND Not detected

Qualifiers:
E Hydrocarbons in diesel range do not have a distinct diesel pattern, and may be heavily weathered per the laboratory. Validity of data cannot be verified by surrogate recovery as dilution of the sample has resulted in poor surrogate recovery that does not provide useful information.
J Indicates the analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample.
R Reanalysis following BTEX quality control or calibration range exceedance.
U Indicates the compound was undetected at the reported concentration.
UJ The analyte was not detected in the sample; the reported sample reporting limit is an estimate.

Table 4.3
Groundwater Analytical Results from Discrete-depth Push-probe Sampling

Date	Location	Depth of Screened Interval (feet bgs)	TPH-G[1] (µg/L)	TPH-D[2] (µg/L)	Benzene[3] (µg/L)	Toluene[3] (µg/L)	Ethyl-benzene[3] (µg/L)	Total Xylenes[3] (µg/L)	Benzene[4] (µg/L)	Naptha-lene[4] (µg/L)	Formalde-hyde[5] (µg/L)
October 2005											
10/5/05	SB-60	11–15	**4,940**	–	**129**	–	–	–	–	–	–
10/5/05	SB-62	11–15	**134**	–	ND	–	–	–	–	–	–
10/4/05	SB-64	11–15	ND	–	ND R	–	–	–	–	–	–
10/4/05	SB-66	11–15	**2,030**	–	**1,010 R**	–	–	–	–	–	–
10/4/05	SB-68	11–15	**1,710**	–	**915 R**	–	–	–	–	–	–
10/4/05	SB-69	11–15	ND	–	ND	–	–	–	–	–	–
10/5/05	SB-70	11–15	ND	–	ND	–	–	–	–	–	–
10/5/05	SB-70	16–20	ND	–	ND	–	–	–	–	–	–
10/5/05	SB-70	21–25	ND	–	ND	–	–	–	–	–	–
10/5/05	SB-70	26–30	ND	–	ND	–	–	–	–	–	–
10/6/05	SB-72	11–15	**2,540**	–	**574**	–	–	–	–	–	–
10/6/05	SB-72	16–20	**140**	–	**2.62**	–	–	–	–	–	–
10/6/05	SB-72	21–25	**147**	–	**0.864**	–	–	–	–	–	–
10/6/05	SB-72	26–30	ND	–	ND	–	–	–	–	–	–
10/6/05	SB-72	31–35	ND	–	ND R	–	–	–	–	–	–
10/6/05	SB-72	36–40	ND	–	ND	–	–	–	–	–	–
10/6/05	SB-74	11–15	**3,000**	–	**80.1**	–	–	–	–	–	–
10/6/05	SB-74	16–20	**1,060**	–	**11.2**	–	–	–	–	–	–
10/6/05	SB-74	21–25	**414**	–	**2.76**	–	–	–	–	–	–
10/6/05	SB-74	26–30	**190**	–	ND	–	–	–	–	–	–
10/6/05	SB-76	11–15	**519**	–	**17.8**	–	–	–	–	–	–
10/6/05	SB-76	16–20	**299**	–	**0.695**	–	–	–	–	–	–
10/6/05	SB-76	21–25	**164**	–	ND R	–	–	–	–	–	–
10/6/05	SB-76	26–30	**214**	–	ND	–	–	–	–	–	–
10/5/05	SB-80	11–15	**186**	–	**5.90 R**	–	–	–	–	–	–
10/5/05	SB-82	11–15	ND	–	ND	–	–	–	–	–	–
10/5/05	SB-84	11–15	ND	–	ND	–	–	–	–	–	–
10/5/05	SB-90	11–15	**949**	–	**9.73**	–	–	–	–	–	–
10/4/05	SB-91	11–15	**2,490**	–	**2.40 R**	–	–	–	–	–	–
10/6/05	SB-92	11–15	**281**	–	ND R	–	–	–	–	–	–
10/4/05	SB-93	11–15	**437**	–	**2.09 R**	–	–	–	–	–	–
10/4/05	SB-94	11–15	ND	–	ND	–	–	–	–	–	–
10/4/05	SB-95	11–15	ND	–	ND	–	–	–	–	–	–
10/4/05	SB-96	11–15	**2,890**	–	ND R	–	–	–	–	–	–
10/4/05	SB-97	11–15	**2,750**	–	ND R	–	–	–	–	–	–
10/4/05	SB-97 Dup[6]	11–15	**1,670**	–	ND R	–	–	–	–	–	–
10/4/05	SB-98	11–15	ND	–	ND	–	–	–	–	–	–
10/4/05	SB-99	11–15	ND	–	ND	–	–	–	–	–	–
November–December 2005											
11/30/05	SB-68	16–20	–	–	**5.49**	ND	ND	ND	–	ND	–
11/30/05	SB-105	12–16	–	–	**1,130**	ND	ND	ND	–	ND	–
11/30/05	SB-106	12–16	–	–	ND	ND	ND	ND	–	ND	–
12/1/05	SB-107	11–15	–	–	**1,260**	**12**	ND	ND	–	ND	–
12/1/05	SB-108	11–15	–	–	**3,160**	**62.6 R**	**121**	**100.9**	–	**11.8**	–
12/1/05	SB-109	11–15	–	–	**2,260**	**65.2**	**40.6**	**66**	–	ND	–
12/1/05	SB 110	11–15	–	–	**1,700**	**57.2**	**36.4**	**49.4**	–	ND	–
12/1/05	SB-111	11–15	–	–	**117**	**2.05**	ND	**2.54**	–	ND	–
12/1/05	SB-112	11–15	–	–	**98.8**	**1.15**	ND	**2.09**	–	ND	–
12/1/05	SB-113	11–15	–	–	**2.19**	ND	ND	ND	–	ND	–
12/2/05	SB-114	11–15	–	–	**160**	ND	ND	ND	–	ND	–
12/2/05	SB-115	11–15	–	–	**189**	**3.84**	ND	**7.78**	–	ND	–
12/2/05	SB-116	11–15	–	–	**946**	**25.7**	**21.3**	**32.5**	–	ND	–
12/2/05	SB-117	11–15	–	–	**3,710**	**119**	**330**	**114**	–	ND	–
May 2006											
5/30/06	SB-201	12–16	**113**	–	**41.9**	< 0.05	< 0.05	< 1.0	–	–	–
5/30/06	SB-202	12–16	< 50	–	**1.65**	< 0.05	< 0.05	< 1.0	–	–	–
5/30/06	SB-203	12–16	< 50	–	< 0.05	< 0.05	< 0.05	< 1.0	–	–	–

Date	Location	Depth of Screened Interval (feet bgs)	TPH-G[1] (µg/L)	TPH-D[2] (µg/L)	Benzene[3] (µg/L)	Toluene[3] (µg/L)	Ethyl-benzene[3] (µg/L)	Total Xylenes[3] (µg/L)	Benzene[4] (µg/L)	Naphtha-lene[4] (µg/L)	Formalde-hyde[5] (µg/L)
May 2006 (continued)											
5/30/06	SB-203 DUP	12–16	< 50	–	< 0.05	< 0.05	< 0.05	< 1.0	–	–	–
5/30/06	SB-204	12–16	< 50	–	< 0.05	< 0.05	< 0.05	< 1.0	–	–	–
5/30/06	SB-205	12–16	< 50	–	< 0.05	< 0.05	< 0.05	< 1.0	–	–	–
5/30/06	SB-206	12–16	< 50	–	< 0.05	< 0.05	< 0.05	< 1.0	–	–	–
5/30/06	SB-207	12–16	< 50	–	< 0.05	< 0.05	< 0.05	< 1.0	–	–	–
5/30/06	SB-208	12–16	**1,550**	–	**9.32**	**1.7**	**27.4**	**3.54**	–	–	–
5/31/06	SB-209	12–16	**885**	–	**3.36**	**1.46**	< 0.05	< 1.0	< 0.05	**2.59**	< 50
5/31/06	EQP BLK	12–16	< 50	–	< 0.05	< 0.05	< 0.05	< 1.0	–	–	–
5/31/06	SB-210	12–16	**10,400**	**3,160**	**11**	**69.9**	**75.8**	**206**	**9.3**	**6,830**	< 50
5/31/06	SB-211	12–16	**3,650 B**	–	**5,850 R**	**23.5**	**2.32**	**22.9**	**6,210**	**112**	–
5/31/06	SB-212	12–16	**383**	–	**71.2**	**0.778**	< 0.05	**3.1**	–	–	–
5/31/06	SB-213	12–16	**7,840**	–	**2,370 R**	**92.6**	**311**	**121**	**2,860**	**247**	< 50
5/31/06	SB-214	12–16	**7,310 B**	–	**3,050 R**	**21.6**	**7.21**	< 1.0	**2,720**	**159**	< 50
5/31/06	SB-215	12–16	**3,570 B**	–	**4,540 R**	**13.2**	**2.8**	**1.42**	**4,950**	**124**	< 50
5/31/06	SB-216	12–16	**3,440 B**	–	**4,490 R**	**27**	**11.9**	**8.15**	**4,650**	**111**	-
5/31/06	SB-217	12–16	**12,400 B**	–	**5,480 R**	**25.1**	**15.5**	**10.6**	**5,080**	< 1.0	< 50
5/31/06	SB-218	12–16	**4,040 B**	–	**7,270 R**	**43.5**	**26.6**	**31.9**	–	–	–
5/31/06	SB-219	12–16	**16,000**	–	**7,190 R**	**73.5**	**172**	**102**	–	–	–
5/31/06	SB-220	12–16	**4,500**	–	**1,440 R**	**47.5**	**68.1**	**101**	–	–	–
5/31/06	SB-220 DUP[6]	12–16	**4,460**	–	**1,470 R**	**50**	**73**	**106**	–	–	–
5/31/06	SB-221	12–16	< 50	–	< 0.05	< 0.05	< 0.05	< 1.0	–	–	–
February 2008											
2/6/2008	FS-1	12–16	**1,940**	–	**141**	**73**	**10.9**	**21.8**	–	–	–
2/6/2008	FS-2	11–15	**484**	–	**24.2**	**0.969**	**1.04**	**3.15**	–	–	–
2/6/2008	FS-3	10–14	**1,920** J	–	**111**	**37.3 J**	**4.68 J**	**5.72 J**	–	–	–
2/7/2008	FS-4	10–14	**5,250**	–	**355**	**266**	**28.6**	**88**	–	–	–
2/6/2008	FS-6	11–15	**4,420**	–	**212**	**133**	**21.5**	**33.2**	–	–	–
2/5/2008	FS-7	12–16	**5,910**	–	**472**	**321**	**20.5**	**54.2**	–	–	–
2/5/2008	FS-11	12–16	**6,110**	–	**218**	**103**	**65**	**400**	–	–	–
2/4/2008	FS-16	12–16	**774**	–	**2.38**	**1.11**	**7.33**	**5.29**	–	–	–
2/7/2008	FS-22	10–14	**2,160**	–	**51**	**129**	**6.66**	**153**	–	–	–
2/4/2008	FS-25	12–16	**2,120**	–	**448**	**35.9**	**51.8**	**53**	–	–	–
2/7/2008	FS-26	12–16	**4,540**	–	**1160**	**45.9**	**64.1**	**101**	–	–	–
2/5/2008	FS-29	12–16	**10,800**	–	**449**	**485**	**27.7**	**461**	–	–	–
January 2009—Work Performed by Landau Associates											
1/12/2009	B1	10–15[7]	**2,300**(a)	–	1 U	**36 J**	**58 J**	**96 J**	–	–	–
1/12/2009	B2	10–15[7]	**1,200**(b),(c)	–	1 U	1 U	1 U	3 U	–	–	–
1/12/2009	B3	10–15[7]	**2,200**(b)	–	1 U	**2**	**13**	**20**	–	–	–
1/12/2009	B4	10–15[7]	**1,600**(b)	–	1 U	**1**	**17**	3 U	–	–	–
1/12/2009	B5	10–15[7]	50 U	–	1 U	1 U	1 U	3 U	–	–	–
1/13/2009	B6	10–15[7]	**130**(b)	–	1 U	1 U	1 U	3 U	–	–	–
1/12/2009	B7	10–15[7]	**960**(b)	–	**13**	**1**	**38**	3 U	–	–	–
1/12/2009	B8	10–15[7]	**1,300**(b)	–	**35**	**2**	**4**	3 U	–	–	–
1/12/2009	B9	10–15[7]	**1,200**(b)	–	**2**	**1**	**7**	**5**	–	–	–
1/12/2009	B10	10–15[7]	50 U	–	**6**	1 U	1 U	3 U	–	–	–
1/13/2009	B11	10–15[7]	50 U	–	1 U	1 U	1 U	3 U	–	–	–
1/13/2009	B12	10–15[7]	50 U	–	1 U	1 U	1 U	3 U	–	–	–
1/13/2009	B13	10–15[7]	50 U	–	1 U	1 U	1 U	3 U	–	–	–
1/13/2009	B14	10–15[7]	**110**(d)	–	1 U	1 U	1 U	3 U	–	–	–
1/13/2009	B15	10–15[7]	**1,900**(b)	–	**9,200**	**18**	**220**	**50**	–	–	–
1/13/2009	B16	10–15[7]	**1,300**(b)	–	**3,900**	**120**	**110**	**18**	–	–	–
1/13/2009	B17	10–15[7]	**1,500**(b)	–	**4,400**	**15**	**140**	**46**	–	–	–
1/14/2009	B18	10–15[7]	**8,600**(b)	–	**1,300**	**54**	**1,400**	**100**	–	–	–
1/13/2009	B19	10–15[7]	50 U	–	1 U	1 U	1 U	3 U	–	–	–
1/14/2009	B20	10–15[7]	**1,500**(b)	–	**14**	**1**	**23**	**13**	–	–	–
1/14/2009	B21	10–15[7]	**6,900**(b)	–	**630**	**160**	**900**	**400**	–	–	–
1/15/2009	B22	10–15[7]	50 U	–	1 U	1 U	1 U	3 U	–	–	–
1/14/2009	B23	10–15[7]	**5,500**(b)	–	**7,000**	**160**	**720**	**270**	–	–	–
1/14/2009	B24	10–15[7]	**6,400**(b)	–	**3,600**	**210**	**910**	**540**	–	–	–
1/13/2009	B25	10–15[7]	**490**(e)	–	**2,400**	**60**	**28**	**50**	–	–	–

Date	Location	Depth of Screened Interval (feet bgs)	TPH-G[1] (µg/L)	TPH-D[2] (µg/L)	Benzene[3] (µg/L)	Toluene[3] (µg/L)	Ethyl-benzene[3] (µg/L)	Total Xylenes[3] (µg/L)	Benzene[4] (µg/L)	Naptha-lene[4] (µg/L)	Formalde-hyde[5] (µg/L)
January 2009—Work Performed by Landau Associates (continued)											
1/13/2009	B26	10–15[7]	**110**(d)	–	**30**	1 U	1 U	3 U	–	–	–
1/14/2009	PZ-1	10–15[7]	**88**(b)	–	**8**	1 U	1 U	3 U	–	–	–
1/14/2009	PZ-2	10–15[7]	**5,800**(b)	–	**1,600**	**29**	**180**	**34**	–	–	–
1/15/2009	PZ-3	10–15[7]	**220**(b)	–	**5,600**	**5**	**2**	**10**	–	–	–
1/15/2009	PZ-4	10–15[7]	**5,500**(b)	–	**1,300**	**18**	**790**	**65**	–	–	–
1/15/2009	PZ-5	10–15[7]	50 U	–	1 U	1 U	1 U	3 U	–	–	–
1/16/2009	PZ-6	10–15[7]	**53,000**(b)	–	**11,000**	**9,600**	**1,200**	**7,500**	–	–	–
1/15/2009	PZ-7	10–15[7]	**6,400**(b)	–	**240**	**25**	**980**	**100**	–	–	–
1/16/2009	PZ-8	10–15[7]	**3,500**(b)	–	**270**	**100**	**290**	**400**	–	–	–
1/15/2009	PZ-9	10–15[7]	**230**(b)	–	**760**	**14**	**25**	**19**	–	–	–
1/15/2009	PZ-10	10–15[7]	**1,200**(b)	–	**500**	**3**	**5**	**7**	–	–	–
1/15/2009	PZ-11	10–15[7]	**2,100**(b)	–	**1,300**	**93**	**330**	**130**	–	–	–
1/15/2009	PZ-12	10–15[7]	**150**(b)	–	**1,100**	**28**	**6**	**12**	–	–	–
1/15/2009	PZ-13	10–15[7]	50 U	–	**5**	1 U	1 U	3 U	–	–	–

Notes:

BOLD Indicates detected value.
1 Samples were analyzed for gasoline-range total petroleum hydrocarbons (TPH-G) by NWTPH-Gx.
2 Samples were analyzed for diesel-range total petroleum hydrocarbons (TPH-D) by NWTPH-Dx.
3 Samples were analyzed for benzene, toluene, ethylbenzene, xylenes (BTEX) by USEPA Method 8021B.
4 Samples were analyzed for volatile organic compounds (VOCs) by USEPA Method 8260.
5 Samples were analyzed for formaldehyde by USEPA Method 8315A.
6 Blind duplicate
7 Depth interval for direct-push probe samples collected by Landau Associates is approximate. Depths are measured relative to the ground surface outside the K-Ply Mill Building, even for borings advanced through the mill floor. Samples were reportedly collected from approximately 2 to 5 feet below the water table from a temporary 1-inch well screen.
(a) Chromatogram indicates sample contains product which is likely highly weathered gasoline.
(b) Chromatogram indicates sample contains product which is likely weathered gasoline.
(c) Volatile range result biased high due to semivolatile-range overlap.
(d) Chromatogram indicates sample contains aviation gasoline-range product.
(e) Chromatogram indicates sample contains product which is likely lightly weathered gasoline.

Qualifiers:

B The total hydrocarbon result in this sample is primarily the result of an individual compound, benzene, eluting in the volatile hydrocarbon range.
J Indicates the analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample.
ND Not detected.
Q Analyte had a low bias in the associated calibration standard.
R Reanalysis following BTEX calibration range exceedance.
U Indicates the compound was undetected at the reported concentration.
UJ The analyte was not detected in the sample; the reported sample reporting limit is an estimate.

Table 4.4
Groundwater Analytical Results from Monitoring Wells

Sampling Event	Monitoring Well	Screened Interval (feet bgs)	TPH-G^{1} (µg/L)	TPH-D^{2} (µg/L)	Benzene^{3} (µg/L)	Toluene^{3} (µg/L)	Ethyl-benzene^{3} (µg/L)	Total Xylenes^{3} (µg/L)
MTCA Method A			**800**	**500**	**5**	**1,000**	**700**	**1,000**
January 30–31, 2007	**Marine Trades Area Monitoring Wells**							
	MW-3	6–20	50 U	250 U	0.5 U	0.5 U	0.5 U	1.0 U
	MW-4	5–5	**4,700 A**	315 Q	**153**	89.4	353	122
	MW-4 Dup^{4}	5–15	**6,020 R**	301 Q	**161 R**	71.8	378 R	88.3
	MW-6	6–16	**1,350 A**	250 U	**9.43**	0.996	1.39	1.59
	MW-8	5–20	142 A	250 U	**32.5**	0.5 U	1.96	1.0 U
	MW-9	5–20	50 U	250 U	0.5 U	0.5 U	0.5 U	1.0 U
	MW-10	5–20	**4,440**	**667 Q**	**304**	18.8	274	103
	MW-12	5–20	**2,750 A**	250 U	**121 R**	30.4 R	211 R	102 R
	MW-13	5–20	50 U	250 U	0.5 U	0.5 U	0.5 U	1.0 U
	MW-14	5–20	50 U	250 U	0.5 U	0.5 U	0.5 U	1.0 U
	MW-20A	5–20	**2,340 A**	**899**	**204 R**	11.7 R	53.5 R	31.2 R
	MW-20B	5–20	50 U	294 U	0.5 U	0.5 U	0.5 U	1.0 U
	MW-21A	5–15	50 U	291 U	0.5 U	0.5 U	0.5 U	1.0 U
	MW-21B	20–25	50 U	275 U	0.5 U	0.5 U	0.5 U	1.0 U
	MW-22	5–5	50 U	272 U	0.5 U	0.5 U	0.5 U	1.0 U
	MW-23	20–25	50 U, A	236 U	0.5 U	0.5 U	0.5 U	1.0 U
	MW-24	5–15	50 U	298 U	0.5 U	0.5 U	0.5 U	1.0 U
	MW-24 Dup^{4}	5–15	50 U	305 U	0.5 U	0.5 U	0.5 U	1.0 U
	MW-25	5–15	**6,030 A**	294 U	**708 R**	111 R	102 R	158 R
	K-Ply Monitoring Wells							
	PP-7	8–13.2	**1,310 A**	**36,000**	3.11 R	1.24 R	0.678 R	1.99 R
	PP-13	10–15	50 U	250 U	0.635	0.5 U	0.5 U	1.0 U
	PP-15	7.5–12.5	**5,320**	253 U	**2,300 R**	2.72	2.5 U	5.0 U
	Pettit Oil Monitoring Wells							
	MW-1	2.5–7.5	48 U	**2,800**	0.5 U	0.5 U	0.5 U	0.5 U
	MW-2	1.5–6.5	97	**11,000**	0.5 U	0.5 U	0.5 U	0.5 U
	MW-4	1.5–7.5	**1,100**	**7,900**	2	0.7	0.5 U	1
	MW-5	3.5–19.5	**890**	**3,600**	3	1	0.5 U	2
	MW-6	4–19	390	**1,800**	**24**	0.8	0.5 U	0.8
May 7–8, 2007	**Marine Trades Area Monitoring Wells**							
	MW-3	6–20	50 U	240 U	0.5 U	0.5 U	0.5 U	1.0 U
	MW-4	5–15	**5,440**	308	**107**	68.3	294	87.0
	MW-6	6–16	**2,870**	240 U	**14.2**	1.78	2.78	2.84
	MW-8	5–20	192	236 U	2.01	0.5 U	0.5 U	1.0 U
	MW-9	5–20	59.6	243 U	0.5 U	0.5 U	0.5 U	1.0 U
	MW-10	5–20	**2,740**	485	**173**	18.9	167	78.3
	MW-12	5–20	**3,610**	287	**171**	38.7	324	150
	MW-12 Dup^{4}	5–20	**2,750**	267	**135**	31.5	250	119
	MW-13	5–20	50 U	236 U	0.5 U	0.5 U	0.5 U	1.0 U
	MW-14	5–20	50 U	240 U	0.5 U	0.5 U	0.5 U	1.0 U
	MW-14 Dup^{4}	5–20	50 U	240 U	0.5 U	0.5 U	0.5 U	1.0 U
	MW-20A	5–20	**1,860**	**509**	**162**	7.95	14.3	12.6
	MW-20B	5–20	50 U	238 U	0.5 U	0.5 U	0.5 U	1.0 U
	MW-21A	5–15	50 U	238 U	1.52	0.5 U	0.5 U	1.0 U
	MW-21B	20–25	50 U	240 U	0.5 U	0.5 U	0.5 U	1.0 U
	MW-22	5–5	50 U	236 U	0.5 U	0.5 U	0.5 U	1.0 U
	MW-23	20–25	50 U	236 U	0.5 U	0.5 U	0.5 U	1.0 U
	MW-24	5–15	50 U	240 U	0.5 U	0.5 U	0.5 U	1.0 U
	MW-25	5–15	**5,850**	240 U	**533**	105	171	145
	K-Ply Monitoring Wells							
	PP-7	8–13.2	**1,350**	**931**	**6.34**	1.54	0.720	1.87
	PP-13	10–15	61.2	238 U	**12.7**	0.5 U	0.5 U	1.0 U
	PP-15	7.5–12.5	**4,480 R**	238 U	**1,750**	2.5 U	2.5 U	2.5 U
	Pettit Oil Monitoring Wells							
	MW-1	2.5–7.5	310	**6,200**	0.5 U	0.5 U	0.5 U	1.5 U
	MW-2	1.5–6.5	50 U	**20,000**	0.5 U	0.5 U	0.5 U	1.5 U
	MW-4	1.5–7.5	**2,600**	**6,200**	5.0 U	1.0	1.7	3.9
	MW-5	3.5–19.5	**1,200**	**18,000**	2.4	1.5	1.1	3.5
	MW-6	4–19	660	**1,800**	**71**	2.7	0.9	2.9
February 1–8, 2008	**Marine Trades Area Monitoring Wells**							
	MW-3	6–20	50	253 U	0.5 U	0.5 U	0.5 U	1 U
	MW-4	5–15	**6,230**	–	154	96.6	297	117

Sampling Event	Monitoring Well	Screened Interval (feet bgs)	TPH-G^1 (μg/L)	TPH-D^2 (μg/L)	Benzene^3 (μg/L)	Toluene^3 (μg/L)	Ethyl-benzene^3 (μg/L)	Total Xylenes^3 (μg/L)
MTCA Method A			**800**	**500**	**5**	**1,000**	**700**	**1,000**
	MW-10	5–20	**2,460**	–	142	14.2	12.6	30.9
February 1–8, 2008	**Marine Trades Area Monitoring Wells (continued)**							
	MW-25	5–15	**4,940**	–	567	66.9	25.5	92.6
	MW-26	5–15	**1,270**	250 U	2.04	5.36	2.54	5.92
	MW-26A	5–15	**1,210**	240 U	2.02	6.14	2.62	6.06
	MW-27	5–20	**2,490**	248 U	125	19.6	4.04	35.1
	MW-28	5–15	114	250 U	4.51	0.5 U	0.5 U	1 U
	MW-29	5–15	**5,400**	420	184	38.6	314	309
	MW-30	5–15	**1,860**	356	63	6.12	26	15.9
	MW-31	5–15	**1,680**	266	36.2	1.23	24	4.4
	MW-32	5–15	**7,440**	399	751	43.6	396	475
	MW-33	5–17	**3,520**	313	82.6	24.2	146	43.7

Notes:
BOLD Value above MTCA Cleanup Criteria.
– Not analyzed.
1 Samples were analyzed for TPH-G by NWTPH-Gx.
2 Samples were analyzed for TPH-D by NWTPH-Dx (with silica gel cleanup).
3 Marine Trades Area, K-Ply, and Pettit Oil samples collected in May, 2007 were analyzed for benzene, toluene, ethylbenzene, and xylenes (BTEX) compounds by USEPA Method 8021B. The Pettit Oil samples collected in January 2007 were analyzed for BTEX compounds by USEPA Method 8260B.
4 Blind duplicate sample.

Abbreviations:
bgs Below ground surface
TPH-D Diesel-range petroleum hydrocarbons
TPH-G Gasoline-range petroleum hydrocarbons

Qualifiers:
A Amended result following reanalysis past method holding time. Refer to Data Validation Report in Appendix C.
Q Results in the diesel-organics range are primarily due to overlap from a gasoline-range product.
R Reanalysis for required dilution.
U Analyte was not detected at concentration greater than or equal to the reporting limit provided.

Table 4.5
Water Quality Parameters from Discrete-depth Push-probe Sampling at Bulkhead

Date	Soil Boring	Depth Interval (feet bgs)	Time	Tidal Elevation (feet MLLW)	pH (pH units)	Temperature (ºC)	Specific Conductivity (mS/cm)	TDS (g/L)	ORP (mV)
10/05/2006	SB-70	11–15	15:30	6.64	NM	16.71	31.3	19.0	-45
		16–20	15:45	6.57	7.61	16.91	3.28	2.1	-227
		21–25	16:00	6.37	8.13	14.93	2.17	1.4	-153
		26–30	16:36	5.94	8.73	15.59	2.32	1.5	-124
10/06/2006	SB-72	11–15	8:30	4.98	6.43	16.11	1.59	1.0	-86
		16–20	8:46	4.84	7.03	15.92	1.54	1.0	-128
		21–25	9:10	4.68	6.97	15.73	1.53	1.0	-113
		26–30	9:49	4.60	8.83	15.76	1.69	1.1	-181
		31–35	10:45	4.74	9.09	14.27	0.971	0.62	-46
		36–40	11:00	4.92	9.19	14.88	0.605	0.39	-16
	SB-74	11–15	12:25	5.91	7.20	16.60	23.0	14.0	-229
		16–20	12:45	6.17	7.23	16.43	2.15	1.3	-169
		21–25	13:05	6.33	7.45	15.67	1.22	0.8	-157
	SB-76	11–15	14:10	6.90	7.26	15.58	1.89	1.2	-136
		16–20	14:45	7.05	7.21	15.24	0.595	0.38	-145
		21–25	15:05	7.11	8.69	14.41	0.523	0.33	-146
		26–30	15:30	7.06	8.80	14.19	0.541	0.35	-149

Abbreviations:

bgs	Below ground surface
C	Celsius
g/L	Grams per liter
MLLW	Mean-low low water
mS/cm	Millisiemens/centimeter
mV	Millivolts
NM	Not measured
ORP	Oxidation-reduction potential
TDS	Total dissolved solid

Table 6.1
Proposed Soil Cleanup Levels

Contaminant of Concern	Maximum Detected Concentration[1] (mg/kg)	Protection of Groundwater	Direct Contact to Subsurface Soils	Proposed CUL[2] (mg/kg)
		MTCA Method A (mg/kg)	MTCA Method C Direct Contact (Ingestion) (mg/kg)	
Diesel-range petroleum hydrocarbons (TPH-D)	11,800	2,000	NA	2,000
Gasoline-range petroleum hydrocarbons (TPH-G)	7,260	30[3]	NA	30
Benzene	24	0.03	2,400	0.03
Ethylbenzene	99	6	350,000	6
Toluene	57	7	280,000	7
Xylenes	370	9	700,000	9

Notes:

1 Maximum detected value during Remedial Investigation.
2 Most conservative value.
3 Use this value when benzene is present in soil.

Abbreviations:

CUL	Cleanup level
MTCA	Model Toxics Control Act
NA	Not applicable

Table 6.2
Proposed Groundwater Cleanup Levels

Contaminant of Concern	Maximum Detected Concentration[1] (µg/L)	Lowest Promulgated Federal or State Water Quality Standard[2] (µg/L)	MTCA Method A Groundwater (µg/L)	Proposed Cleanup Level (µg/L)
Diesel-range petroleum hydrocarbons	20,000[3]	NA	500	500
Gasoline-range petroleum hydrocarbons	53,000	NA	800[4]	800
Benzene	11,000	51	5[5]	51

Notes:

1 Maximum detected value during Remedial Investigation.
2 Lowest of WAC 173-201A, National Toxics Rule, and National Recommended Water Quality Criteria.
3 36,000 µg/L was detected in PP-7 in January–February 2007. This result was not used as it was biased high due to the presence of free product in the sample.
4 Use this value when benzene is present in soil.
5 Based on groundwater consumption, which is not applicable to the MTA Site. The highest beneficial use of site groundwater is discharge to surface water.

Abbreviations:

MTCA Model Toxics Control Act
NA Not applicable

Table 7.1
Identification and Screening of Remedial Technologies

Remedial Action Objective	Implemented By	Technology Options	Description	Retained or Rejected
Bulkhead Cleanup Area				
1. Prevent contaminants of concern (COCs) in groundwater from discharging to surface water at concentrations greater than groundwater cleanup levels (CULs) protective of surface water.	Monitored natural attenuation (MNA) of groundwater.	MNA may be implemented as a stand-alone option or with enhancements to promote attenuation.	Regular groundwater sampling to monitor the results of one or more physical, chemical, or biological processes that reduce the mass, toxicity, volume, or concentration of contaminants in soil or groundwater. These in-situ processes include biodegradation; dispersion; dilution; sorption; volatilization; and chemical or biological stabilization, transformation, or destruction of contaminants.	**Rejected.** Benzene plumes are currently close to or at bulkhead, so MNA is not applicable as a standalone measure. Does not meet RAO of preventing contaminated groundwater from discharging to the Harbor within a reasonable restoration timeframe. Must be accompanied by source control under MTCA.
	Groundwater containment barrier at bulkhead.	Slurry wall or sheetpile wall at bulkhead	Subsurface containment barrier prevents discharge of benzene in shallow groundwater to harbor waters.	**Rejected as a stand-alone remedy.** **Retained in conjunction with groundwater recovery or in-situ treatment.** Considered a reliable, durable approach for containment. Needs to be augmented with in-situ treatment or active groundwater recovery to prevent COCs from migrating around or under barrier.
	In-situ groundwater treatment at bulkhead.	Permeable reactive barrier (PRB).	Reactive media promotes degradation and/or adsorption of benzene/TPH in groundwater in-situ as it travels through barrier.	**Rejected**. Unproven technology for BTEX and TPH, more developed for reductive dechlorination of halogenated VOCs. Considered potentially applicable when based on proven underlying technologies, such as adsorption using granulated activated carbon (GAC), or combined with air sparging to promote bioremediation. Full-scale barrier along bulkhead considered infeasible. Would require prohibitive periodic replacement.
		Funnel and gate PRB with treatment at gate.	Funnels groundwater to central gate, using wing walls and in-situ treatment at gate to treat benzene and TPH.	**Rejected.** Funnel and gate is a proven technology to capture contaminated groundwater. In-situ technology, however, is unproven and would require prohibitive periodic replacement,
		Air sparging or in-well stripping.	Injected air strips volatiles, flushes contaminants to the surface for extraction. Oxygen may enhance biodegradation. May need vapor extraction system to capture stripped volatiles.	**Retained.** Proven technology for VOCs and TPH-G. Limited effectiveness for TPH-D, which is not substantially greater than groundwater CULs. Implementability depends on site-specific factors, including soil heterogeneity.
		In-situ chemical oxidation.	Injection of oxidizing agents such as ozone, hydrogen peroxide, or permanganate to rapidly destroy benzene and TPH.	**Rejected as stand-alone remedy.** Though a proven technology for benzene, TPH-G, and TPH-D, is not suitable for a point-of-discharge “curtain” application. Success depends on matching the oxidant and in-situ delivery system to contaminant concentrations, and the site conditions, including natural oxidant demand and interference from saline water. In-situ chemical oxidation may be dangerous, because oxidants are corrosive and can explode under certain conditions. **Retained as a contingency.** In-situ chemical oxidation could be used as a temporary and focused contingency for recalcitrant areas in conjunction with other retained technologies, such as air sparging.

Remedial Action Objective	Implemented By	Technology Options	Description	Retained or Rejected
Bulkhead Cleanup Area (continued)				
1. Prevent COCs in groundwater from discharging to surface water at concentrations greater than groundwater CULs protective of surface water. (continued)	In-situ groundwater treatment at bulkhead. (continued)	Enhanced biodegradation.	Acceleration of the natural biodegradation process by providing nutrients, electron acceptors, and competent degrading microorganisms to degrade (metabolize) organic contaminants in groundwater. Typical enhancements include oxygen, nitrates, or solid phase peroxide products such as ORC.	**Rejected.** Proven technology for BTEX. Considered unlikely to be effective in achieving RAO as a point of compliance treatment at the bulkhead.
		Phytoremediation.	Plant-based processes to remove or destroy benzene and TPH that include enhanced rhizosphere biodegradation, hydraulic control, phyto-degradation and phyto-volatilization	**Rejected.** Unproven technology. Plants at bulkhead would be subject to salt water mixing zone. Could transfer contaminants across media.
	Groundwater recovery at bulkhead with treatment by standard ex-situ technologies (e.g., carbon adsorption, column air stripping) and/or discharge to POTW.	Interceptor trench.	Trench perpendicular to groundwater flow captures groundwater and conveys it by gravity or pumping to treatment system.	**Retained.** Standard technology that appears suited to site conditions and ensuring complete recovery of impacted groundwater.
		Groundwater extraction wells.	Pumping wells spaced at intervals to ensure sufficient capture zone for recovery along bulkhead.	**Retained.** Standard technology for groundwater recovery.
		Dual-phase extraction/bioslurping.	A high vacuum system removes various combinations of contaminated ground water, separate-phase petroleum product, and hydrocarbon vapor from the subsurface. Extracted liquids and vapor are treated and collected for disposal.	**Retained.** Proven remedy for petroleum hydrocarbons. Dual-phase recovery may not be needed to meet RAOs at the bulkhead, in which case groundwater extraction wells would be a more applicable technology.
		Interceptor swale with constructed wetlands.	Shallow groundwater is intercepted by swale connected to constructed wetlands, where microbial activity breaks down benzene and TPH that is filtered by organic soils, microbial fauna, algae, and vascular plants.	**Rejected.** Impractical to construct as a passive system due to depth of groundwater. Wetlands at interceptor swale would be subject to saline mixing zone and loss of efficiency due to temperature and flow rate changes.
	Hotspot source removal near bulkhead.	Excavation and disposal or on-site treatment with standard ex-situ soil technologies.	Excavation of areas of highly contaminated soil near bulkhead point of compliance, transport to appropriate landfill or on-site treatment cell.	**Rejected as stand-alone remedy.** Would not prevent benzene from discharging to harbor because plume originates upgradient of bulkhead. **Retained.** Excavation of contaminated soil is retained as a potential remedy component to increase the effectiveness and reduce the restoration timeframe of meeting RAO 1.
Upgradient Cleanup Area				
1. Prevent COCs in groundwater from discharging to surface water at concentrations greater than groundwater CULs protective of surface water.	Monitoring of contaminated soil through groundwater quality.	Monitoring may be implemented as a stand-alone option or with enhancements to promote attenuation.	Regular groundwater sampling to monitor natural biodegradation in soils resulting from one or more physical, chemical, or biological processes that reduce the mass, toxicity, volume, or concentration of contaminants in soil or groundwater. These in-situ processes include biodegradation; dispersion; dilution; sorption; volatilization; and chemical or biological stabilization, transformation, or destruction of contaminants.	**Retained in conjunction with other active remedial alternatives**. Site data indicate that natural processes have effectively reduced TPH concentrations in soil over time. Petroleum compounds typically break down in a predictable manner. Monitoring appears highly compatible with the widespread and often inaccessible soil contamination.
	In-situ soil treatment.	Enhanced biodegradation.	The activity of naturally occurring microbes is stimulated by circulating water-based solutions through contaminated soils, or mixing amendments using heavy equipment with in-situ soils to enhance *in-situ* biological degradation of organic contaminants. Nutrients, oxygen, or other amendments such as ORC may be used to enhance bioremediation and contaminant desorption from subsurface materials.	**Rejected.** Though this technology has been demonstrated to be effective for petroleum hydrocarbons and BTEX, accessibility and the widespread nature of soil contamination remain such significant obstacles that this technology is considered unsuitable.

Remedial Action Objective	Implemented By	Technology Options	Description	Retained or Rejected
Upgradient Cleanup Area (continued)				
1. Prevent COCs in groundwater from discharging to surface water at concentrations greater than groundwater CULs protective of surface water. (continued)	In-situ soil treatment. (continued)	Bioventing.	Bioventing stimulates the natural in-situ biodegradation of aerobically degradable compounds in soil by providing oxygen to existing soil microorganisms. In contrast to soil vapor vacuum extraction, bioventing uses low air flow rates to provide only enough oxygen to sustain microbial activity. Oxygen is most commonly supplied through direct air injection into residual contamination in soil. In addition to degradation of adsorbed fuel residuals, volatile compounds are biodegraded as vapors move slowly through biologically active soil.	**Rejected.** Although demonstrated effective for petroleum hydrocarbons, this technology is not effective for smear zone soil at or below the water table. It also requires high permeability soils, and can result in increased vapor accumulation in nearby buildings. Tidal fluctuations, accessibility and widespread nature of soil contamination are additional obstacles.
		Chemical oxidation.	Injection of oxidizing agents such as ozone, hydrogen peroxide, or permanganate to rapidly destroy TPH.	**Rejected.** Limited in effectiveness due to lack of appropriate in-situ delivery system for soils, especially as a large scale application. May result in soil off-gassing or decreased soil stability. In-situ chemical oxidation may be dangerous, because oxidants are corrosive and can explode under certain conditions. Accessibility and widespread nature of soil contamination are additional obstacles.
		Soil flushing.	Water, or water containing an additive to enhance contaminant solubility, is applied to the soil or injected into the ground water to raise the water table into the contaminated soil zone. Contaminants are leached into the ground water, which is then extracted and treated.	**Rejected.** Developing technology that is not well suited for TPH-contaminated soils. Requires injection of surfactants into subsurface that may cause additional impacts or adhere to soil and reduce porosity. May flush contaminants beyond capture zone. Requires highly permeable system. Requires extensive aboveground treatment system with significant waste stream. Accessibility and widespread nature of soil contamination are additional obstacles.
		Thermal Treatment.	In-situ thermal treatment uses electric current to heat soil to boiling point of water to volatilize organic pollutants. Water vapor and organic compounds that are volatized are captured by recovery wells using a SVE system and vapors treated in an off-gas treatment system.	**Rejected.** While thermal can be effective against gasoline range organics, there have been very few applications of the technology in waterfront settings where tidal fluctuations may cause excessive heat loss. Also, the technology is poorly suited to widespread areas of relatively thin and shallow smear zone contaminant.
		Soil vapor extraction (SVE; with or without air sparging) or in-well stripping.	Unsaturated zone soil remediation technology in which a vacuum is applied through extraction wells to the soil to induce the controlled flow of air and remove volatile and some semivolatile contaminants from the soil. The gas leaving the soil may be treated to recover or destroy the contaminants. May be enhanced with thermal treatment or air sparging, or combined with groundwater pumping to increase the effective depth of soil treatment.	**Rejected**. Would not be effective in the highly contaminated saturated smear zone soils. Accessibility and widespread nature of soil contamination are additional obstacles.
		Phytoremediation.	Phytoremediation uses plants to remove, transfer, stabilize, and destroy contaminants in soil and sediment. The mechanisms of phytoremediation include enhanced rhizosphere biodegradation, phyto-extraction (also called phyto-accumulation), phyto-degradation, and phyto-stabilization.	**Rejected.** Relatively unproven technology with limited applicability for site soils. Depth of treatment limited to upper few feet. Facility unsuitable for significant plant growth. Accessibility and widespread nature of contamination are additional obstacles.

Remedial Action Objective	Implemented By	Technology Options	Description	Retained or Rejected
Upgradient Cleanup Area (continued)				
1. Prevent COCs in groundwater from discharging to surface water at concentrations greater than groundwater CULs protective of surface water.	Source area removal.	Excavation of source area soils and disposal or on-site treatment with standard ex-situ soil technologies.	Excavation of areas of highly contaminated soil throughout the Upgradient CA, transport to appropriate landfill or on-site treatment cell.	**Retained for accessible source areas.** Removal of accessible areas of soil contamination, namely in the area north of Westport Marine, may effectively decrease the overall site restoration timeframe by reducing the volume of contaminated media causing continued dissolution from the remaining source material to the groundwater table.
	Source area containment.	Slurry wall or sheetpile wall and impermeable cap where appropriate.	Installation of one or more low-permeability barriers in the subsurface to isolate highly-contaminated soil source areas from groundwater flowing toward the bulkhead. Installation of an impermeable cap where needed to prevent infiltration and accumulated groundwater.	**Rejected.** Would not achieve RAO due to inaccessibility of large areas of contaminated soil and likely need for pumping to maintain hydraulic control. Widespread nature of contaminated soil makes containment impractical, and continued dissolution from remaining source areas makes partial containment ineffective.
	Capping.	Asphalt, concrete, or equivalent impervious ground cover.	Cover accessible areas of the site to prevent leaching from unsaturated zone contaminated soil by infiltration. May require upgrades to manage and direct newly-created stormwater.	**Retained.** Would decrease leaching of contaminants from vadose zone soils not already covered by buildings.
2. Prevent direct contact exposure by workers to subsurface soils with COC concentrations greater than CULs protective of the direct contact pathway.	Capping.	Asphalt, gravel, or similar.	Cover accessible areas of the site to prevent direct contact with contaminated soil.	**Rejected.** Would block pathway only to direct contact with surface soils. Would not address the RAO due to risk from trenching through capped areas.
	Institutional controls.	Signage, fencing, and other use restrictions.	Implement physical barriers and institutional rules concerning site usage, including trenching by utility workers, to prevent exposure to areas of contamination.	**Retained.** Would address risks from exposure to subsurface soils by requiring safety precautions or other measures.
	Soil removal.	Excavation of accessible contaminated soils and disposal or on-site treatment with standard ex-situ soil technologies.	Excavation of areas of highly contaminated soil throughout the Upgradient CA, transport to appropriate landfill or on-site treatment cell.	**Rejected.** Most of the remaining soil contamination is associated with the smear zone, making excavation very difficult. Impractical to achieve RAO due to widespread nature and large area of contaminated soil.
	In-situ soil treatment.	Use of one of several in-situ soil treatment technologies, such as enhanced biodegradation or soil vapor extraction.	Treat accessible contaminated soils to meet cleanup levels.	**Rejected.** Impractical to achieve RAO due to widespread nature and large area of contaminated soil.
3. Prevent inhalation exposure in buildings with underlying benzene soil contamination to indoor air with benzene concentrations greater than CULs.	Improved ventilation or equivalent mitigation.	Vents and fans or equivalent.	Improve the ventilation by installation of vents and fans to prevent accumulation of benzene at concentrations above cleanup levels.	**Retained.** Improved ventilation is a direct and appropriate measure to address the exposure risk in this setting.
	Vapor barrier.	PVC liner or equivalent.	Install a vapor barrier beneath the building to prevent migration of benzene from soil to indoor.	**Rejected for K-Ply.** Vapor barrier construction beneath the K-Ply mill is considered infeasible due to the construction of the mill, which includes a raised concrete slab over one area of elevated soil benzene. **Retained for potential future buildings**. As with Westport Marine, installation of a vapor barrier may be an effective precaution to close this potential exposure pathway.

Remedial Action Objective	Implemented By	Technology Options	Description	Retained or Rejected
Upgradient Cleanup Area (continued)				
3. Prevent inhalation exposure in buildings with underlying benzene soil contamination to indoor air with benzene concentrations greater than CULs. (continued)	Subslab vapor capture.	Soil Vapor Extraction.	SVE wells or lateral piping would capture unsaturated zone vapors prior to their migration into the building breathable air space.	**Rejected for K-Ply.** Sub-slab vapor capture construction beneath the K-Ply mill is considered infeasible due to the construction of the mill, which includes a raised concrete slab over one area of elevated soil benzene. **Retained for potential future buildings.** Standard technology for control of subsurface soil vapors under slabs and buildings.
	Soil remediation or excavation.	Excavation of contaminated soils and disposal or on-site treatment with standard ex-situ soil technologies, or use of one of several in-situ soil treatment technologies, such as enhanced biodegradation or soil vapor extraction.	Excavation of accessible areas of highly contaminated soil beneath the K-Ply Mill building, transport to appropriate landfill or on-site treatment cell, or treatment of accessible contaminated soils in-situ to meet cleanup levels protective of indoor air benzene concentrations.	**Rejected.** Excavation or soil remediation beneath the K-Ply mill is considered infeasible.
Pettit Oil Cleanup Area				
5. Remove, to the extent practicable, LNAPL accumulations on the water table.	Groundwater/product containment barrier.	Slurry wall or sheetpile wall.	Subsurface containment barrier only prevents further migration of free product or contaminated groundwater. Barrier may be augmented with product recovery such as skimming system or channeled to specific outlet for recovery.	**Rejected**. Product has already spread to its maximum extent and does not need containment to facilitate recovery.
	In-situ treatment of product.	In-situ chemical oxidation.	Injection of oxidizing agents such as ozone, hydrogen peroxide, or permanganate to rapidly destroy and TPH.	**Rejected.** Although a proven technology for TPH, this technology has little proven effectiveness in destruction of separate phase product. In-situ chemical oxidation may be dangerous, because oxidants are corrosive and can explode under certain conditions.
		Enhanced biodegradation.	Acceleration of the natural biodegradation process by providing nutrients, electron acceptors, and competent degrading microorganisms to degrade (metabolize) organic contaminants in groundwater. Typical enhancements include oxygen, nitrates, or solid phase peroxide products such as ORC.	**Rejected.** Although a proven technology for TPH, this technology has little proven effectiveness in rapid degradation of separate phase product and would not meet RAOs in a reasonable time frame.
	“Passive” product recovery (existing gradient).	Hand bailing or passive recovery inserts.	Product is lifted manually out of well with a bailer or absorbent inserts and collected in containers for disposal.	**Rejected for Pettit Oil.** Hand bailing has already been implemented at Pettit Oil with limited effect. The limited capture area of hand bailing and absorbent inserts is not an efficient recovery method for large accumulations of LNAPL. Would leave in place substantial residual product in soils at Pettit Oil. May not meet RAO in suitable restoration time frame. **Retained for PP-7 area.** These technologies appear to be suitable for this localized, intermittent accumulation of LNAPL.
		Skimming wells.	Multiple skimming wells recover product using a variety of means (floating skimmers, pneumatic pumps, mechanical belt skimmers, passive bailer/filter canisters, and passive absorbent bailers) with little groundwater recovery.	**Rejected.** Technology results in a high efficiency of product/water recovery, although the rate of recovery is generally very slow. Would leave in place residual product in soils. Unlikely to meet RAO in suitable restoration time frame.

Remedial Action Objective	Implemented By	Technology Options	Description	Retained or Rejected
Pettit Oil Cleanup Area (continued)				
5. Remove, to the extent practicable, LNAPL accumulations on the water table. (continued)	"Passive" product recovery (existing gradient). (continued)	Trench skimming.	Product is recovered from a series of wells contained within a trench constructed of coarser material and located to intercept groundwater and product flow.	**Rejected.** Highly efficient product/water recovery, but rate of recovery is generally slow since product migration into trench is controlled by natural gradient. Would leave in place residual product in soils. Unlikely to meet RAO in suitable restoration timeframe.
	"Active" product recovery (induced gradient).	Water table depression.	A cone of depression is created to induce a product gradient toward an extraction well, where both product and groundwater are recovered, using single- (combined) or dual-pump (separate) systems. Extracted liquids are treated and collected for disposal.	**Retained.** Proven and widely-utilized technology applicable to site conditions, flexible in operation, and suitable for meeting RAOs. Would leave in place residual product in soils.
		Vacuum enhanced recovery (VER).	Applies a vacuum to skimmer wells or induced water table gradient recovery wells to induce a larger potential gradient toward the recovery well through negative pressure, while minimizing the physical movement of the oil water interface. Extracts volatile hydrocarbons from the unsaturated zone and minimizes smearing from the cone of depression. Extracted liquids and vapor are treated and collected for disposal.	**Retained.** Proven and highly effective technology would meet RAOs in a relatively fast restoration timeframe. Would leave residual product in soils.
		Bioslurping.	Similar to VER but uses only one pump and a drop tube to recover vapor, oil, and water, and extracts product from the water table and the capillary fringe, allowing for removal of product with minimal depression of the water table. Vapor recovery remediates residual product in the unsaturated zone and enhances bioremediation. Extracted liquids and vapor are treated and collected for disposal.	**Retained.** Proven and highly effective technology would meet RAOs in a relatively fast restoration timeframe. Would leave residual product in soils.
	Source removal.	Excavation and off-site disposal or on-site treatment with standard ex-situ soil technologies.	Excavation of large area of contaminated soil and free product, transport to appropriate recycling facility or on-site treatment cell.	**Retained**. Proven technology to address residual product in soils.

Table 9.1
Bulkhead Cleanup Area Alternatives Evaluation and Disproportionate Cost Analysis

	Alternative B1: No Action	Alternative B2: Groundwater Recovery Wells and Ex-situ Treatment	Alternative B3: Air Sparge Curtain	Alternative B4: Barrier Wall with Active Interceptor Trench and Ex-situ Treatment
Alternative Description	The baseline alternative would involve no additional action at the Bulkhead Cleanup Area. This alternative would leave in place the status quo conditions, in which groundwater with elevated benzene and TPH concentrations may be discharging to Port Angeles Harbor surface water at concentrations above applicable cleanup levels.	This alternative would utilize a system of groundwater recovery wells to extract contaminated groundwater for treatment. The system would be designed to meet the RAO without drawing the plumes forward by induced gradient, or extracting excessive saline water or uncontaminated groundwater. Accommodating tidal variation would be an important factor in the design of the system. The system would target the MTA and K-Ply/Cedar Street plumes and span approximately 700 to 800 linear feet of shoreline. The recovery system would be designed to capture the upper 10 feet of groundwater. Extracted groundwater would be conveyed to either a new, on-site groundwater treatment facility or to a discharge point to the local sanitary sewer for treatment at the Port Angeles POTW. Groundwater treated on site would then either be discharged under a NPDES permit to Port Angeles Harbor, or discharged to the sanitary sewer under an industrial wastewater discharge permit. A barrier wall (e.g., a slurry wall) along the waterfront is considered a contingency for this alternative. If necessary, to achieve the RAO of preventing discharge of COCs to surface water, a barrier wall could be used to mitigate the effects of tidal variation on system operation, including unnecessary volume of extracted groundwater and increased maintenance. Compliance would be monitored in groundwater at the discharge point to Port Angeles Harbor.	This alternative consists of the use of air sparging to treat petroleum hydrocarbons in groundwater by stripping volatiles from the compounds and enhancing bioremediation as a means of preventing the potential discharge of groundwater with elevated COC concentrations. The system is likely to consist primarily of a treatment zone or "curtain" oriented approximately parallel to the shoreline and perpendicular to the direction of groundwater flow. Curtain sections would target the downgradient ends of the MTA and K-Ply/Cedar Street Plumes, and span approximately 700 to 800 feet of shoreline. The system would be designed to treat the upper 10 feet of groundwater where the contaminants are located. Air sparging is expected to remediate soil inside its radius of influence. Because air sparging increases the rate of contaminant volatilization, it increases the potential for migration of VOC-impacted vapor. An SVE system may need to be integrated into the air sparge system to mitigate vapor migration problems for health and safety reasons. Tidal variation, including the chemical effects of shallow saline mixing from Port Angeles Harbor into fresh groundwater, are not expected to be significant factors in the engineering of the air sparge curtain. If necessary, a hanging barrier wall could be added as a contingency measure following initial operations. The operation and maintenance requirements of air sparging are relatively minimal. The inclusion of an SVE system would increase the operation and maintenance effort required. Alternative B3 may include collection of additional design data prior to implementation. Compliance would be monitored in groundwater downgradient of the treatment system.	This alternative consists of a subsurface groundwater containment barrier, such as a slurry wall, combined with a trench to intercept and actively recover groundwater. Water would be treated prior to discharging to Port Angeles Harbor. The trench is expected to be able to be operated with minimal effects from tidal variation, because of dampening by the barrier wall. The system would span approximately 700 - 800 feet of shoreline downgradient of the MTA and K-Ply/Cedar Street Plumes. Extracted groundwater would be conveyed to either a new, on-site groundwater treatment facility or to a discharge point to the local sanitary sewer for treatment at the Port Angeles POTW. Groundwater treated on site would then either be discharged under a NPDES permit to Port Angeles Harbor, or discharged to the sanitary sewer under an industrial wastewater discharge permit. Compliance would be monitored in groundwater and the extracted water in the treatment train, including the discharge point to Port Angeles Harbor if applicable.

	Alternative B1: No Action	Alternative B2: Groundwater Recovery Wells and Ex-situ Treatment	Alternative B3: Air Sparge Curtain	Alternative B4: Barrier Wall with Active Interceptor Trench and Ex-situ Treatment
Overall Protectiveness - *Degree to which existing risks are reduced* - *Time required to reduce risks and attain cleanup standards* - *On- and Off-site risks resulting from alternative implementation* - *Improvement in overall environmental quality*	**LOW** Alternative 1 does not provide risk reduction, nor does it provide an improvement in overall environmental quality, as there are no remedial actions associated with Alternative B1. Groundwater with elevated COC concentrations may continue to discharge to Port Angeles Harbor. The timeframe required to reduce risk and attain cleanup standards is long, as the Alternative does not increase the existing rate of risk reduction through natural attenuation processes. No additional on-site or off-site risks are generated by implementation of Alternative B1, as no actions are included.	**HIGH** Alternative B2 provides a high degree of risk reduction and improvement in overall environmental quality, as implementation will result in attainment of RAO 1, by preventing contaminated groundwater from discharging to surface water shortly after installation. This level of protectiveness may depend on a contingent barrier wall at the bulkhead to mitigate engineering challenges from tidal effects. Under Alternative B2 the cleanup levels will be attained at the point of compliance (the bulkhead) shortly after installation and startup of the remedial system; however, Alternative B2 must continue to be operated until groundwater migrating to the bulkhead is less than cleanup levels.	**HIGH** Alternative B3 provides a high degree of risk reduction, and improvement in overall environmental quality, as implementation is expected to result in attainment of the RAO 1 by treating groundwater to within acceptable levels prior to discharge to the harbor at the point of compliance. There is a low probability that this level of protectiveness may depend on a contingent barrier wall at the bulkhead to contain COCs that might pass through the treatment zone at concentrations greater than cleanup levels. Under Alternative B3 the cleanup levels will be attained at the point of compliance (the bulkhead) shortly after installation and startup of the remedial system; however, Alternative B3 must continue to be operated until groundwater migrating to the bulkhead is less than cleanup levels. Due to the flexibility of the system, it may be feasible to achieve RAO 1 through partial operation as groundwater impacts attenuate over time.	**HIGH** Alternative B4 provides a high degree of risk reduction and improvement in overall environmental quality, as implementation will result in attainment of the Bulkhead Cleanup Area RAO 1, by preventing contaminated groundwater discharge to surface water shortly after installation. The timeframe associated with Alternative B4 is short, as the cleanup levels will be attained at the point of compliance (the bulkhead) shortly after installation and startup of the remedial system. However, Alternative B4 must continue to be operated until groundwater migrating to the bulkhead is below cleanup levels.
Permanence - *Degree of reduction of contaminant toxicity, mobility, and volume* - *Adequacy of destruction of hazardous substances* - *Reduction or elimination of substance releases, and source of release,* - *Degree of irreversibility of waste treatment processes* - *Volume and characteristics of generated treatment residuals*	**LOW** Alternative B1 does not immediately provide an increased level of permanence through reduction in contaminant toxicity, mobility or volume, as it relies on natural attenuation processes for contaminant destruction. Natural attenuation processes are irreversible, and over a period of time, will result in adequate and permanent destruction of hazardous substances. Alternative B1 does not provide reduction or elimination of contaminant source releases. There is no treatment residual associated with Alternative B1.	**LOW** Alternative B2, as with the other point-of-compliance alternatives evaluated for the Bulkhead Cleanup Area, will reduce contaminants discharged to surface water to below cleanup levels but will not be considered a permanent remedy until COCs in groundwater migrating to the recovery area at the bulkhead naturally degrade to be less than cleanup levels.	**LOW** Alternatives B3, as with the other point-of-compliance alternatives evaluated for the Bulkhead Cleanup Area, will achieve cleanup levels at the point of discharge to surface water but will not be considered a permanent remedy until COCs in groundwater migrating to the treatment area at the bulkhead naturally degrade to be less than cleanup levels. Alternative B3 would result in a greater reduction of contaminant volume through remediation of impacted soil within the radius of influence of the air sparge curtain, and establishment of a zone favorable to bioremediation.	**LOW** Alternative B4, as with the other point-of-compliance alternatives evaluated for the Bulkhead Cleanup Area, will achieve cleanup levels at the point of discharge to surface water but will not be considered a permanent remedy until COCs in groundwater migrating to the recovery area at the bulkhead naturally degrade to be less than cleanup levels.

	Alternative B1: No Action	Alternative B2: Groundwater Recovery Wells and Ex-situ Treatment	Alternative B3: Air Sparge Curtain	Alternative B4: Barrier Wall with Active Interceptor Trench and Ex-situ Treatment
Effectiveness over the Long-term - *Degree of certainty of alternative success* - *Reliability while contaminants remain onsite above cleanup levels* - *Magnitude of residual risk* - *Effectiveness of controls implemented to manage residual risk*	**LOW** Alternative B1 provides a low degree of certainty of success, and the No Action alternative is not expected to meet cleanup levels at the point of compliance within a reasonable timeframe. The alternative does not include actions for elimination of exposure pathways while contaminants remain onsite, nor does it provide any additional controls to manage residual risk. The magnitude of residual risk is high, as contaminants are not actively treated or reduced with this alternative, and the potential discharge of contaminated groundwater to the harbor at the bulkhead is not addressed.	**MODERATE** Alternative B2 is projected to have moderate effectiveness over the long term. The overall reliability and long-term certainty of success of the technology without the contingent barrier wall, is considered moderate due to the known maintenance and operational issues associated with groundwater recovery and ex-situ treatment. The degree of reliability would be improved by the addition of a barrier wall, because it would provide redundancy to containment. This moderate level of reliability applies for the duration of the remedy. The remedy will be operational while contaminants remain on-site at concentrations greater than the cleanup levels. Residual risk associated with Alternative B2 is low to moderate because the remedy is expected to prevent discharge of COCs to surface water with moderate reliability over the long term.	**HIGH** Alternative B3 is projected to have a high degree of long-term effectiveness. The certainty of success for Alternative B3 is high, as air sparging is considered a presumptive remedy for petroleum hydrocarbons in groundwater because of its well documented record of success over the long term. Air sparge components are simpler and less prone to failure than groundwater recovery components. Air sparging remediates soil within its radius of influence, providing a better long-term outcome than groundwater recovery, which usually results in repeated rebound. The air sparging curtain is also highly flexible in how it is operated, and sections can readily be decommissioned as groundwater compliance is achieved on an area-by-area basis. The remedy will be operational while contaminants remain on-site at concentrations greater than the cleanup levels. Residual risk associated with Alternative B3 is low because the remedy is expected to prevent discharge of COCs to surface water reliably over the long term.	**MODERATE-HIGH** Alternative B4 is projected to have a moderate to high degree of long-term effectiveness. The overall reliability and certainty of long-term success for Alternative B4 is moderate to high because, while the alternative includes redundant containment and is based on demonstrated and appropriate technologies, there are known maintenance and operational issues with groundwater recovery that reduce its reliability. The technologies are commonly used, based on blocking groundwater flow and intercepting excess shallow groundwater, and appropriate for site conditions. Inclusion of a barrier wall minimizes the engineering challenge associated with tidal variation, and provides for greater overall long-term reliability by adding redundancy. Overall reliability is reduced by the known maintenance and operational issues associated with groundwater recovery and ex-situ treatment. A moderate to high level of reliability applies for the duration of the remedy. The remedy will be operational while contaminants remain on-site at concentrations greater than the cleanup levels. Residual risk associated with this alternative is low as the remedy is expected to prevent discharge of COCs to surface water with moderate to high reliability over the long term.
Short-term Risk Management - *Risk to human health and the environment associated with alternative construction* - *The effectiveness of controls in place to manage short-term risks*	**HIGH** There are no short term risks associated with alternative construction, as there are no actions associated with this alternative.	**HIGH** Construction of Alternative B2 will involve a drilling of a number of extraction wells and excavation of shallow trenches. During this time, there is a potential for worker exposure to contaminated soil and groundwater. Contaminated soil removed from the site and transported offsite for treatment and/or disposal presents potential risks to workers that would readily be addressed by standard health and safety planning and procedures. The construction activities involved with installation of Alternative B2 are common, and not overly complex. Inclusion of a barrier wall increases the complexity of construction, though health and safety planning and procedures appropriate to the construction activities will likely be highly effective at managing these short-term risks.	**HIGH** Construction of Alternative B3 will involve installation of air sparge and monitoring wells and excavation of shallow trenches. During this time, there is a potential for worker exposure to contaminated soil and groundwater. Potential risks to workers that would readily be addressed by standard health and safety planning and procedures. . The construction activities involved with installation of Alternative B3 are common, and not overly complex. Inclusion of a barrier wall increases the complexity of construction, though health and safety planning and procedures appropriate to the construction activities will likely be highly effective at managing these short-term risks.	**MODERATE-HIGH** Construction of Alternative B4 will involve relatively deep trenching through contaminated soil in addition to well installation. There is a potential for worker injury and exposure to contaminated soil and groundwater during trench excavation and drilling. These risks, and potential risks to workers from removal and transportation of contaminated soil would readily be addressed by standard health and safety planning and procedures. The construction activities involved with Alternative B4 are slightly more complex than alternatives that do not include a deep trench or barrier wall, though they are not uncommon. Health and safety planning and procedures appropriate to the construction activities will likely be highly effective at managing these short-term risks.

	Alternative B1: No Action	**Alternative B2: Groundwater Recovery Wells and Ex-situ Treatment**	**Alternative B3: Air Sparge Curtain**	**Alternative B4: Barrier Wall with Active Interceptor Trench and Ex-situ Treatment**
Technical and Administrative Implementability • *Technical possibility* • *Availability of off-site facilities, services and materials* • *Administrative and Regulatory requirements* • *Schedule, size and complexity of construction* • *Monitoring requirements* • *Site access for construction, and operations and monitoring* • *Integration with existing site operations or other current and potential future remedial action*	**LOW** No actions are associated with Alternative B1.	**MODERATE** Alternative B2 is moderately implementable because of the interference with site operations from the well drilling and shallow trenching associated with the recovery well network. Construction is expected to last weeks and to partially block access to the bulkhead area, at times restricting the Port's use of Terminal 3 and Westport Marine's ability to move ships between its facility and the waterfront. Alternative B2 is readily implementable, technically. Construction is not complex, though construction of a barrier wall will increase the complexity and invasiveness of the construction activities. All necessary facilities, materials, and services are available, and no administrative or regulatory requirements are expected to impact implementation of the alternative. Due to the vicinity of the construction area near an open water body, Best Management Practices (BMPs) will be required to control migration of contaminants, and control erosion to the harbor.	**MODERATE** Alternative B3 is moderately implementable due to the interference with site operations from the well drilling and shallow trenching associated with the air sparge curtain. Construction is expected to last weeks and to partially block access to the bulkhead area, at times restricting the Port's use of Terminal 3 and Westport Marine's ability to move ships between its facility and the waterfront. Alternative B3 is readily implementable, technically. Construction is not complex, though construction of an SVE system and/or a barrier wall will increase the complexity and invasiveness of the construction activities. The alternative design must include consideration of subsurface utilities and pipelines located along the bulkhead, and throughout the area where trenching would take place and injection points would be installed. Necessary facilities, materials and services are locally, regionally, or nationally available. Due to the vicinity of the construction area near an open water body, Best Management Practices (BMPs) will be required to control migration of contaminants, and control erosion to the harbor.	**LOW-MODERATE** Alternative B4 is low-to-moderately-implementable due to the large interference with site operations from the intrusive nature and the long duration of construction of the long, deep interceptor trench and barrier wall. Construction is expected to last months and to block off access to the bulkhead area, in including the Port's use of Terminal 3 and Westport Marine's ability to move ships between its facility and the waterfront. Alternative B4 is readily implementable, technically. Construction activities are moderately complex due to the inclusion of a barrier wall, though not uncommon. Construction will need to work around subsurface utilities and pipelines located along the bulkhead. All necessary facilities, materials and services are available. Due to the vicinity of the construction area near an open water body, Best Management Practices (BMPs) will be required to control migration of contaminants, and control erosion to the harbor.
Consideration of Public Concerns • *Whether the community has concerns* • *Degree to which the alternative addresses those concerns*	Public concerns will be addressed following completion of the public comment period.	Public concerns will be addressed following completion of the public comment period.	Public concerns will be addressed following completion of the public comment period.	Public concerns will be addressed following completion of the public comment period.
Cost • *Cost of Construction* • *Long-term monitoring and O&M costs*	**B1:** Capital construction = $0 Annual O&M = $0	**B2:** Capital construction = $858,000 Annual O&M = $111,000 30-year present value total= $2,570,000	**B3:** Capital construction = $1,001,000 Annual O&M = $91,000 30-year present value total= $2,400,000	**B4:** Capital construction = $1,690,000 Annual O&M = $108,000 30-year present value total= $3,350,000
Time Frame Required to Attain RAO	30 years (estimated minimum)	RAO will be achieved within weeks of construction completion and startup. Operation will be required for decades (estimated 30 years minimum) until upgradient soil and groundwater attenuates to be less than cleanup levels.	RAO will be achieved within one year of construction completion and startup, with substantial decreases in COC concentrations occurring within weeks. Partial operation will be required for decades (estimated 30 years minimum) until upgradient soil and groundwater attenuates to be less than cleanup levels. Air sparging will remediate surrounding soil over time, reducing source mass, and may only require partial operation as areas of groundwater come into compliance.	RAO will be achieved immediately Following Construction Completion. Operation will be required for decades (estimated 30 years minimum) until upgradient soil and groundwater attenuates to be less than cleanup levels.

Table 9.2
Upgradient Cleanup Area Alternatives Evaluation and Disproportionate Cost Analysis

	Alternative U1: No Action	Alternative U2: Capping, Monitoring, and Institutional Controls	Alternative U3: Accessible Source Removal, Monitoring, and Institutional Controls
Alternative Description	The baseline alternative would involve no additional action at the Upgradient Cleanup Area. This alternative would leave in place the status quo conditions, in which widespread scattered areas of contaminated subsurface soil may be continuing to leach petroleum hydrocarbons into groundwater and posing potential risks to utility workers.	This alternative consists of • monitoring of groundwater to track the leaching of COCs from soil to groundwater, • construction of an impervious cap over the soil contamination north of Westport Marine to decrease leaching, • stormwater modifications to the K-Ply mill to decrease leaching, • institutional controls to protect workers from risks associated with subsurface soil contamination, • air sampling and analysis in the K-Ply mill, with subsequent potential mitigation efforts such as improved ventilation. Monitoring would consist of the installation of a small number of additional groundwater monitoring wells to ensure thorough site coverage, and quarterly or semi-annual groundwater monitoring events and reporting. The alternative would include a contingency plan to address unexpected increases in COC concentrations in groundwater. Institutional controls to protect workers from risks associated with subsurface contamination are expected to consist of a requirement that contractors or utility workers prepare a site-specific health and safety plan, or be subject to specific safety rules, training, or warnings prior to trenching or other subsurface work. An environmental covenant would be put in place to prohibit recovery of shallow groundwater and prevent exposure to contaminated soil.	This alternative consists of • removal of contaminated soil from the area of highly-elevated source soils accessible for excavation north of the Westport Marine building, • groundwater monitoring to ensure continued decreases in leaching of COCs from soil to groundwater, • stormwater modifications to the K-Ply mill to decrease leaching, • institutional controls to prevent exposure of workers to subsurface soil, • air sampling and analysis in the K-Ply mill with subsequent potential mitigation efforts such as improved ventilation. This alternative would remove approximately a third of the contaminated soil source of COCs to groundwater at the site. It would involve excavation of the entire area of contaminated soil identified north of Westport Marine, which is estimated to include approximately 11,000 cubic yards of contaminated soil. Contaminated soil would be excavated and loaded into trucks for transport to a recycling or disposal facility. Clean overburden would be stockpiled and reused for backfill. Excavation activities at the bulkhead may require partial demolition and reconstruction of the bulkhead lagging, rip-rap armoring, and dock connections. Utilities disrupted during soil removal activities must be relocated or replaced. Shoring and excavation dewatering may be necessary. The scale of the excavation would severely impact the operations of the Port, Westport Marine, and other tenants for several months.
Overall Protectiveness • *Degree to which existing risks are reduced* • *Time required to reduce risks and attain cleanup standards* • *On- and Off-site risks resulting from alternative implementation* • *Improvement in overall environmental quality*	**LOW** Alternative U1 would provide a low degree of overall protectiveness because it does not provide risk reduction, nor does it provide an improvement in overall environmental quality**.** The timeframe required to reduce risk and attain cleanup standards is long, as the alternative does not increase the existing rate of natural attenuation processes that reduce risks over time. No additional on-site or off-site risks are generated by implementation of Alternative U1, as no actions are included.	**MODERATE** Alternative U2 would provide a high degree of risk reduction for human contact with subsurface soil through elimination of exposure pathways and through institutional controls. Alternative U2 would only partially address the leaching pathway, by decreasing the leaching from vadose soil through capping and stormwater modifications to K-Ply, but would not reduce the mass of contamination leaching to groundwater in the saturated zone. The risks from the leaching pathway to surface water through groundwater, however, are addressed via the Bulkhead Cleanup Action. The time required to reduce risks through capping and institutional controls is minimal. A low degree of on-site and off-site risks would be generated by implementation of Alternative U2, associated with the construction of the impervious cap.	**MODERATE** Alternative U3 would provide a high degree of risk reduction for human contact with subsurface soil through elimination of exposure pathways and through institutional controls. Alternative U3 would address the leaching pathway by decreasing the leaching from vadose soil through capping and stormwater modifications to K-Ply. Alternative U3 would immediately reduce the leaching of COCs from soil through permanent removal of contaminated soil from accessible areas of the site. However, COCs will continue to leach from inaccessible areas with substantial volumes of contaminated soil upgradient of the excavation. The risks from the leaching pathway to surface water through groundwater are addressed via the Bulkhead Cleanup Action. The time required to reduce risks through source removal and institutional controls is minimal. A moderate degree of on-site and off-site risks would be generated by implementation of Alternative U3, associated with the exposure and transport of contaminated media from the site.

	Alternative U1: No Action	**Alternative U2: Capping, Monitoring, and Institutional Controls**	**Alternative U3: Accessible Source Removal, Monitoring, and Institutional Controls**
Permanence • *Degree of reduction of contaminant toxicity, mobility, and volume* • *Adequacy of destruction of hazardous substances* • *Reduction or elimination of substance releases, and source of release,* • *Degree of irreversibility of waste treatment processes* • *Volume and characteristics of generated treatment residuals*	**LOW** Alternative U1 relies on natural attenuation processes for reduction of contaminant toxicity, mobility and volume, therefore providing a low degree of permanence. Natural attenuation processes are irreversible, and over long a period of time, will result in adequate and permanent destruction of hazardous substances. Alternative U1 does not provide reduction or elimination of contaminant source releases. There is no treatment residual associated with Alternative U1.	**LOW** Alternative U2 would not directly reduce contaminant concentrations in upgradient soil and groundwater. Institutional controls would be needed to address the risk of exposure to subsurface soil as long as these risks remain. Alternative U2 relies primarily on natural attenuation processes for reduction of contaminant toxicity, mobility and volume, which would require an extended restoration time frame. Capping and K-Ply stormwater modifications will decrease the mobility of a fraction of contaminants in soil by preventing leaching from vadose soil. Natural attenuation processes are irreversible, and over a period of time, will result in adequate and permanent destruction of hazardous substances. Alternative U2 provides a reduction of contaminant source releases from vadose soils through capping.	**LOW** Alternative U3 would reduce contaminant concentrations in soil in limited accessible areas of the site via removal and off-site disposal. However, large volumes of contaminated soil would be left in place beneath inaccessible areas further from the bulkhead. Removal of contaminated media is irreversible, and will result in immediate destruction of hazardous substances though off site treatment and permanent disposal or recycling. K-Ply stormwater modifications will decrease the mobility of a fraction of contaminants in soil by preventing leaching from vadose soil. An estimated 11,000 cubic yards of contaminated soil from excavation activities will be generated, requiring handling, transport and disposal, however, the health risk associated with these soils is assumed to be low, as petroleum-contaminated soil is a commonly transported material.
Effectiveness over the Long Term • *Degree of certainty of alternative success* • *Reliability while contaminants remain onsite above cleanup levels* • *Magnitude of residual risk* • *Effectiveness of controls implemented to manage residual risk*	**LOW** Alternative U1 provides a low degree of certainty of success because it would not address the risks to workers from subsurface soil and groundwater. Natural attenuation processes are highly effective over the long term, although Alternative U1 is not expected to address the leaching pathway successfully within a reasonable timeframe. These risks are addressed at the Bulkhead Cleanup Area. The alternative does not include actions for elimination of exposure pathways while contaminants remain onsite, nor does it provide any additional controls to manage residual risk. The magnitude of residual risk is substantial, and there are no controls provided to manage the residual risk to subsurface workers.	**MODERATE** Alternative U2 provides a high degree of certainty of success for the subsurface soil exposure pathway by directly addressing potential exposures to subsurface workers through institutional controls. Alternative U2 is not expected to address the leaching pathway fully or successfully within a reasonable timeframe because capping would reduce leaching from vadose zone soils north of Westport Marine only, and stormwater modifications to K-Ply would address leaching from vadose zone soils beneath K-Ply only. Leaching pathway risks are addressed at the Bulkhead Cleanup Area. Institutional controls can mitigate risks while contaminants remain onsite above cleanup levels.	**MODERATE** Alternative U3 provides a high degree of certainty for the subsurface soil exposure pathway by directly addressing potential exposures to subsurface workers through institutional controls. Excavation activities will provide a low degree of certainty of success for the leaching pathway because a substantial volume of contaminated material will remain onsite in locations covered by buildings. Leaching pathway risks are addressed at the Bulkhead Cleanup Area. Institutional controls can mitigate risks while contaminants remain onsite above cleanup levels.
Short-term Risk Management • *Risk to human health and the environment associated with alternative construction* • *The effectiveness of controls in place to manage short-term risks*	**HIGH** There are no short term risks associated with alternative construction, as there are no actions associated with this alternative.	**MODERATE to HIGH** Alternative U2 provides a low degree of short-term risk associated with cap construction and contact with contaminated soils and groundwater during monitoring well installation.	**MODERATE** Alternative U3 provides a moderate degree of short-term risks associated with large-scale soil excavation and transportation and monitoring well installation. These risks would be addressed by standard health and safety planning and procedures.

	Alternative U1: No Action	**Alternative U2: Capping, Monitoring, and Institutional Controls**	**Alternative U3: Accessible Source Removal, Monitoring, and Institutional Controls**
Technical and Administrative Implementability • *Ability of alternative to be implemented considering below* • *Technical possibility* • *Availability of off-site facilities, services and materials* • *Administrative and Regulatory requirements* • *Schedule, size and complexity of construction* • *Monitoring requirements* • *Site access for construction, and operations and monitoring* • *Integration with existing site operations or other current and potential future remedial action*	**LOW** Not applicable	**HIGH** Alternative U2 is highly implementable, with no apparent technical and limited administrative obstacles. Capping would cause a temporary interference with the operations of Westport Marine, by blocking access to the large bay on the north side of the structure for a short period of time and disrupting the employee parking lot. Alternative U2 monitoring requirements are compatible with other monitoring requirements at the Site. Alternative U2 institutional controls and monitoring requirements appear able to be integrated with existing site operations or other current and potential future remedial action.	**LOW** Alternative U3 has low implementability, with technical limitations primarily due to shoring adjacent to the bulkhead and negotiating subsurface utilities; and substantial administrative obstacles associated with the interference of the excavation with existing site operations. The excavation would dramatically disrupt the transfer of logs from west of Tumwater Creek to cargo vessels docked at Terminal 3 north of the bulkhead and would prevent Westport Marine from moving watercraft in and out of the facility through the large bay at the north side of the building, effectively shutting down these businesses for several months. Additionally, the staging area and substantial truck traffic required would interfere with Platypus Marine's ability to transport watercraft between the waterfront and the repair facility. There is a potential for administrative or regulatory obstacles associated with the hundreds of trucks that would be required to haul the contaminated soil off-site by road. There are no appropriate soil disposal facilities available on the Olympic Peninsula. An extended travel distance is anticipated for disposal of excavated materials.
Consideration of Public Concerns • *Whether the community has concerns* • *Degree to which the alternative addresses those concerns*	Public concerns will be addressed following completion of the public comment period.	Public concerns will be addressed following completion of the public comment period.	Public concerns will be addressed following completion of the public comment period.
Estimated Cost • *Cost of Construction* • *Long-term monitoring and O&M costs*	Construction Capital = $ 0 Annual O&M = $ 0	Construction Capital = $900,000 (Monitoring costs included with Bulkhead CA alternatives)	Construction Capital = $ 5,360,000 (Monitoring costs included with Bulkhead CA alternatives)
Timeframe to Achieve Direct Contact RAO	Does not achieve RAO 30 Years (estimated minimum)	Immediate	Immediate
Timeframe to Achieve Surface Water Protection RAO	Does not achieve RAO 30 Years (estimated minimum)	Achieves surface water protection RAO if performed in conjunction with Bulkhead Cleanup Action. Reduction in vadose zone leaching immediately following construction.	Achieves surface water protection RAO if performed in conjunction with Bulkhead Cleanup Action. Substantial but incomplete reduction in vadose and saturated zone leaching immediately following construction
Time Frame to Achieve Inhalation Pathway RAO	Does not achieve RAO	Within weeks to months of indoor air sampling.	Within weeks to months of indoor air sampling.

Table 9.3
Pettit Oil Cleanup Area Alternatives Evaluation and Disproportionate Cost Analysis

	Alternative P1: No Action	**Alternative P2: Active Product Recovery**	**Alternative P3: Source Removal**
Alternative Description	The baseline alternative would involve no additional action at the Pettit Oil CA. This alternative would leave in place the status quo conditions, in which a large area of free diesel product is present at the groundwater surface.	This alternative would involve implementing one of the three technologies that utilize an induced gradient for removal of LNAPL such as the diesel product at the Pettit Oil CA. These include one or a combination of water table depression, vacuum-enhanced recovery, and/or bioslurping. The system will be operated until measurable product is removed from the water table surface, as determined by an appropriately designed monitoring plan. The alternative is likely to consist of limited additional delineation of the LNAPL, installation of extraction wells/VER wells/bioslurping wells, and installation of a product recovery tank, groundwater treatment system (if applicable), and vapor recovery system (if applicable) and associated plumbing and electrical connections, and installation of a small number of additional groundwater monitoring wells. The extracted groundwater may be treated on site as part of this system and then discharged to the sanitary sewer or discharged directly to the sanitary sewer for treatment at the POTW. Operations, maintenance, and monitoring for Alternative P2 are likely to include maintaining the system components, periodic transportation, and off-site disposal or recycling of recovered free product, monitoring the product thickness, volume of free product recovered, and the downgradient edge of the product lense; and quarterly or semi-annual groundwater monitoring events and reporting.	This alternative consists of the excavation and disposal of LNAPL to the extent practicable, and the excavation of LNAPL-impacted soil. Because Pettit Oil is an active facility with inaccessible contamination, the work would be divided into two phases. The initial phase would consist of excavating accessible LNAPL-impacted soil from the southern edge of the property, beneath the former ASTs. This area to be excavated constitutes approximately 5,000 square feet and between 1,000 tons and 3,000 tons of contaminated soil accessible for excavation and disposal. A second phase of excavation would be implemented at a future time to complete the removal of LNAPL and LNAPL-impacted soil at a time and in a manner that does not interfere with operations. In the interim period, institutional controls, including a restrictive covenant, would prevent exposure to COCs by direct contact. The area to be excavated during the second phase would total approximately 10,000 square feet and include between 2,000 tons and 6,000 tons of contaminated soil accessible for excavation and disposal. In the period between phases, vacuum-enhanced recovery (VER) would be performed using Ecology-approved surfactants at Recovery Wells MW-8, MW-9, and MW-10 using a vacuum truck in regular, discrete events. Product thickness would continue to be monitored. For both phases, excavation would be conducted using standard construction equipment. Free product, once exposed at the water table, may be removed using a vacuum recovery truck. Contaminated soil and free product would be transported off-site for disposal or recycling. Following confirmation of the removal of the free product, the excavations would be backfilled with clean imported fill, compacted, and re-graded/repaved to return the area to its former condition. The alternative may include installing a small number of additional groundwater monitoring wells to ensure no reaccumulation of LNAPL, as well as groundwater monitoring events and reporting.
Overall Protectiveness • *Degree to which existing risks are reduced* • *Time required to reduce risks and attain cleanup standards* • *On- and Off-site risks resulting from alternative implementation* • *Improvement in overall environmental quality*	**LOW** Alternative P1 would provide a low degree of overall protectiveness because it does not provide risk reduction, nor does it provide an improvement in overall environmental quality. The timeframe required to reduce risk and attain cleanup standards is very long, as the Alternative does not increase the existing rate of risk reduction through natural attenuation processes. LNAPL would be present for the foreseeable future. No additional on-site or off-site risks are generated by implementation of Alternative P1, as no actions are included.	**MODERATE-HIGH** Alternative P2 would provide a moderate to high degree of risk reduction and moderate to high overall improvement in environmental quality by removing the majority of LNAPL. The alternative would leave in place residual soil contamination. Risks would be reduced by removing LNAPL within 10 years or less. Alternative P2 would result in a low degree of on-site risks, such as exposure to free product during construction and operation of the system.	**HIGH** Alternative P3 would provide a high degree of risk reduction and improvement in overall environmental quality by removing virtually all LNAPL and LNAPL-impacted soil. Between the first and second phase of excavation, exposure risks would be addressed through institutional controls and LNAPL would be controlled with regular VER events. Alternative P3 would result in a low degree of on-site risks, such as exposure to free product or contaminated soil during excavation and construction-related hazards.

	Alternative P1: No Action	**Alternative P2: Active Product Recovery**	**Alternative P3: Source Removal**
Permanence • *Degree of reduction of contaminant toxicity, mobility, and volume* • *Adequacy of destruction of hazardous substances* • *Reduction or elimination of substance releases, and source of release,* • *Degree of irreversibility of waste treatment processes* • *Volume and characteristics of generated treatment residuals*	**LOW** Alternative P1 relies on natural attenuation processes for reduction of contaminant toxicity, mobility and volume, therefore providing a very low degree of permanence. Free product would not attenuate for many years. Natural attenuation processes are irreversible, and over a long period of time, will result in adequate and permanent destruction of hazardous substances. Alternative P1 does not provide reduction or elimination of contaminant source releases. There is no treatment residual associated with Alternative P1.	**MODERATE-HIGH** Alternative P2 would provide a moderate to high degree of reduction in contaminant volume, mobility, and toxicity, by removing LNAPL to the extent practicable while leaving residual soil contamination. LNAPL would be transported off-site for permanent destruction or recycling, and recovery of LNAPL would reduce but not eliminate a source of releases to groundwater. Alternative P2 would result in a substantial volume of generated treatment residuals, including the free product removed from the subsurface and any groundwater treatment residuals, requiring storage on-site and transport to a recycling/disposal facility.	**HIGH** Alternative P3 would provide a high degree of reduction in contaminant volume, mobility, and toxicity, by removing virtually all LNAPL and LNAP-impacted soil. Excavation is the most permanent option available. LNAPL and contaminated soil would be transported off-site for permanent destruction or recycling. Excavation would effectively eliminate a source of releases to groundwater. Alternative P3 would result in no significant treatment residuals. Excavated soil and/or LNAPL may require temporary storage on-site, prior to transport to a recycling/disposal facility.
Effectiveness over the Long-term • *Degree of certainty of alternative success* • *Reliability while contaminants remain onsite above cleanup levels* • *Magnitude of residual risk* • *Effectiveness of controls implemented to manage residual risk*	**LOW** Alternative P1 provides a low degree of success certainty, because it would not remove free product, which can persist in the environment for decades. The alternative would leave residual risk associated with the residual soil contamination left in place; however, this residual soil contamination is adequately addressed by the controls established for the Upgradient CA to protect utility workers.	**MODERATE to HIGH** Because it relies on proven technologies, Alternative P2 would provide a moderate to high degree of certainty of success in removing the majority of the LNAPL in a reasonable timeframe. The induced gradients would capture separate pockets of LNAPL, if applicable, and would be a reliable means of containing the LNAPL until it can be completely recovered. Even with the most aggressive recovery technologies, however, LNAPL recovery may require many years for near-complete recovery; complete recovery of LNAPL is unlikely. The alternative would leave residual risk associated with the residual soil contamination left in place; however, this residual soil contamination is adequately addressed by the controls established for the Upgradient CA to protect utility workers.	**HIGH** Alternative P3 is expected to be highly effective over the long term because it is the most complete solution, carries a higher likelihood of success, and results in the lowest residual risk when excavation is complete. Prior to the completion of all excavation activities, the alternative would leave some residual risk associated with the residual LNAPL and soil contamination temporarily left in place; however, this residual soil contamination is adequately addressed by the controls established for the Upgradient Cleanup Area to protect utility workers, and VER events to control LNAPL.
Short-term Risk Management • *Risk to human health and the environment associated with alternative construction* • *The effectiveness of controls in place to manage short-term risks*	**HIGH** There are no short term risks associated with alternative construction, as there are no actions associated with this alternative.	**MODERATE to HIGH** Alternative P2 would result in a limited increase in short-term risks associated with the construction of the recovery system, operation and maintenance of the system, and transportation and disposal of LNAPL. The alternative includes effective controls to manage these short-term risks.	**MODERATE** Alternative P3 would result in increased short-term risk associated with the excavation of petroleum-contaminated soil, removal of LNAPL, transport and disposal of LNAPL, and other construction-related risks associated with the operation of heavy equipment. The short-term risks are considered moderate due to the large size of the open excavation in the work area, structural stability concerns for nearby site structures, and the potential for exposure to the large areas of exposed LNAPL and contaminated soil as well as associated vapors. The alternative includes effective controls to manage these short-term risks.

	Alternative P1: No Action	**Alternative P2: Active Product Recovery**	**Alternative P3: Source Removal**
Technical and Administrative Implementability - *Ability of alternative to be implemented considering below* - *Technical possibility* - *Availability of off-site facilities, services and materials* - *Administrative and Regulatory requirements* - *Schedule, size and complexity of construction* - *Monitoring requirements* - *Site access for construction, and operations and monitoring* - *Integration with existing site operations or other current and potential future remedial action*	**LOW** Alternative P1 carries a low ability to be implemented due to MTCA requirements to remove LNAPL from the subsurface as part of groundwater remedial actions. Alternative P1 is otherwise implementable.	**MODERATE to HIGH** Alternative P2 is highly implementable, with some apparent technical and administrative obstacles. The installation, operation, and maintenance of a product recovery system may interfere with site operations to a small degree, though it appears that the system would be feasible to be integrated with existing site operations. Alternative P2 is technically possible, with readily available off-site services and materials. Alternative P2 monitoring requirements are compatible with other monitoring requirements at the MTA Site.	**MODERATE to HIGH** Alternative P3 is highly implementable. Because excavation is divided into two phases, source removal is feasible to be implemented without severe disruption of business at Pettit Oil. The initial excavation and regular VER events may interfere with site operations to a small degree. Alternative P3 is technically possible, with reasonably available off-site services. There is a potential for minor administrative or regulatory obstacles associated with the dozens of trucks that would be required to haul the contaminated soil off-site by road. There are no appropriate soil disposal facilities available on the Olympic Peninsula, so an extended travel distance is anticipated for disposal of excavated media.
Consideration of Public Concerns - *Whether the community has concerns* - *Degree to which the alternative addresses those concerns*	Public concerns will be addressed following completion of the public comment period.	Public concerns will be addressed following completion of the public comment period.	Public concerns will be addressed following completion of the public comment period.
Estimated Cost - *Cost of Construction* - *Long-term monitoring and O&M costs*	Capital Construction= $ 0 Annual O&M = $ 0	Capital construction = $385,000 Annual O&M = $157,000 10-year present value total = $1,595,000	Capital construction = $1,109,000 Annual O&M = $8,000 10-year present value total= $1,502,000
Time Required to Attain LNAPL removal RAO	Indefinite	3 – 10 Years to remove majority of LNAPL; trace LNAPL likely to remain indefinitely.	The initial excavation will remove a large mass of LNAPL and LNAPL-impacted soil. The time frame for completion of source removal is dependent on site usage considerations. Following completion, virtually all LNAPL will be removed.

Table 9.4
Evaluation Summary

Bulkhead Cleanup Area				
Evaluation Criteria	**Alternative B1: No Action**	**Alternative B2: Groundwater Recovery Wells and Ex-situ Treatment**	**Alternative B3: Air Sparge Curtain**	**Alternative B4: Barrier Wall with Active Interceptor Trench and Ex-situ Treatment**
Overall Protectiveness	Low = 1	High = 5	High = 5	High = 5
Permanence*	Low = 1	Low = 1	Low = 1	Low = 1
Long-term Effectiveness	Low = 1	Moderate = 3	High = 5	Moderate to High = 4
Short-term Risk Management	High = 5	High = 5	High = 5	Moderate to High = 4
Tech & Admin. Implementability	Low = 1	Moderate = 3	Moderate = 3	Low to Moderate to = 2
Total Points	9	17	19	16
Average Result	Low to Moderate	Moderate	Moderate to High	Moderate
Cost:				
Capital Annual O&M Present Value 30-year Total Cost	$0 $0 $0	$858,000 $111,000 $2,570,000	$1,001,000 $91,000 $2,400,000	$1,690,000 $108,000 $3,350,000
Time Frame to Achieve Surface Water Protection RAO	30 Years (estimated minimum)	Within weeks of construction completion and startup. Operation will be required for decades (estimated 30 years minimum).	Within one year of construction completion and startup. Substantial decreases in COC concentrations are expected within weeks. Partial operation will be required for decades (estimated 30 years minimum).	Immediately following construction completion. Operation will be required for decades (estimated 30 years minimum).

Note:

* “Permanence” is ranked low for Alternatives B2 – B4 because “permanence” as defined under MTCA will not be attained until upgradient soil and groundwater attenuates to be less than applicable cleanup levels. Alternatives B2 – B4 require operation of remediation systems for an extended restoration time frame until this process is completed. Alternatives B2– B4 will be protective of groundwater discharging to surface water during the restoration time frame.

Upgradient Cleanup Area			
Evaluation Criteria	**Alternative U1: No Action**	**Alternative U2: Capping, Monitoring, and Institutional Controls**	**Alternative U3: Accessible Source Removal, Monitoring, and Institutional Controls**
Overall Protectiveness	Low = 1	Moderate = 3	Moderate = 3
Permanence*	Low = 1	Low = 1	Low = 1
Long-term Effectiveness	Low = 1	Moderate = 3	Moderate = 3
Short-term Risk Management	High = 5	Moderate to High = 4	Moderate = 3
Tech & Admin. Implementability	Low = 1	High = 5	Low = 1
Total Points	9	16	11
Average Result	Low	Moderate	Low to Moderate
Cost (Capital)[1]	$0	$900,000	$5,360,000
Time Frame to Achieve Direct Contact RAO	Does not achieve RAO 30 Years (estimated minimum)	Immediate	Immediate
Time Frame to Achieve Surface Water Protection RAO	Does not achieve RAO 30 Years (estimated minimum)	Achieves RAO if performed in conjunction with Bulkhead Cleanup Action Reduction in vadose zone leaching immediately following construction	Achieves RAO if performed in conjunction with Bulkhead Cleanup Action Substantial but incomplete reduction in vadose and saturated zone leaching immediately following construction
Time Frame to Achieve Inhalation Pathway RAO	Does not achieve RAO	Within weeks to months of indoor air sampling	Within weeks to months of indoor air sampling

Note:

***** “Permanence” is ranked low for Alternatives U2 and U3 because “permanence” as defined under MTCA will not be attained until upgradient soil and groundwater attenuates to be less than applicable cleanup levels. Alternatives U2 and U3, if performed in conjunction with operation of bulkhead remediation alternatives for an extended restoration time frame, will be protective of groundwater discharging to surface water during the restoration time frame.

Pettit Oil Cleanup Area			
Evaluation Criteria	**Alternative P1: No Action**	**Alternative P2: Active Recovery**	**Alternative P3: Source Removal**
Overall Protectiveness	Low = 1	Moderate to High = 4	High = 5
Permanence	Low = 1	Moderate to High = 4	High = 5
Long-term Effectiveness	Low = 1	Moderate to High = 4	High = 5
Short-term Risk Management	High = 5	Moderate to High = 4	Moderate = 3
Tech & Admin. Implementability	Low = 1	Moderate to High = 4	Moderate to High = 4
Total Points	9	20	22
Average Result	Low	Moderate to High	Moderate to High
Cost:			
Capital	$0	$385,000	$1,109,000
Annual O&M[2]	$0	$157,000	$8,000
Present Value 30-year Total Cost	$0	$1,595,000	$1,502,000
Timeframe to Achieve LNAPL Removal RAO		3 to10 years to remove majority of LNAPL; trace LNAPL likely to remain indefinitely.	Initial excavation will remove a large mass of LNAPL and soil contaminated with concentrations greater than MTCA C. The timeframe for completion of source removal is dependent on site usage considerations. Following completion, virtually all LNAPL will be removed.

Notes:

1 Upgradient Cleanup Area O&M costs are included in costs for Bulkhead Cleanup Area remedial alternatives.

2 Pettit Oil Cleanup Area O&M costs are projected for 10 years, which is the approximate interval of time expected to be required to remediate LNAPL to the extent practiceable. Long-term monitoring costs for the Pettit Oil Cleanup Area are included in costs for Bulkhead Cleanup Area remedial alternatives.

Table 10.1
Summary of Preferred Remedy Elements

Cleanup Area	Applied To	Technology	Cleanup Goal	Approximate Time Frame to Achieve Remedial Goal
Bulkhead	Groundwater discharging to marine waters at bulkhead	In-situ air sparging treatment curtain	51 µg/L (benzene) 800 µg/L (TPH-G) 500 µg/L (TPH-D)	Within 1 year of construction completion; substantial decreases in COC concentrations are expected within weeks
Upgradient (site-wide unless otherwise noted)	Unpaved vadose zone soil > 30 mg/kg TPH	Impervious Capping	Prevention of leaching from infiltration in area between Westport Marine and Westport Bulkhead	Immediately following construction completion
	Subsurface soil	Institutional controls (property use restrictions, monitoring and maintenance requirements)	Limit or prohibit activities that may result in exposure or interfere with integrity of remedy	Immediate
	Groundwater	Monitoring	Assess trends in COC concentrations until groundwater treatment not necessary	Projected to be 10 to 30 years Operation will be subject to frequent reviews for refinement Partial shutdown possible
Light Non-aqueous Phase Liquid (LNAPL)	LNAPL-impacted soil and groundwater with measurable LNAPL (>0.1 feet)	Initial excavation of LNAPL-impacted soil from accessible areas Secondary excavation of remaining LNAPL-impacted soil following land use change	Recovery of free product to the extent practical	For initial excavation, immediately following construction completion (following CAP) For secondary excavation, following land use change

Marine Trades Area Site
Port Angeles, Washington

Final
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Figures

Approximate Scale in Feet

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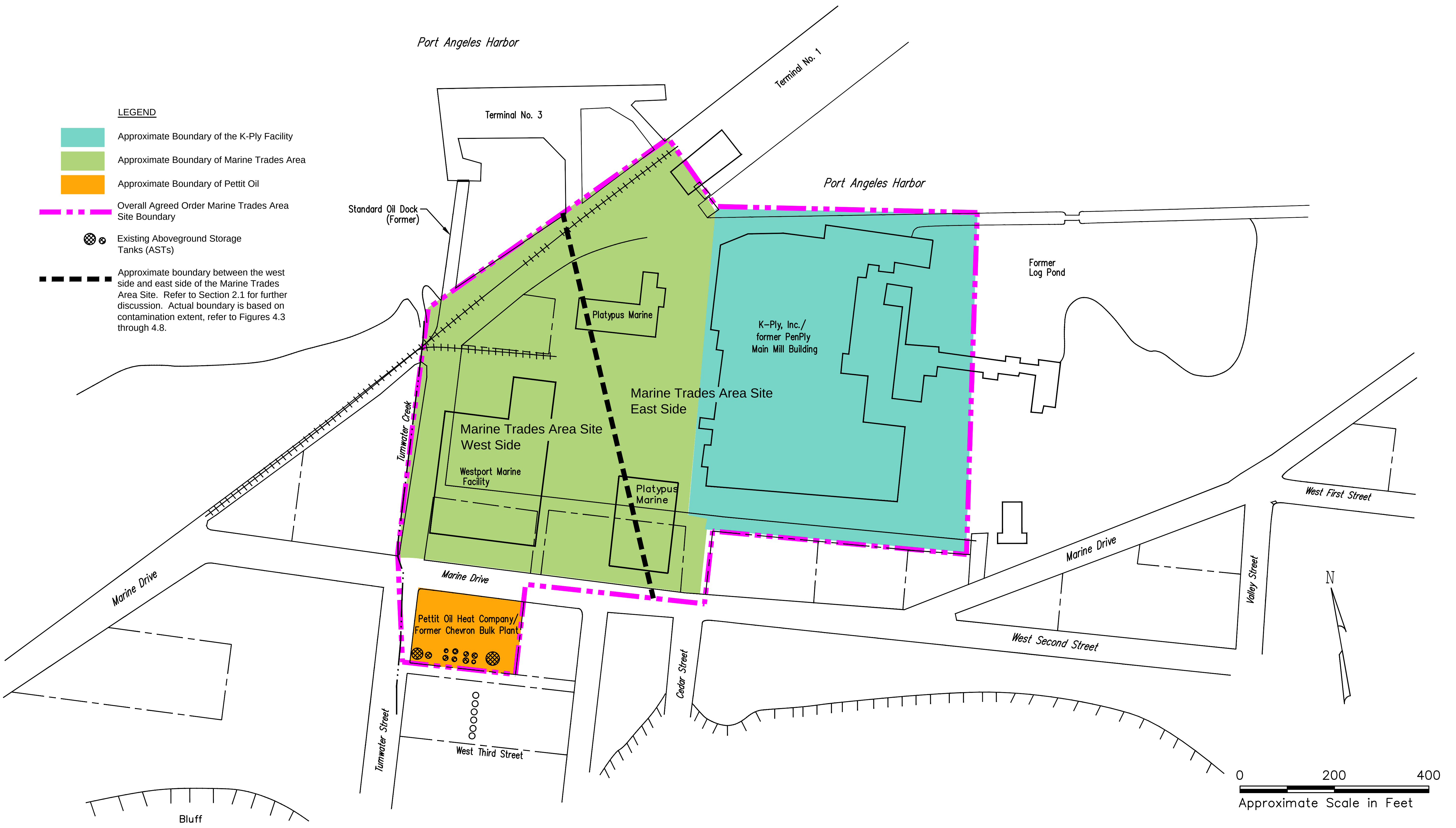
**Remedial Investigation/
Feasibility Study
Marine Trades Area Site
Port Angeles, WA**

Figure 1.1
Vicinity Map

G:Project\Clients\Floyd Snider\SJZ\Vicinity



Source: Shannon & Wilson 1996

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Marine Trades Area Site
Port Angeles, Washington

Figure 2.1
Agreed Order Site Boundary

DATE: K:\Project\clients\Floyd and Snider\PPA-OMW\ppa0045April2012rev.dwg
DWG NAME: 4/3/2012 11:16 AM

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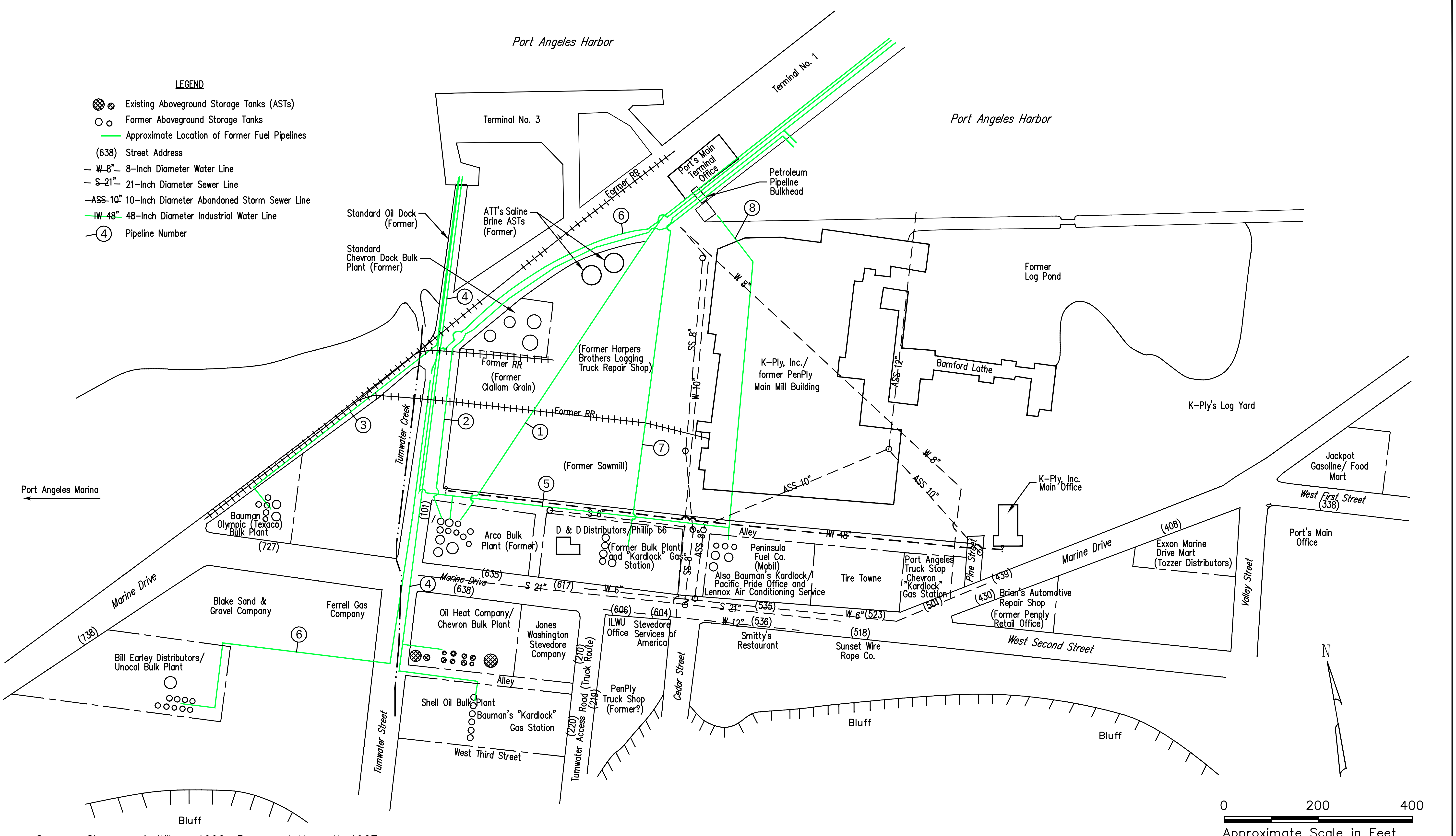
Port Angeles, Washington

Figure 2.2
Revised MTA Site Boundary

I:\GIS\Projects\SJZ-MTA\MXD\Figure 2.2 (Revised MTA Site Boundary).mxd
2/11/2013



Source: Shannon & Wilson 1996; Ryan and Haworth 1967

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Figure 2.3
Historical Land Use Map

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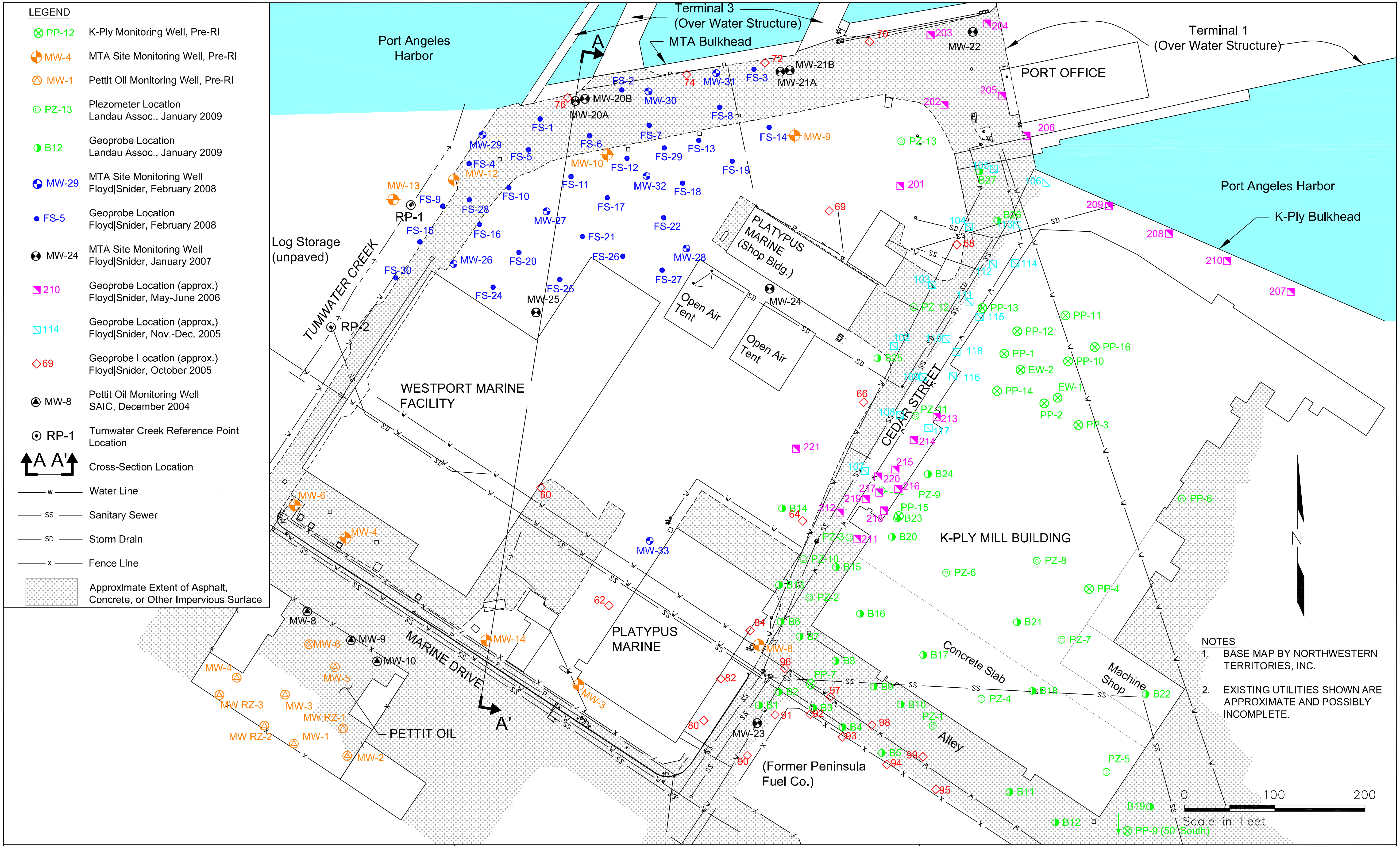
DWG NAME: 2/11/2013 9:24 AM



NOTES
1. BASE MAP BY NORTHWESTERN TERRITORIES, INC.
2. EXISTING UTILITIES SHOWN ARE APPROXIMATE AND POSSIBLY INCOMPLETE.

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Figure 3.1
Site Map Showing RI Explorations

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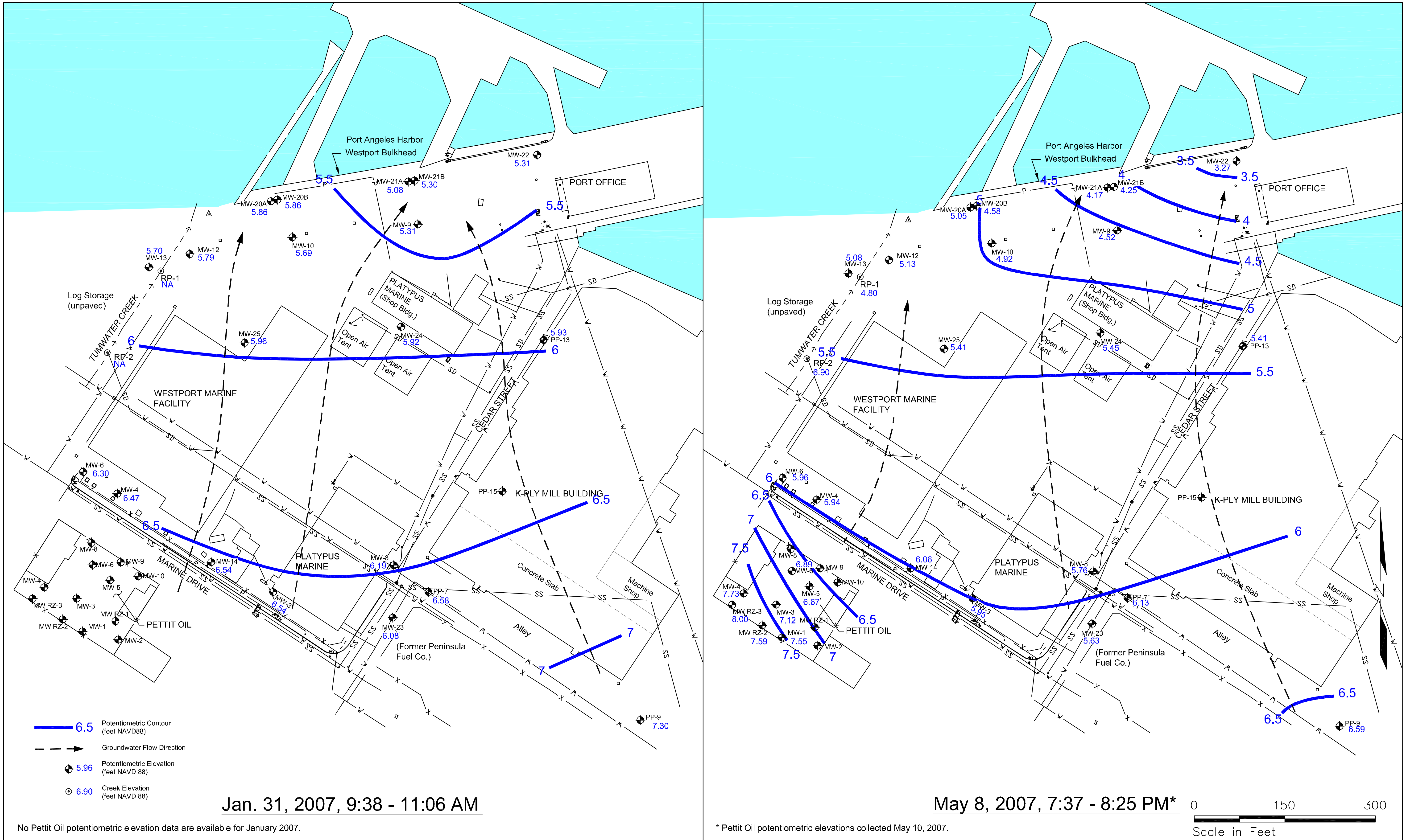
DATE: 8/11/2010 1:30 PM



Jan. 31, 2007, 9:38 - 11:06 AM

No Pettit Oil potentiometric elevation data are available for January 2007.

May 8, 2007, 7:37 - 8:25 PM*

* Pettit Oil potentiometric elevations collected May 10, 2007.

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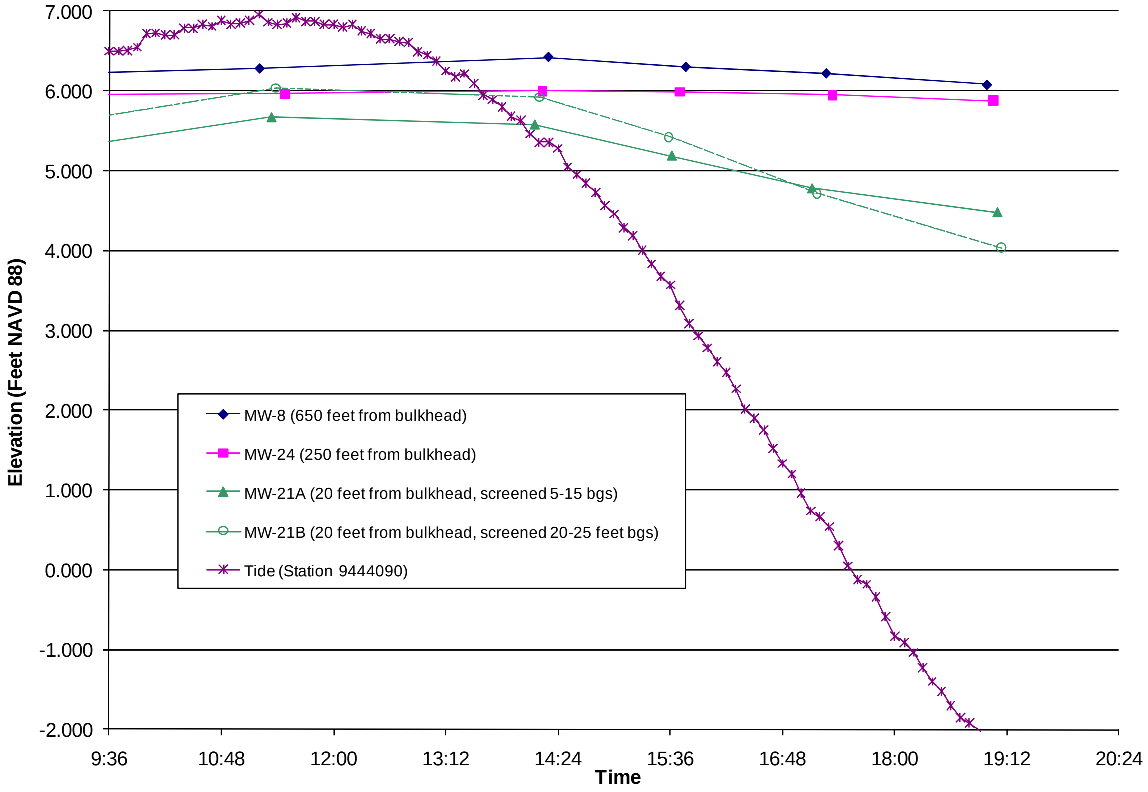
Figure 4.1
Potentiometric Contour Maps,
Jan. 31, 2007 and May 8, 2007

DWG NAME: G:\project\Clients\Floyd and Snider\PPA-OMW\ppa0077.dwg
DATE: 3/30/2010 9:02 PM

Potentiometric and Tidal Elevation Along a Flow Path—January 31, 2007



Tidal Influence on Potentiometric Surface in Bulkhead Monitoring Well Pairs—May 7, 2007

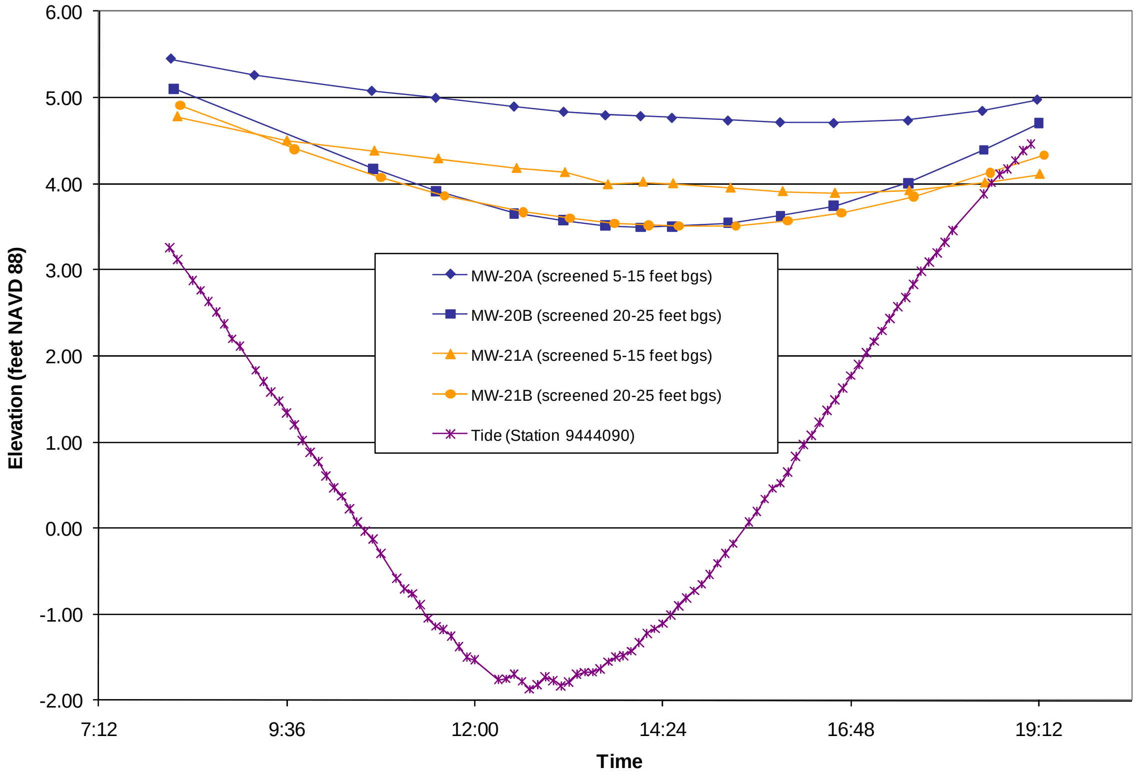


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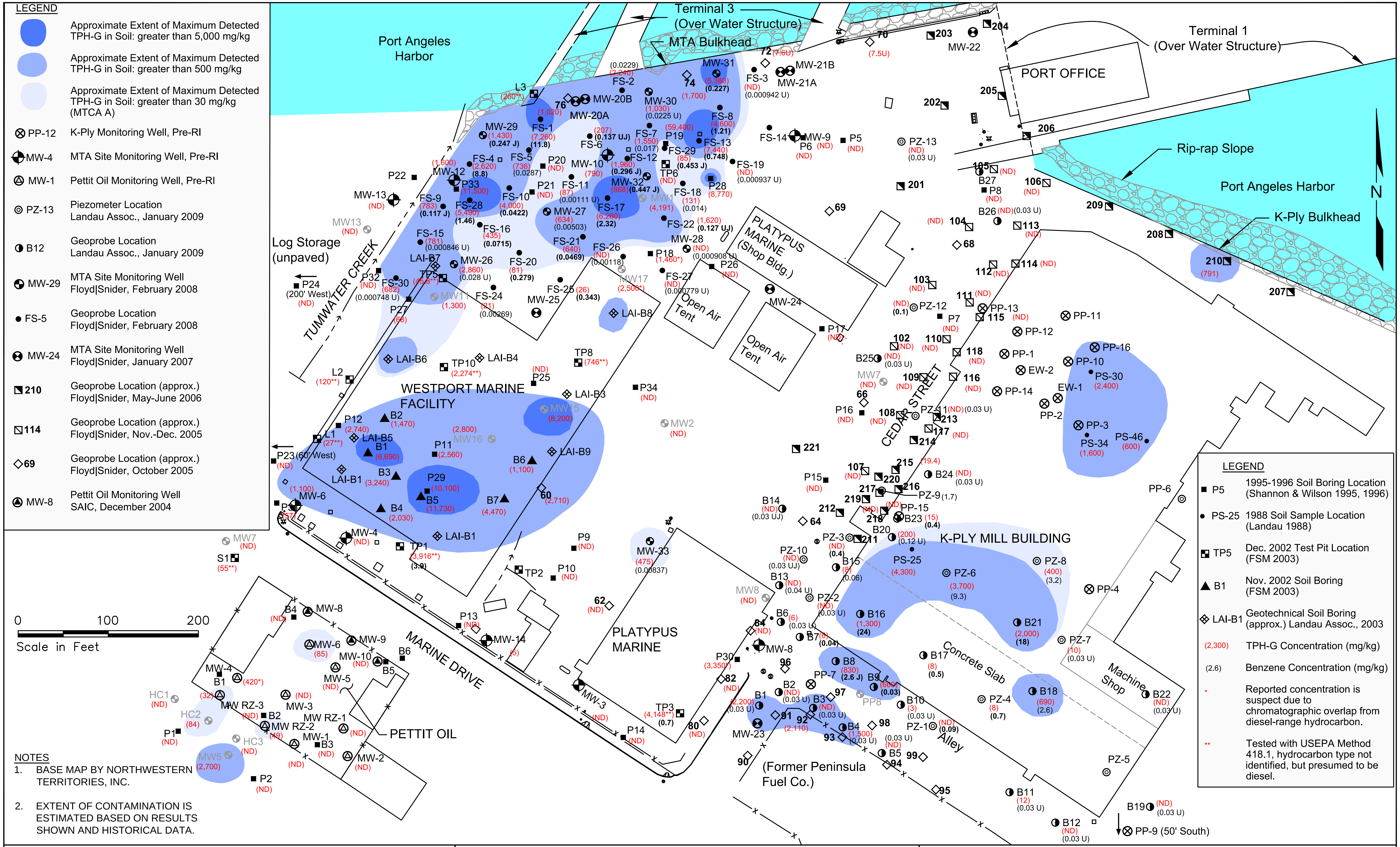
Figure 4.2
Tidal Influence on Selected
Monitoring Wells



LEGEND

🟦	Approximate Extent of Maximum Detected TPH-G in Soil: greater than 5,000 mg/kg
🟦	Approximate Extent of Maximum Detected TPH-G in Soil: greater than 500 mg/kg
⬜	Approximate Extent of Maximum Detected TPH-G in Soil: greater than 30 mg/kg (MTCA A)
⊗ PP-12	K-Ply Monitoring Well, Pre-RI
MW-4	MTA Site Monitoring Well, Pre-RI
MW-1	Pettit Oil Monitoring Well, Pre-RI
◎ PZ-13	Piezometer Location Landau Assoc., January 2009
◑ B12	Geoprobe Location Landau Assoc., January 2009
MW-29	MTA Site Monitoring Well Floyd|Snider, February 2008
• FS-5	Geoprobe Location Floyd|Snider, February 2008
MW-24	MTA Site Monitoring Well Floyd|Snider, January 2007
210	Geoprobe Location (approx.) Floyd|Snider, May-June 2006
114	Geoprobe Location (approx.) Floyd|Snider, Nov.-Dec. 2005
◇69	Geoprobe Location (approx.) Floyd|Snider, October 2005
MW-8	Pettit Oil Monitoring Well SAIC, December 2004

LEGEND

■ P5	1995-1996 Soil Boring Location (Shannon & Wilson 1995, 1996)
• PS-25	1988 Soil Sample Location (Landau 1988)
TP5	Dec. 2002 Test Pit Location (FSM 2003)
▲ B1	Nov. 2002 Soil Boring (FSM 2003)
◈ LAI-B1	Geotechnical Soil Boring (approx.) Landau Assoc., 2003
(2,300)	TPH-G Concentration (mg/kg)
(2.6)	Benzene Concentration (mg/kg)
*	Reported concentration is suspect due to chromatographic overlap from diesel-range hydrocarbon.
**	Tested with USEPA Method 418.1, hydrocarbon type not identified, but presumed to be diesel.

NOTES
1. BASE MAP BY NORTHWESTERN TERRITORIES, INC.
2. EXTENT OF CONTAMINATION IS ESTIMATED BASED ON RESULTS SHOWN AND HISTORICAL DATA.

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Figure 4.3
Historical and Current Areas of Elevated TPH-G and Benzene in Soil

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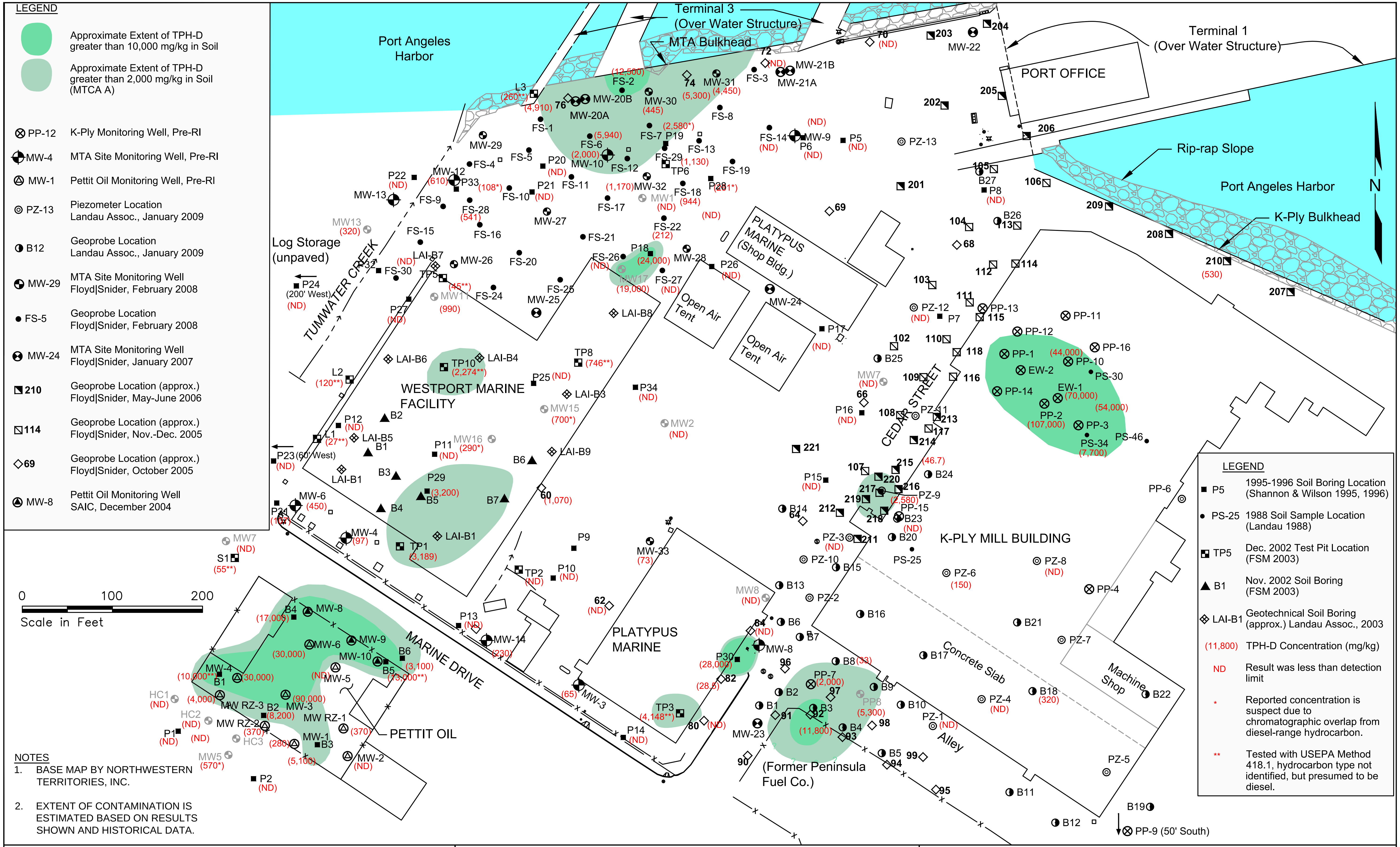
DATE: 4/3/2012 3:19 PM



NOTES
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2. EXTENT OF CONTAMINATION IS ESTIMATED BASED ON RESULTS SHOWN AND HISTORICAL DATA.

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Figure 4.4
Historical and Current Areas of Elevated TPH-D in Soil

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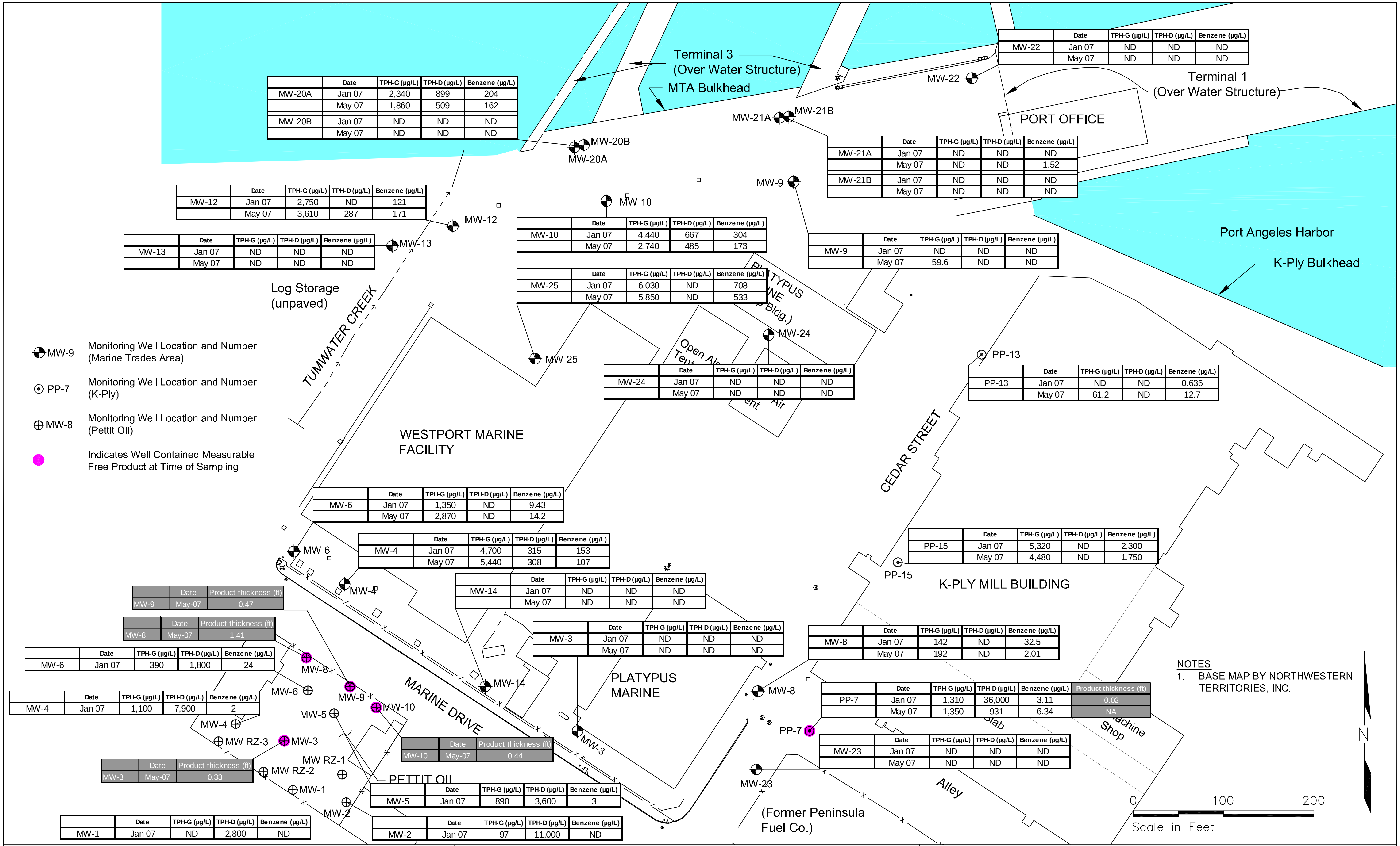
DATE: 3/14/2012 8:44 PM



MW-9 Monitoring Well Location and Number (Marine Trades Area)

⊙ PP-7 Monitoring Well Location and Number (K-Ply)

⊕ MW-8 Monitoring Well Location and Number (Pettit Oil)

● Indicates Well Contained Measurable Free Product at Time of Sampling

NOTES
1. BASE MAP BY NORTHWESTERN TERRITORIES, INC.

	Date	TPH-G (µg/L)	TPH-D (µg/L)	Benzene (µg/L)
MW-22	Jan 07	ND	ND	ND
	May 07	ND	ND	ND

	Date	TPH-G (µg/L)	TPH-D (µg/L)	Benzene (µg/L)
MW-20A	Jan 07	2,340	899	204
	May 07	1,860	509	162
MW-20B	Jan 07	ND	ND	ND
	May 07	ND	ND	ND

	Date	TPH-G (µg/L)	TPH-D (µg/L)	Benzene (µg/L)
MW-21A	Jan 07	ND	ND	ND
	May 07	ND	ND	1.52
MW-21B	Jan 07	ND	ND	ND
	May 07	ND	ND	ND

	Date	TPH-G (µg/L)	TPH-D (µg/L)	Benzene (µg/L)
MW-12	Jan 07	2,750	ND	121
	May 07	3,610	287	171

	Date	TPH-G (µg/L)	TPH-D (µg/L)	Benzene (µg/L)
MW-10	Jan 07	4,440	667	304
	May 07	2,740	485	173

	Date	TPH-G (µg/L)	TPH-D (µg/L)	Benzene (µg/L)
MW-13	Jan 07	ND	ND	ND
	May 07	ND	ND	ND

	Date	TPH-G (µg/L)	TPH-D (µg/L)	Benzene (µg/L)
MW-9	Jan 07	ND	ND	ND
	May 07	59.6	ND	ND

	Date	TPH-G (µg/L)	TPH-D (µg/L)	Benzene (µg/L)
MW-25	Jan 07	6,030	ND	708
	May 07	5,850	ND	533

	Date	TPH-G (µg/L)	TPH-D (µg/L)	Benzene (µg/L)
MW-24	Jan 07	ND	ND	ND
	May 07	ND	ND	ND

	Date	TPH-G (µg/L)	TPH-D (µg/L)	Benzene (µg/L)
PP-13	Jan 07	ND	ND	0.635
	May 07	61.2	ND	12.7

	Date	TPH-G (µg/L)	TPH-D (µg/L)	Benzene (µg/L)
MW-6	Jan 07	1,350	ND	9.43
	May 07	2,870	ND	14.2

	Date	TPH-G (µg/L)	TPH-D (µg/L)	Benzene (µg/L)
MW-4	Jan 07	4,700	315	153
	May 07	5,440	308	107

	Date	TPH-G (µg/L)	TPH-D (µg/L)	Benzene (µg/L)
PP-15	Jan 07	5,320	ND	2,300
	May 07	4,480	ND	1,750

	Date	TPH-G (µg/L)	TPH-D (µg/L)	Benzene (µg/L)
MW-14	Jan 07	ND	ND	ND
	May 07	ND	ND	ND

	Date	Product thickness (ft)
MW-9	May-07	0.47

	Date	Product thickness (ft)
MW-8	May-07	1.41

	Date	TPH-G (µg/L)	TPH-D (µg/L)	Benzene (µg/L)
MW-3	Jan 07	ND	ND	ND
	May 07	ND	ND	ND

	Date	TPH-G (µg/L)	TPH-D (µg/L)	Benzene (µg/L)
MW-8	Jan 07	142	ND	32.5
	May 07	192	ND	2.01

	Date	TPH-G (µg/L)	TPH-D (µg/L)	Benzene (µg/L)
MW-6	Jan 07	390	1,800	24

	Date	TPH-G (µg/L)	TPH-D (µg/L)	Benzene (µg/L)	Product thickness (ft)
PP-7	Jan 07	1,310	36,000	3.11	0.02
	May 07	1,350	931	6.34	NA

	Date	TPH-G (µg/L)	TPH-D (µg/L)	Benzene (µg/L)
MW-4	Jan 07	1,100	7,900	2

	Date	Product thickness (ft)
MW-10	May-07	0.44

	Date	TPH-G (µg/L)	TPH-D (µg/L)	Benzene (µg/L)
MW-23	Jan 07	ND	ND	ND
	May 07	ND	ND	ND

	Date	Product thickness (ft)
MW-3	May-07	0.33

	Date	TPH-G (µg/L)	TPH-D (µg/L)	Benzene (µg/L)
MW-5	Jan 07	890	3,600	3

	Date	TPH-G (µg/L)	TPH-D (µg/L)	Benzene (µg/L)
MW-1	Jan 07	ND	2,800	ND

	Date	TPH-G (µg/L)	TPH-D (µg/L)	Benzene (µg/L)
MW-2	Jan 07	97	11,000	ND

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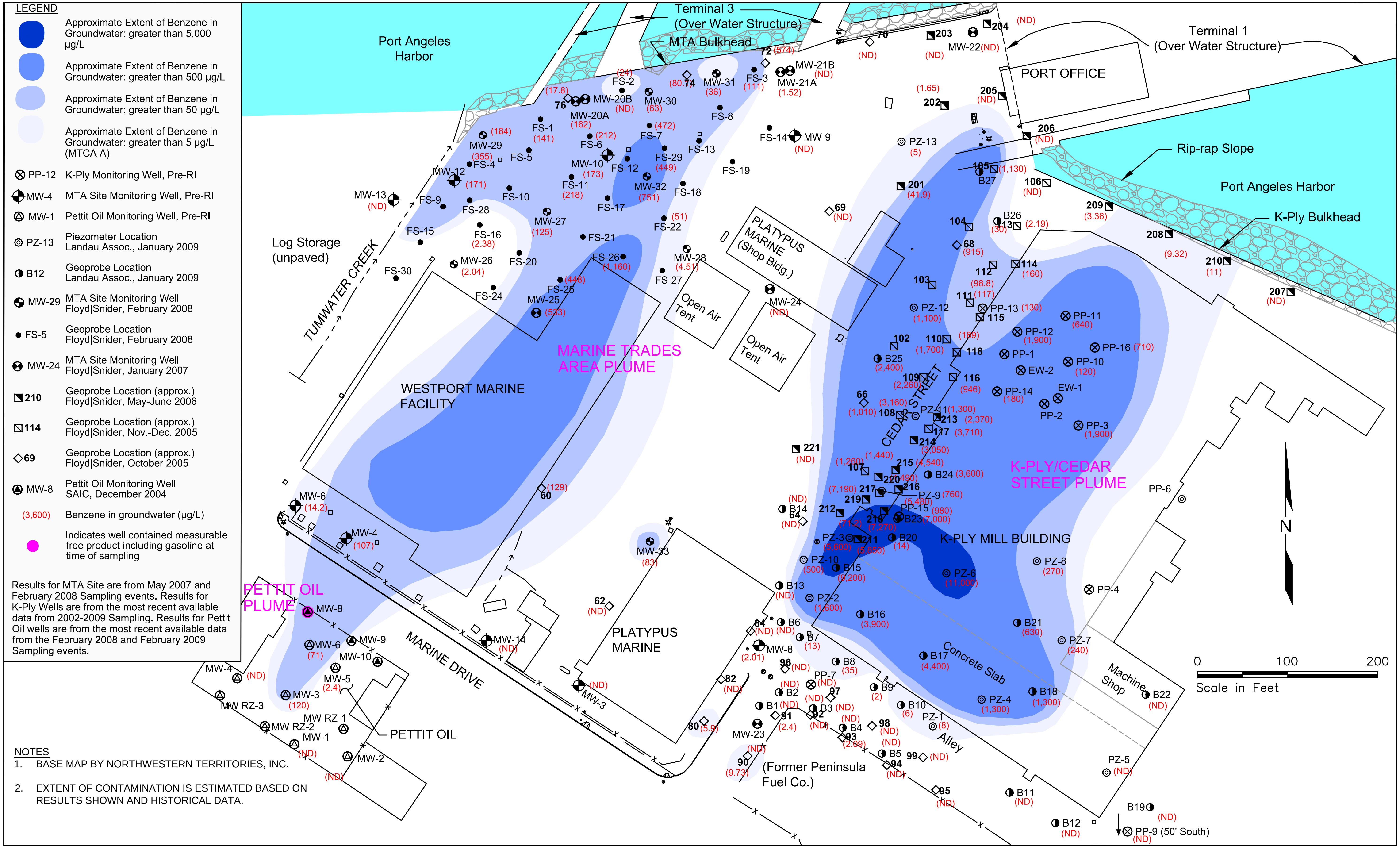
Figure 4.5
Summary of 2007 Groundwater Analytical Results
From Monitoring Wells

DWG NAME: G:\project\Clients\Floyd and Snider\PPA-OMW\ppa0080rev2010-08.dwg
DATE: 8/11/2010 1:37 PM



LEGEND

🟦	Approximate Extent of Benzene in Groundwater: greater than 5,000 µg/L
🟦	Approximate Extent of Benzene in Groundwater: greater than 500 µg/L
🟦	Approximate Extent of Benzene in Groundwater: greater than 50 µg/L
⬜	Approximate Extent of Benzene in Groundwater: greater than 5 µg/L (MTCA A)
⊗ PP-12	K-Ply Monitoring Well, Pre-RI
⊕ MW-4	MTA Site Monitoring Well, Pre-RI
Ⓐ MW-1	Pettit Oil Monitoring Well, Pre-RI
◎ PZ-13	Piezometer Location Landau Assoc., January 2009
◑ B12	Geoprobe Location Landau Assoc., January 2009
◕ MW-29	MTA Site Monitoring Well Floyd|Snider, February 2008
● FS-5	Geoprobe Location Floyd|Snider, February 2008
◕ MW-24	MTA Site Monitoring Well Floyd|Snider, January 2007
◪ 210	Geoprobe Location (approx.) Floyd|Snider, May-June 2006
⧅ 114	Geoprobe Location (approx.) Floyd|Snider, Nov.-Dec. 2005
◇ 69	Geoprobe Location (approx.) Floyd|Snider, October 2005
Ⓐ MW-8	Pettit Oil Monitoring Well SAIC, December 2004
(3,600)	Benzene in groundwater (µg/L)
●	Indicates well contained measurable free product including gasoline at time of sampling

Results for MTA Site are from May 2007 and February 2008 Sampling events. Results for K-Ply Wells are from the most recent available data from 2002-2009 Sampling. Results for Pettit Oil wells are from the most recent available data from the February 2008 and February 2009 Sampling events.

NOTES
1. BASE MAP BY NORTHWESTERN TERRITORIES, INC.
2. EXTENT OF CONTAMINATION IS ESTIMATED BASED ON RESULTS SHOWN AND HISTORICAL DATA.

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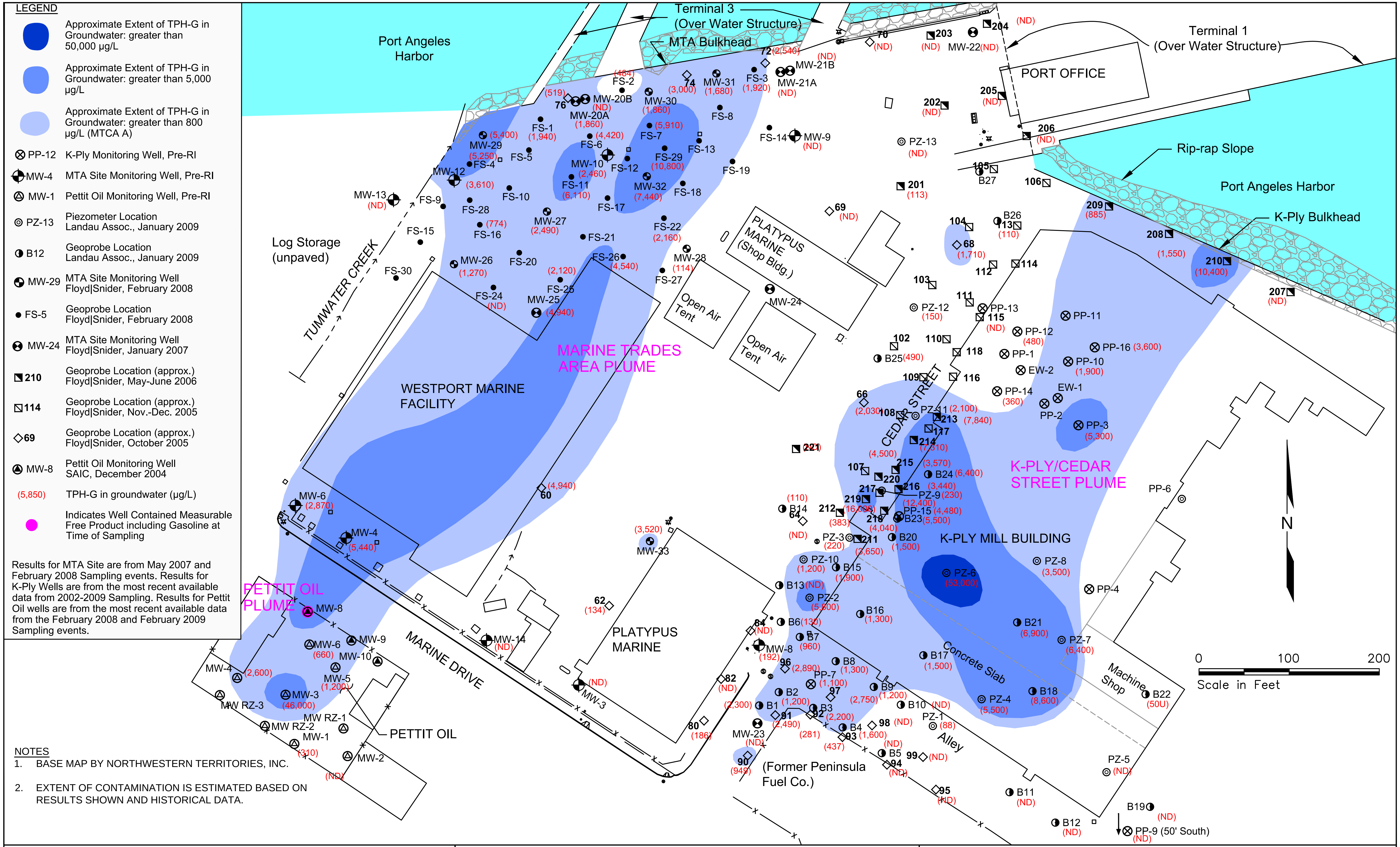
Figure 4.6
Benzene in Groundwater

DWG NAME: K:\Project\clients\Floyd and Snider\PPA-OMW\ppa0081rev2012-03.dwg
DATE: 3/14/2012 8:47 PM



NOTES
1. BASE MAP BY NORTHWESTERN TERRITORIES, INC.
2. EXTENT OF CONTAMINATION IS ESTIMATED BASED ON RESULTS SHOWN AND HISTORICAL DATA.

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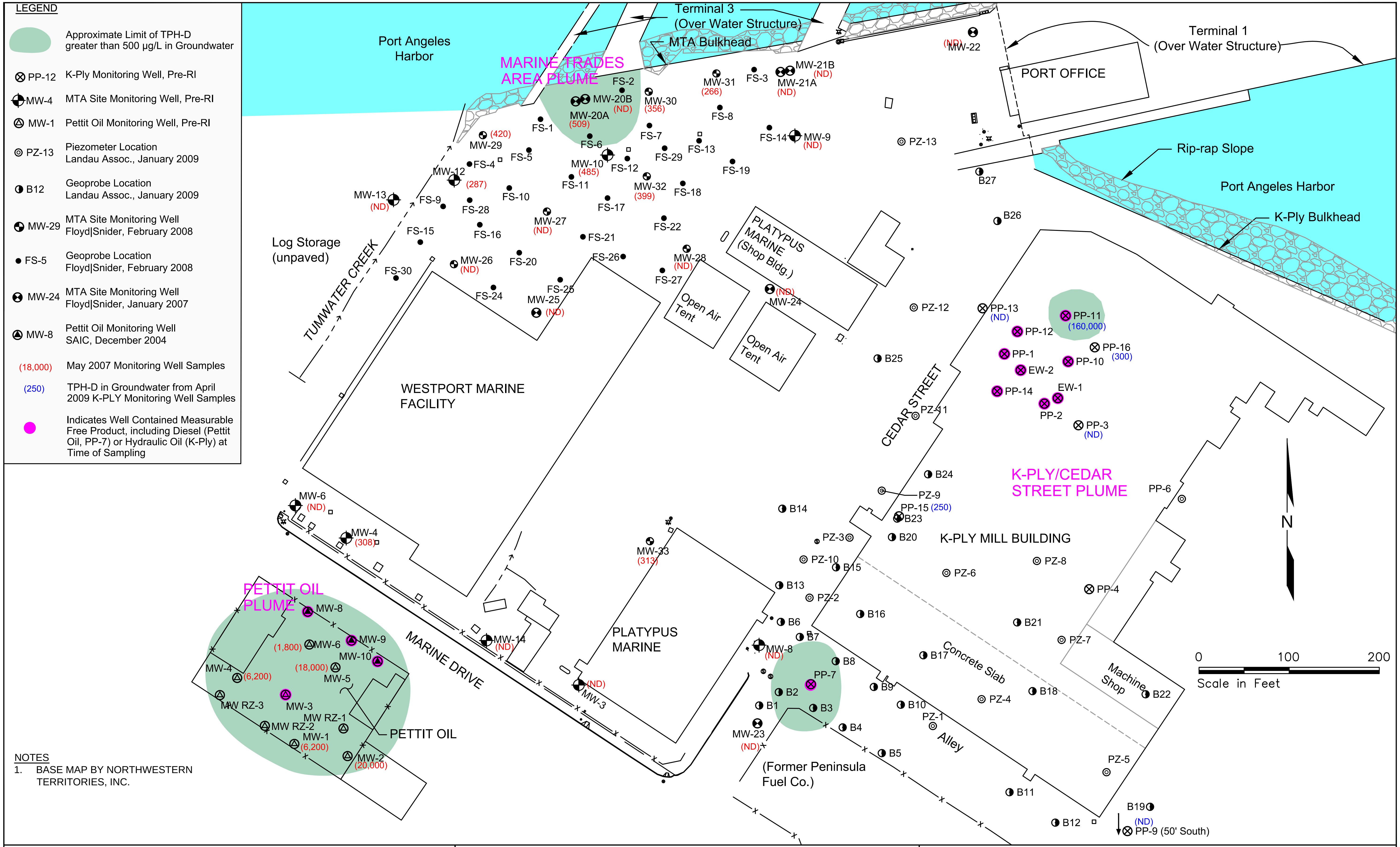
Marine Trades Area Site
Port Angeles, Washington

Figure 4.7
TPH-G in Groundwater

DWG NAME: K:\Project\clients\Floyd and Snider\PPA-OMW\ppa0082rev2012-03.dwg
DATE: 3/14/2012 8:48 PM



NOTES
1. BASE MAP BY NORTHWESTERN TERRITORIES, INC.

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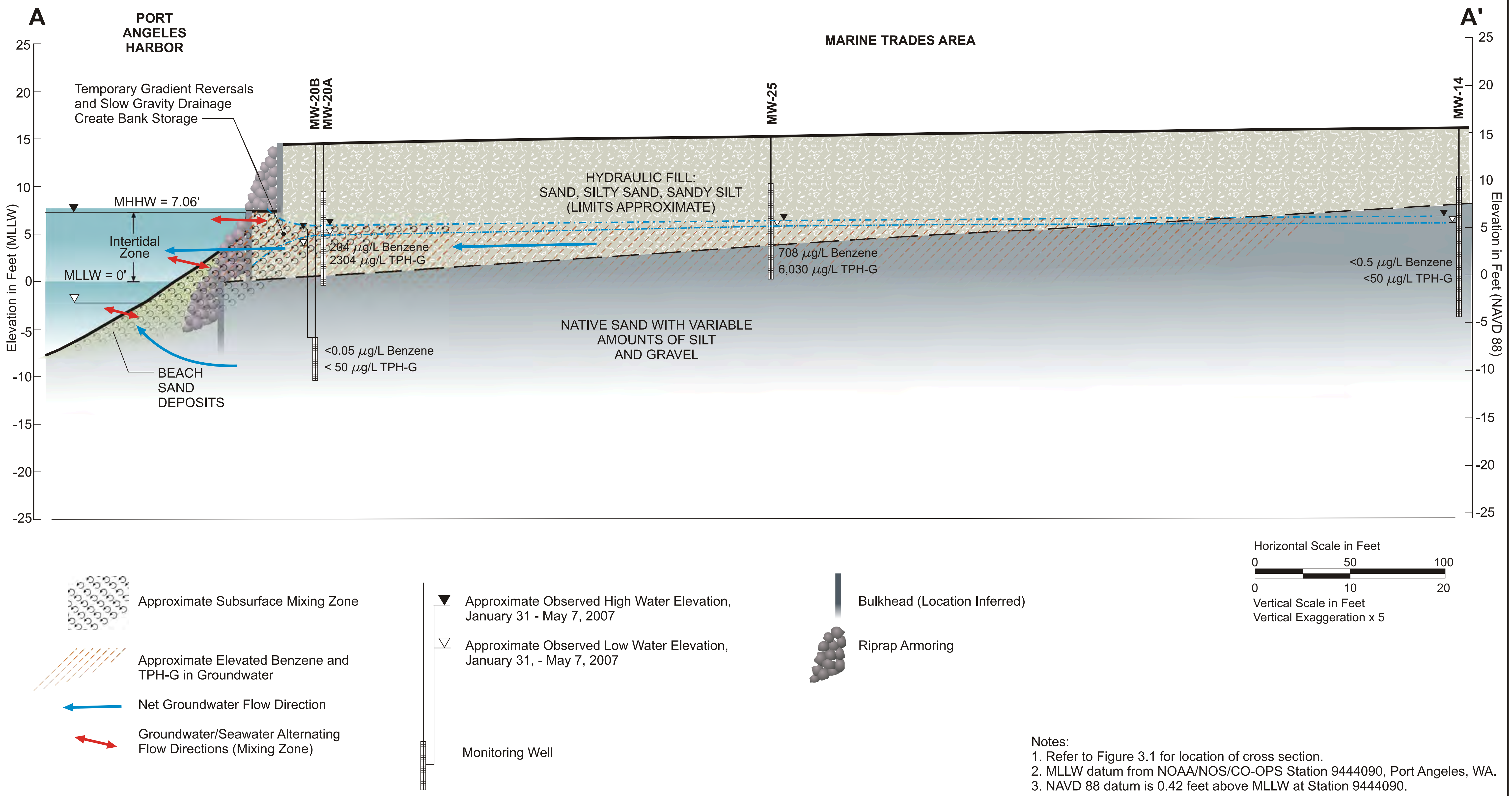
Figure 4.8
TPH-D in Groundwater

DWG NAME: K:\Project\clients\Floyd and Snider\PPA-OMW\ppa0083rev2012-03.dwg
DATE: 3/14/2012 8:48 PM



Notes:
1. Refer to Figure 3.1 for location of cross section.
2. MLLW datum from NOAA/NOS/CO-OPS Station 9444090, Port Angeles, WA.
3. NAVD 88 datum is 0.42 feet above MLLW at Station 9444090.

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Marine Trades Area Site
Port Angeles, WA

Figure 4.9
Conceptual Cross Section A-A' Illustrating
Tidal Influence along Bulkhead

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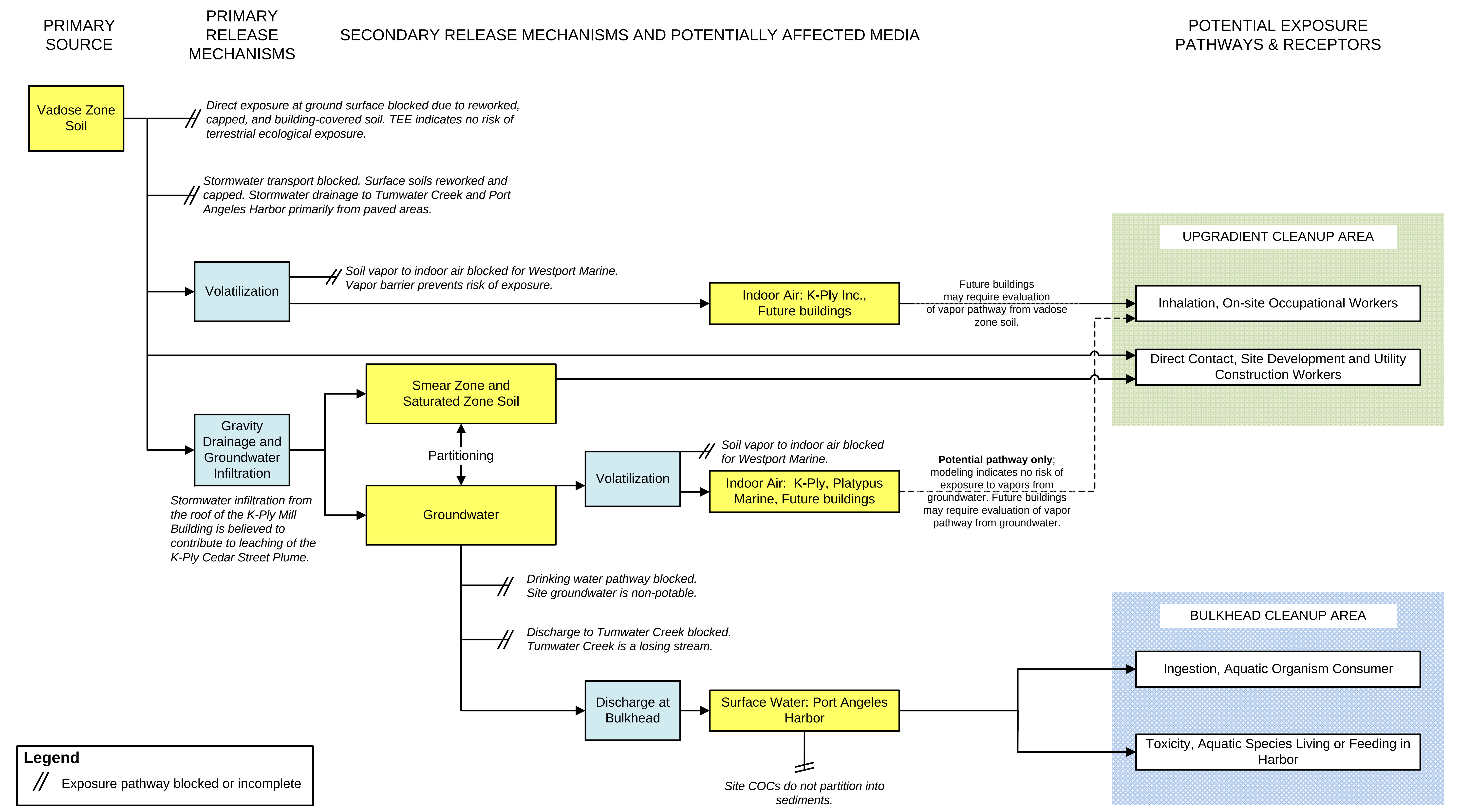

Direct exposure at ground surface blocked due to reworked, capped, and building-covered soil. TEE indicates no risk of terrestrial ecological exposure.

Stormwater transport blocked. Surface soils reworked and capped. Stormwater drainage to Tumwater Creek and Port Angeles Harbor primarily from paved areas.

Soil vapor to indoor air blocked for Westport Marine. Vapor barrier prevents risk of exposure.

Future buildings may require evaluation of vapor pathway from vadose zone soil.

Stormwater infiltration from the roof of the K-Ply Mill Building is believed to contribute to leaching of the K-Ply Cedar Street Plume.

Soil vapor to indoor air blocked for Westport Marine.

Potential pathway only; modeling indicates no risk of exposure to vapors from groundwater. Future buildings may require evaluation of vapor pathway from groundwater.

Drinking water pathway blocked. Site groundwater is non-potable.

Discharge to Tumwater Creek blocked. Tumwater Creek is a losing stream.

Site COCs do not partition into sediments.

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Marine Trades Area Site
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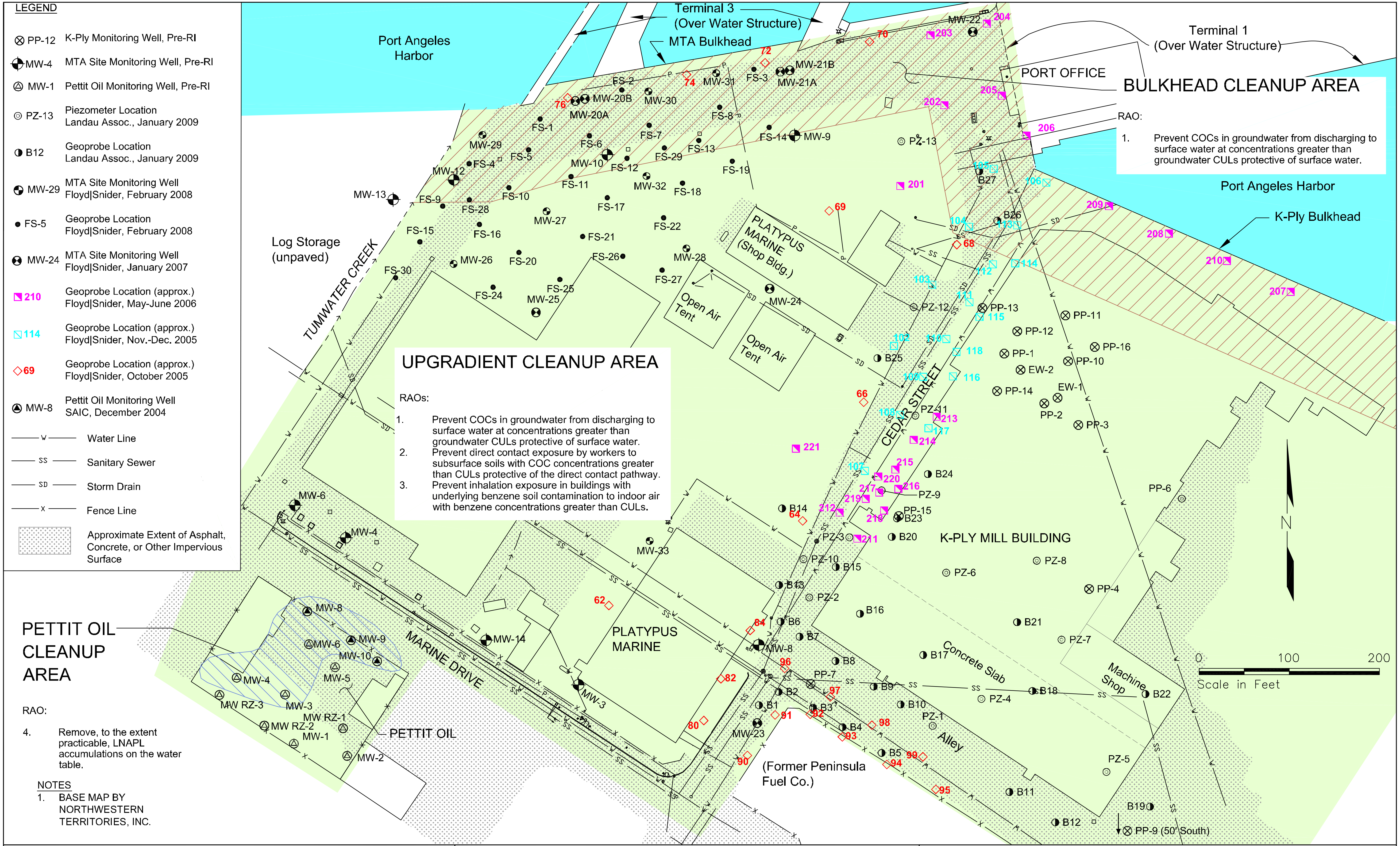
Figure 5.1
Conceptual Site Model of Potential Exposure Pathways and Receptors

F:\projects\SJZ-MTA\Task 7 Final RIFS West Side\RIFS Report\MTA RIFS Final August 2013\MTA RIFS F5_1 082113.vsd



LEGEND

⊗ PP-12	K-Ply Monitoring Well, Pre-RI
MW-4	MTA Site Monitoring Well, Pre-RI
MW-1	Pettit Oil Monitoring Well, Pre-RI
◎ PZ-13	Piezometer Location Landau Assoc., January 2009
◑ B12	Geoprobe Location Landau Assoc., January 2009
MW-29	MTA Site Monitoring Well Floyd|Snider, February 2008
• FS-5	Geoprobe Location Floyd|Snider, February 2008
MW-24	MTA Site Monitoring Well Floyd|Snider, January 2007
210	Geoprobe Location (approx.) Floyd|Snider, May-June 2006
114	Geoprobe Location (approx.) Floyd|Snider, Nov.-Dec. 2005
◇69	Geoprobe Location (approx.) Floyd|Snider, October 2005
MW-8	Pettit Oil Monitoring Well SAIC, December 2004
——W——	Water Line
——SS——	Sanitary Sewer
——SD——	Storm Drain
——X——	Fence Line
▒	Approximate Extent of Asphalt, Concrete, or Other Impervious Surface

BULKHEAD CLEANUP AREA

RAO:

1. Prevent COCs in groundwater from discharging to surface water at concentrations greater than groundwater CULs protective of surface water.

UPGRADIENT CLEANUP AREA

RAOs:

1. Prevent COCs in groundwater from discharging to surface water at concentrations greater than groundwater CULs protective of surface water.
2. Prevent direct contact exposure by workers to subsurface soils with COC concentrations greater than CULs protective of the direct contact pathway.
3. Prevent inhalation exposure in buildings with underlying benzene soil contamination to indoor air with benzene concentrations greater than CULs.

PETTIT OIL CLEANUP AREA

RAO:

4. Remove, to the extent practicable, LNAPL accumulations on the water table.

NOTES

1. BASE MAP BY NORTHWESTERN TERRITORIES, INC.

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Figure 5.2
Cleanup Areas

DWG NAME: G:\project\Clients\Floyd and Snider\PPA-OMW\ppa0084rev2010-08.dwg
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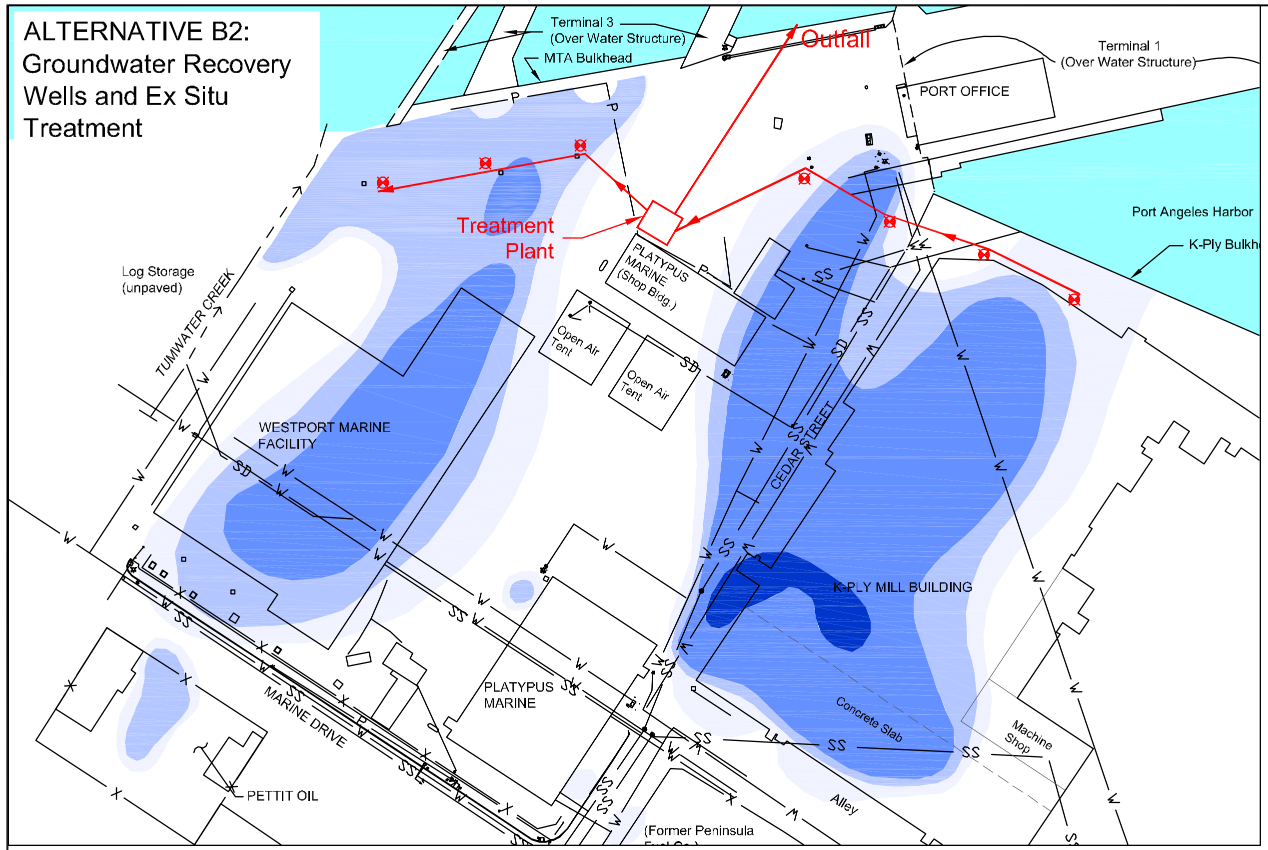
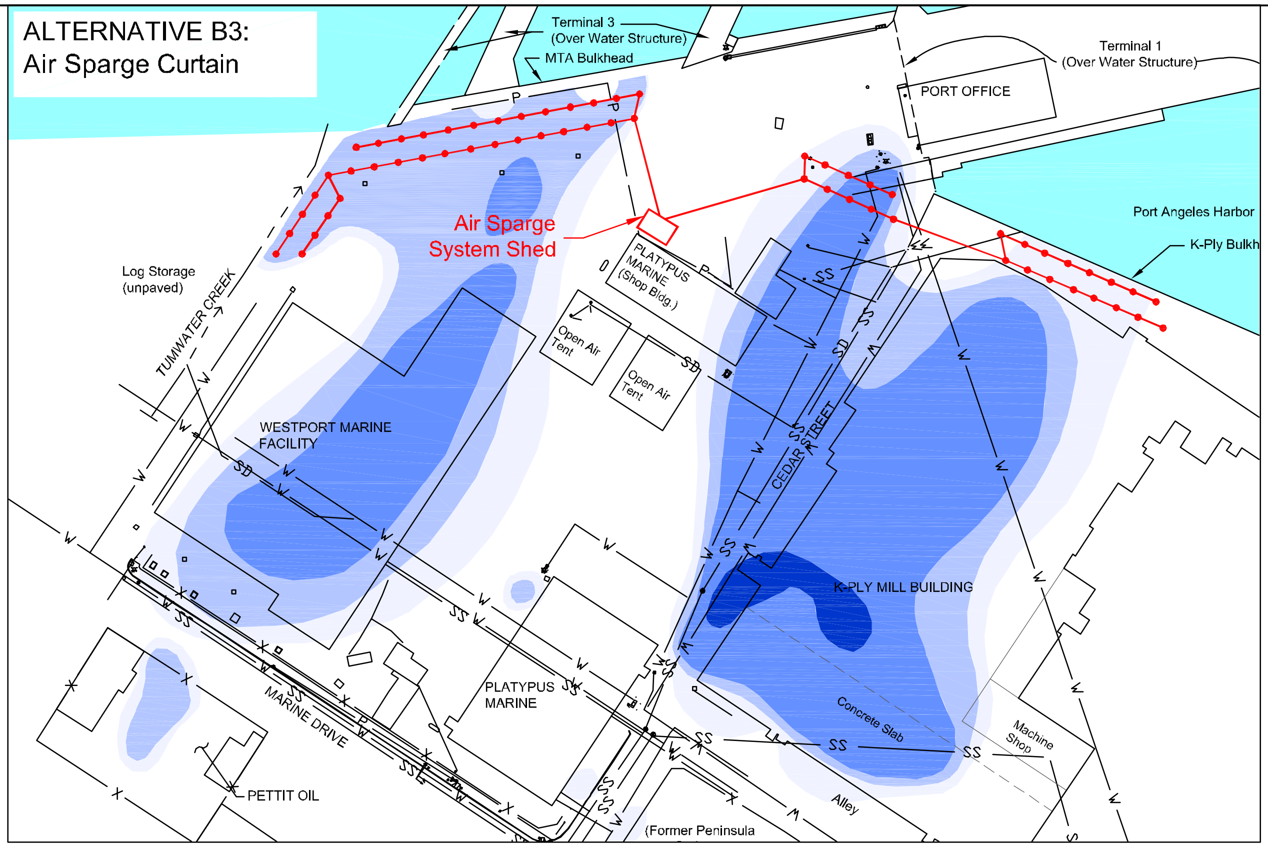


ALTERNATIVE B2:
Groundwater Recovery Wells and Ex Situ Treatment



ALTERNATIVE B3:
Air Sparge Curtain

LEGEND

●	Approximate Extent of Benzene in Groundwater: greater than 5,000 µg/L
●	Approximate Extent of Benzene in Groundwater: greater than 500 µg/L
●	Approximate Extent of Benzene in Groundwater: greater than 50 µg/L
●	Approximate Extent of Benzene in Groundwater: greater than 5 µg/L (MTCA A)

Alternative B2 Legend

⊠	Extraction Well
←	Pipe and/or Electrical Trench. Arrow indicates direction of flow.

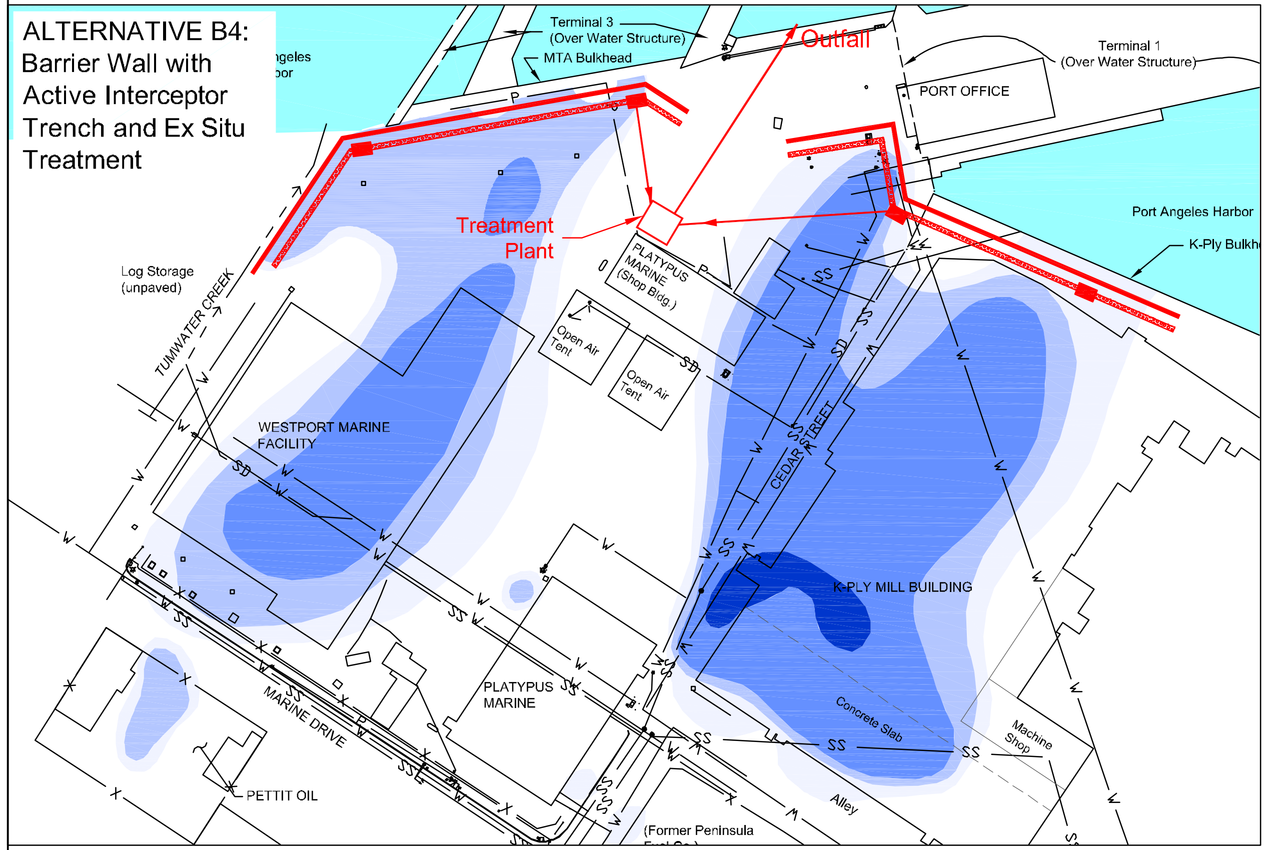
Alternative B3 Legend

•	Air Sparge Well
—	Air Injection Trench

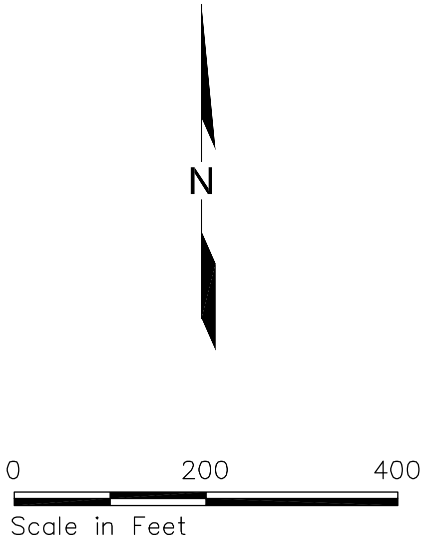
Alternative B4 Legend

—	Subsurface Barrier Wall
▨	Interceptor Trench
■	Lift Station
←	Pipe and/or Electrical Trench. Arrow indicates direction of flow.

Note: For simplicity, the groundwater monitoring network is not shown in these conceptual illustrations.



ALTERNATIVE B4:
Barrier Wall with Active Interceptor Trench and Ex Situ Treatment



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Marine Trades Area Site
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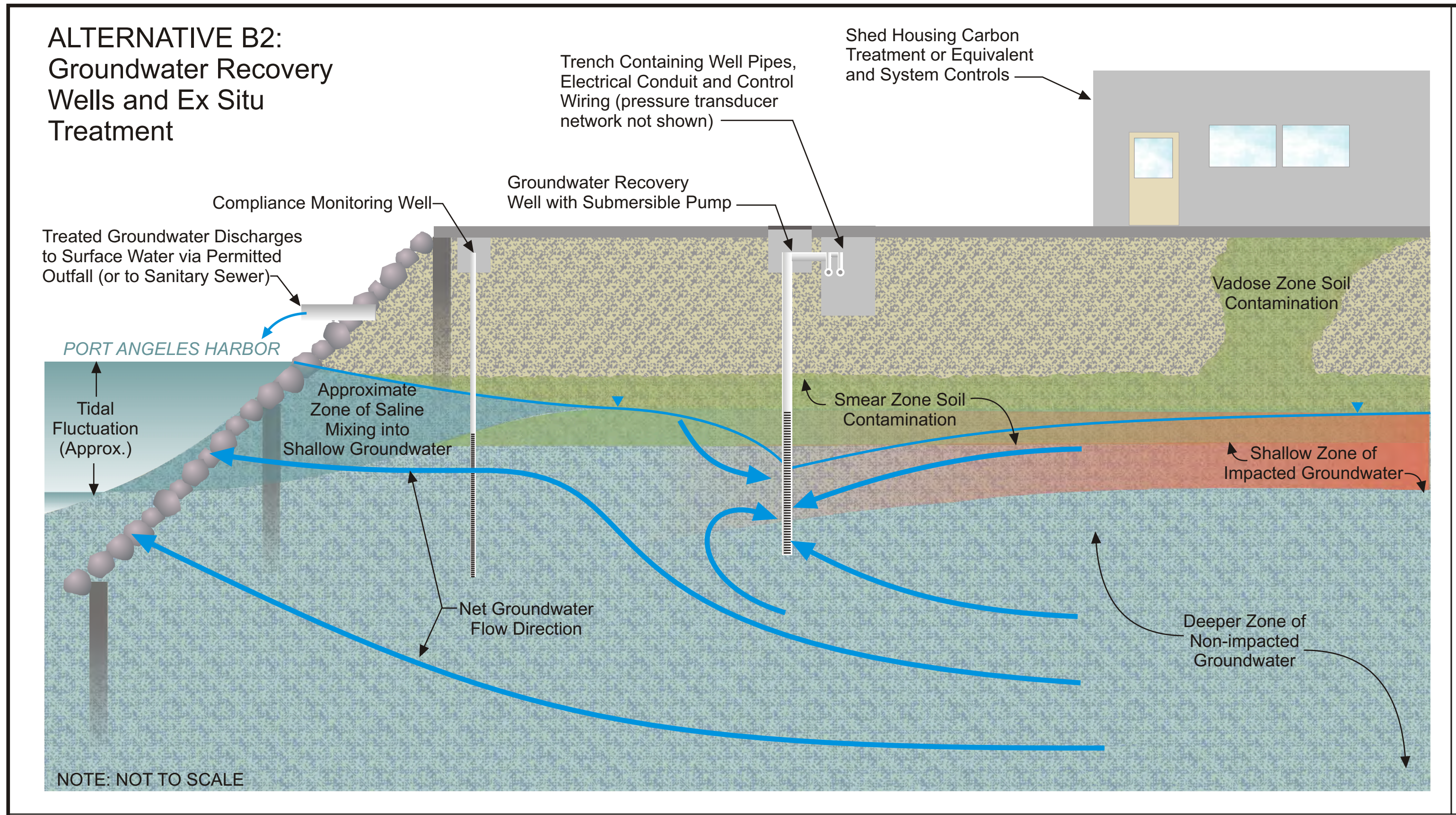
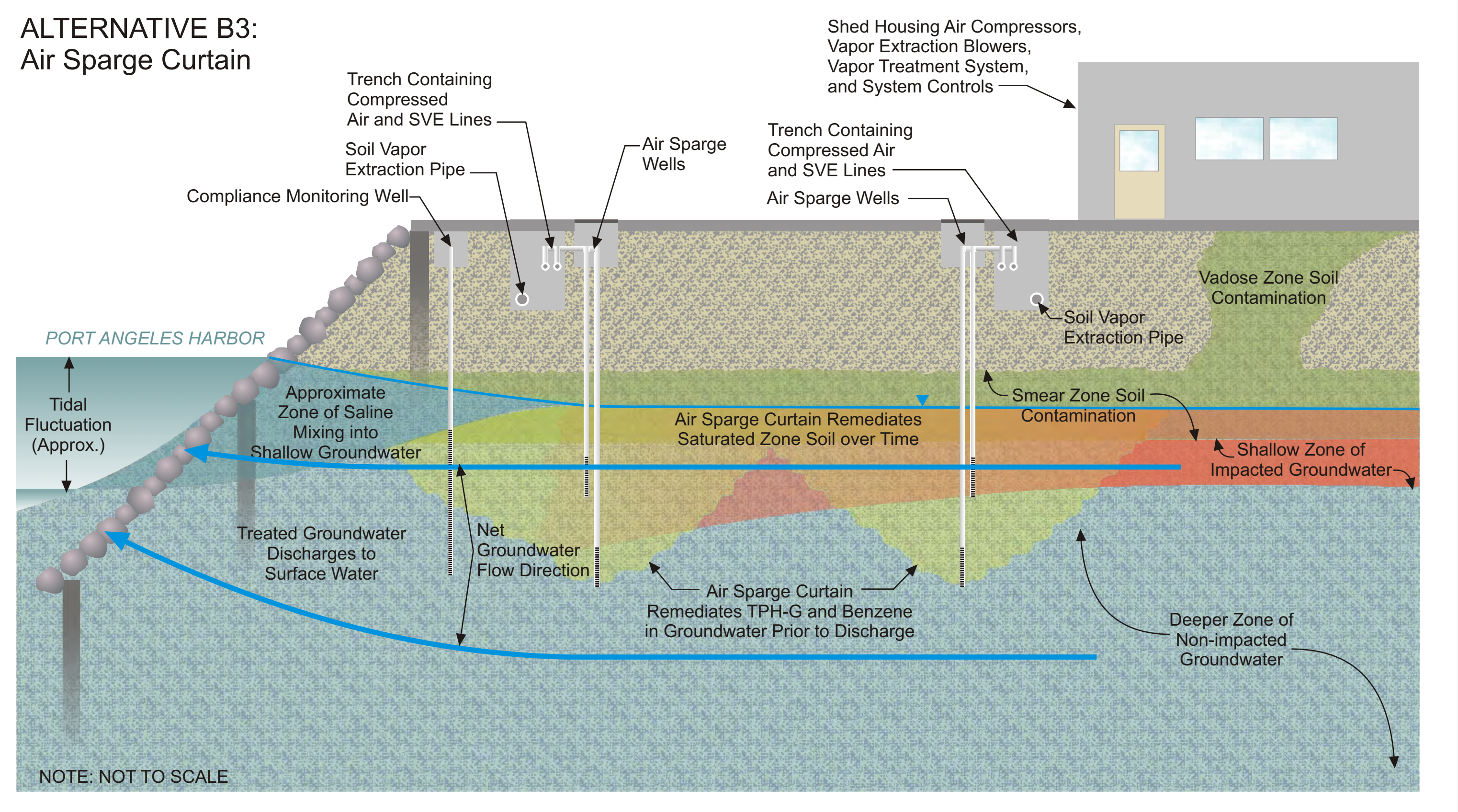
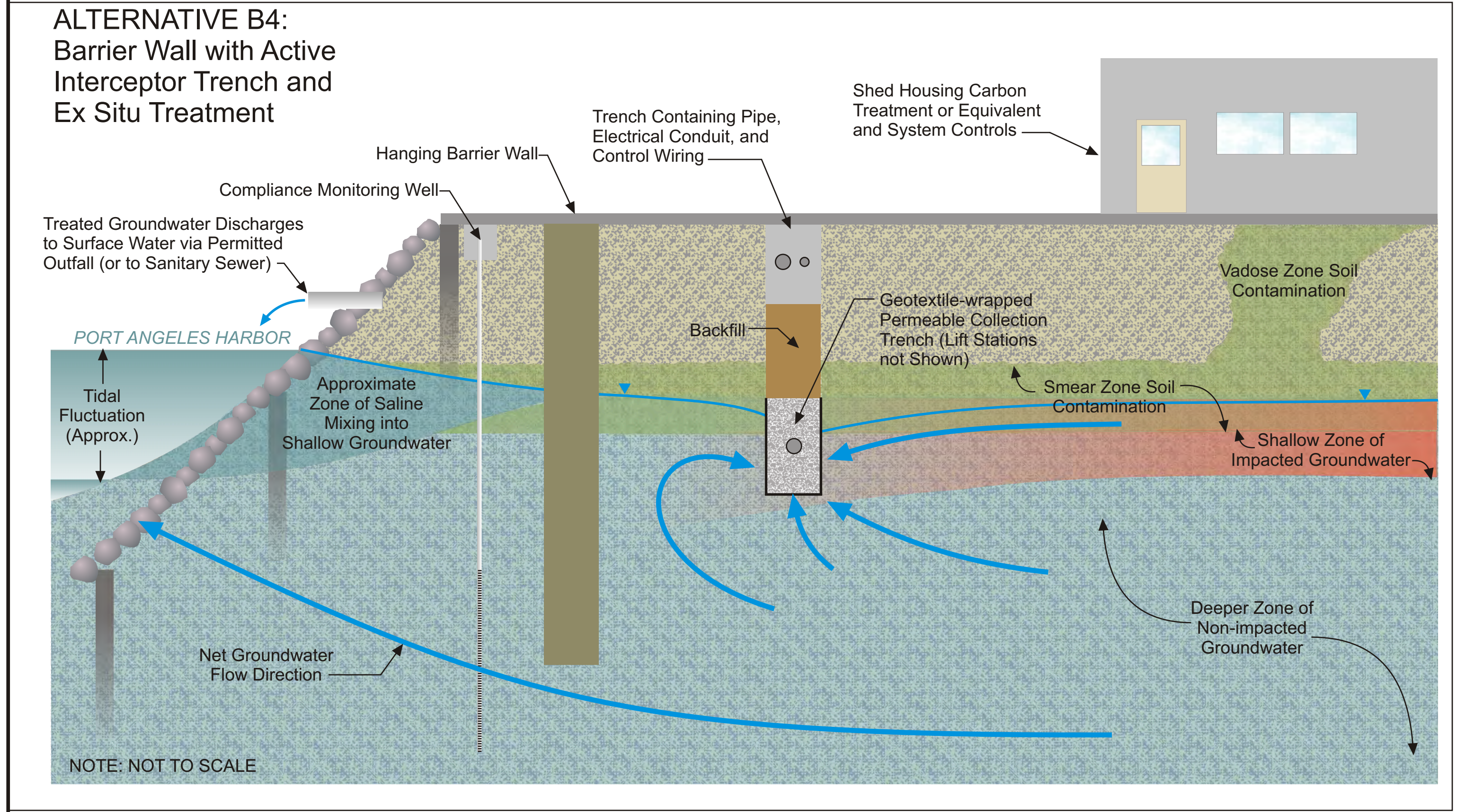
Figure 8.1
Bulkhead Cleanup Area Alternatives
Conceptual Illustrations

DWG NAME: G:\project\Clients\Floyd and Snider\PPA-OMW\ppa0085rev2011-04.dwg
DATE: 4/4/2011 12:30 PM


ALTERNATIVE B2: Groundwater Recovery Wells and Ex Situ Treatment


ALTERNATIVE B3: Air Sparge Curtain


ALTERNATIVE B4: Barrier Wall with Active Interceptor Trench and Ex Situ Treatment

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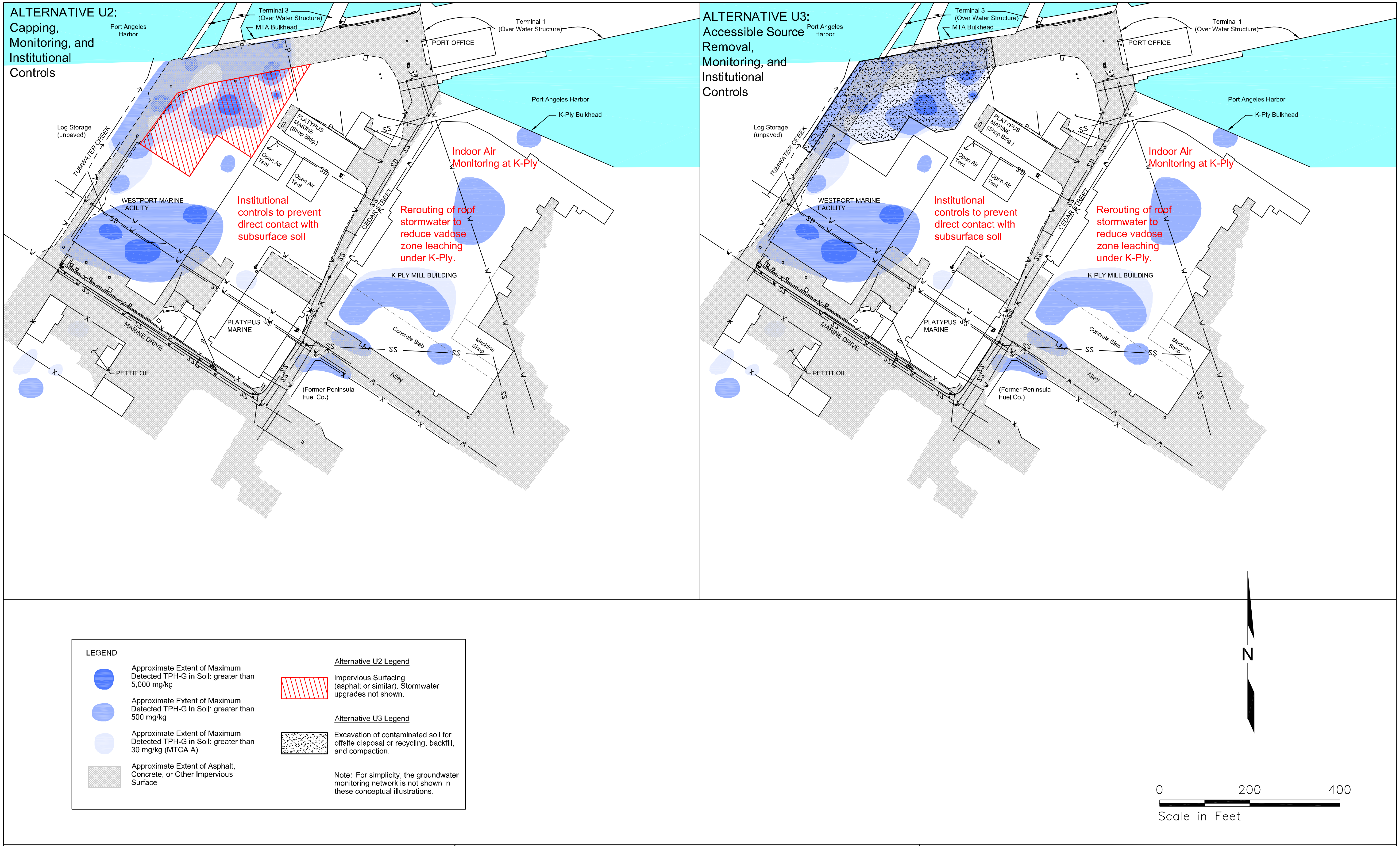
Marine Trades Area Site
Port Angeles, WA

Figure 8.2
Bulkhead Cleanup Area Alternatives
Conceptual Cross Sections



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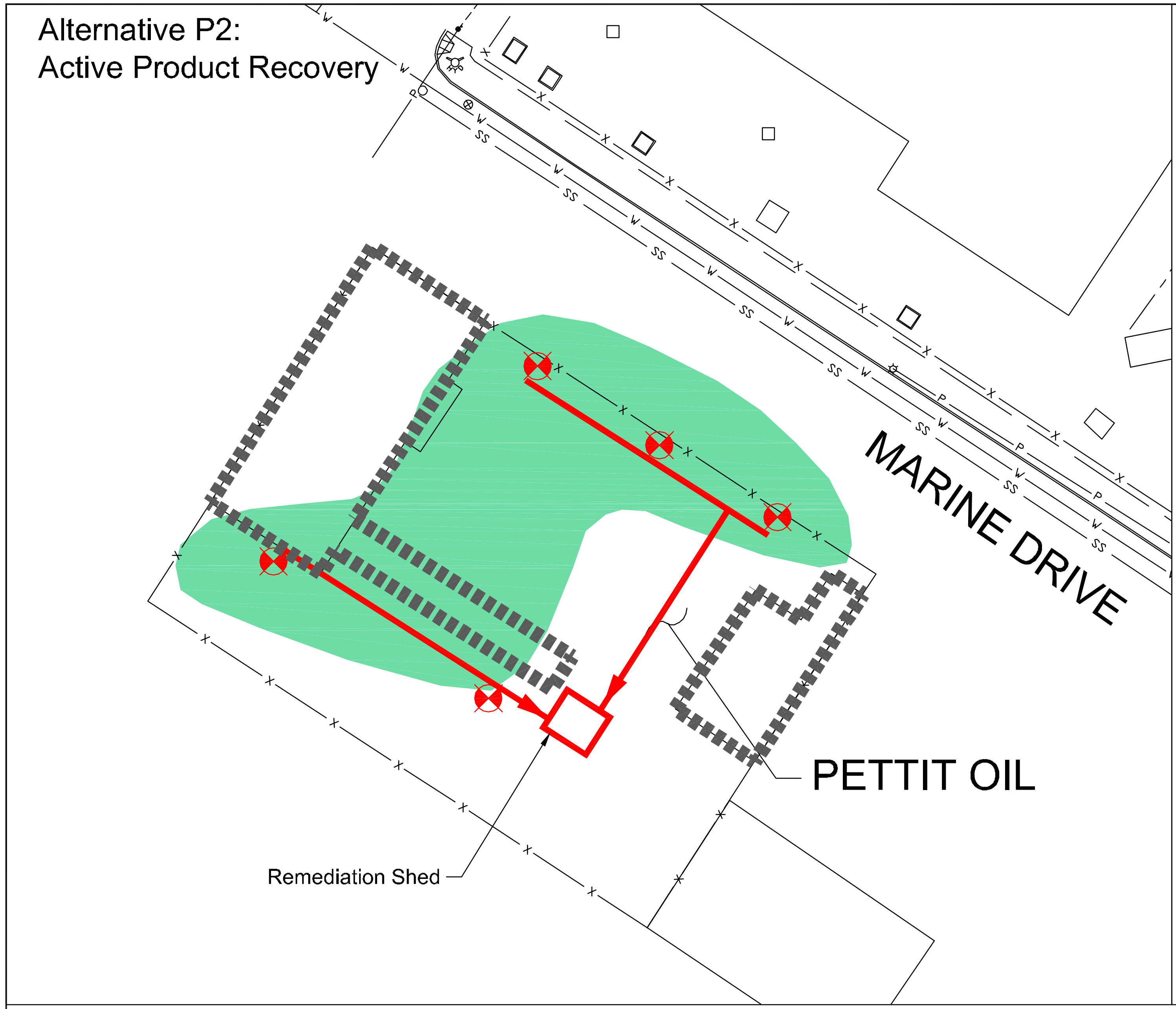
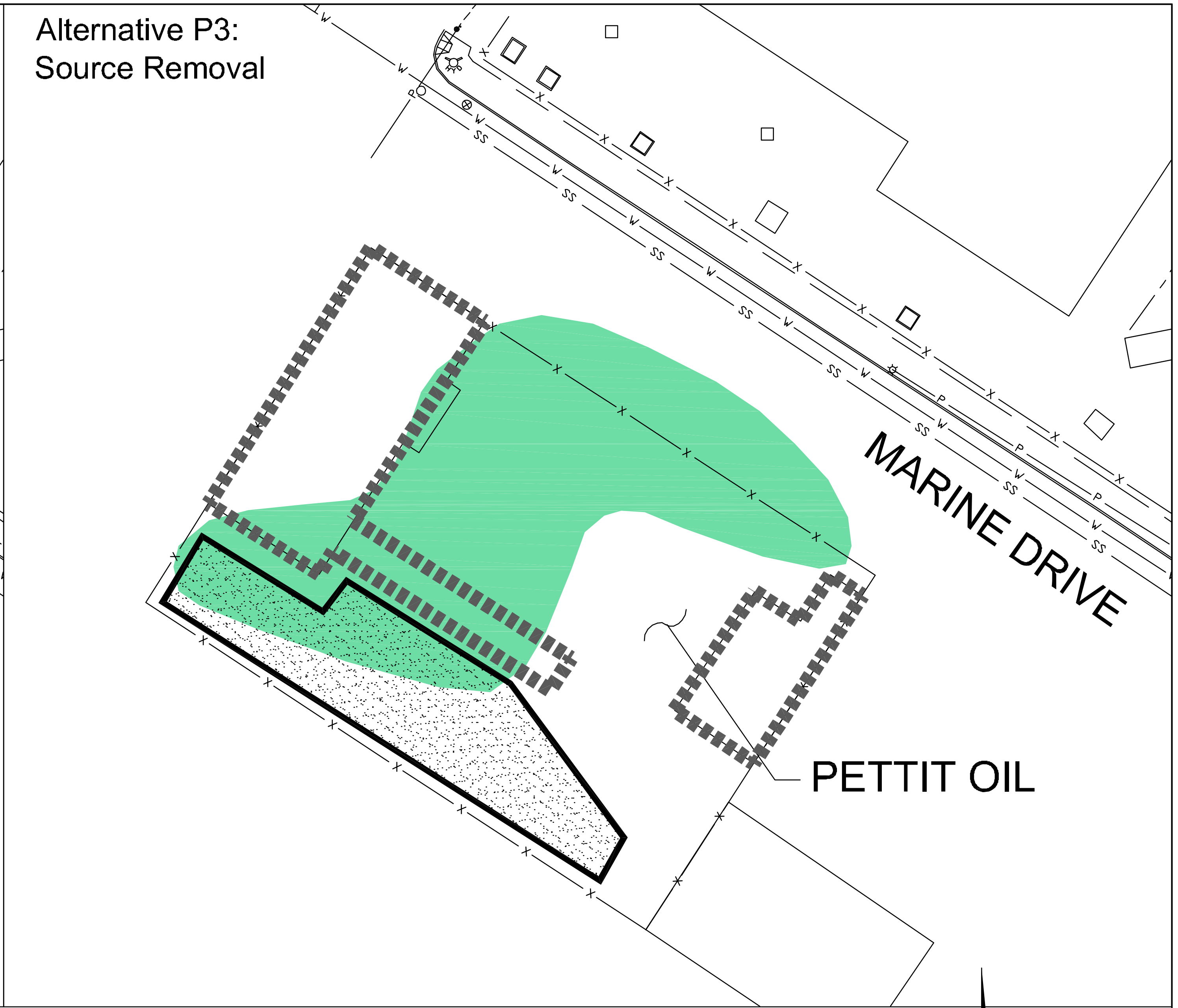
Marine Trades Area Site
Port Angeles, Washington

Figure 8.3
Upgradient Cleanup Area Alternatives
Conceptual Illustrations

DWG NAME: G:\project\Clients\Floyd and Snider\PPA-OMW\ppa0086rev2010-08.dwg
DATE: 5/11/2011 10:26 AM


Alternative P2:
Active Product Recovery


Alternative P3:
Source Removal

LEGEND

🟩	Approximate Extent of TPH-D greater than 10,000 mg/kg in soil and potential extent of LNAPL
LNAPL	Light, non-aqueous phase liquid
AST	Above-ground storage tank

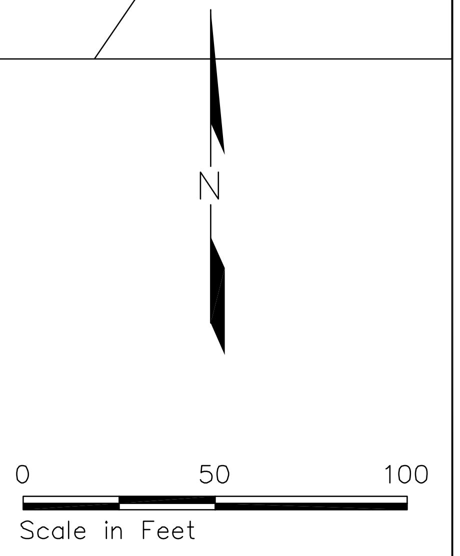
Note: For simplicity, the groundwater monitoring network is not shown in these conceptual illustrations.

Alternative P2 Legend

⊗	Recovery Well, vacuum-enhanced recovery well, or bioslurping well
←	LNAPL recovery piping and electrical trench. Arrow indicates direction of flow
▭	Approximate footprint occupied by buildings, ASTs, and other structures

Alternative P3 Legend

▨	Approximate initial excavation of contaminated soil and removal of LNAPL for offsite disposal or recycling. Remainder of LNAPL and soil impacted to concentrations greater than MTCA C to be excavated at a future time.
▭	Approximate footprint occupied by buildings, ASTs, and other structures



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Port Angeles, Washington

Figure 8.4
Pettit Oil Cleanup Area Alternatives
Conceptual Illustrations

DWG NAME: G:\project\Clients\Floyd and Snider\PPA-OMW\ppa0087rev2011-04.dwg
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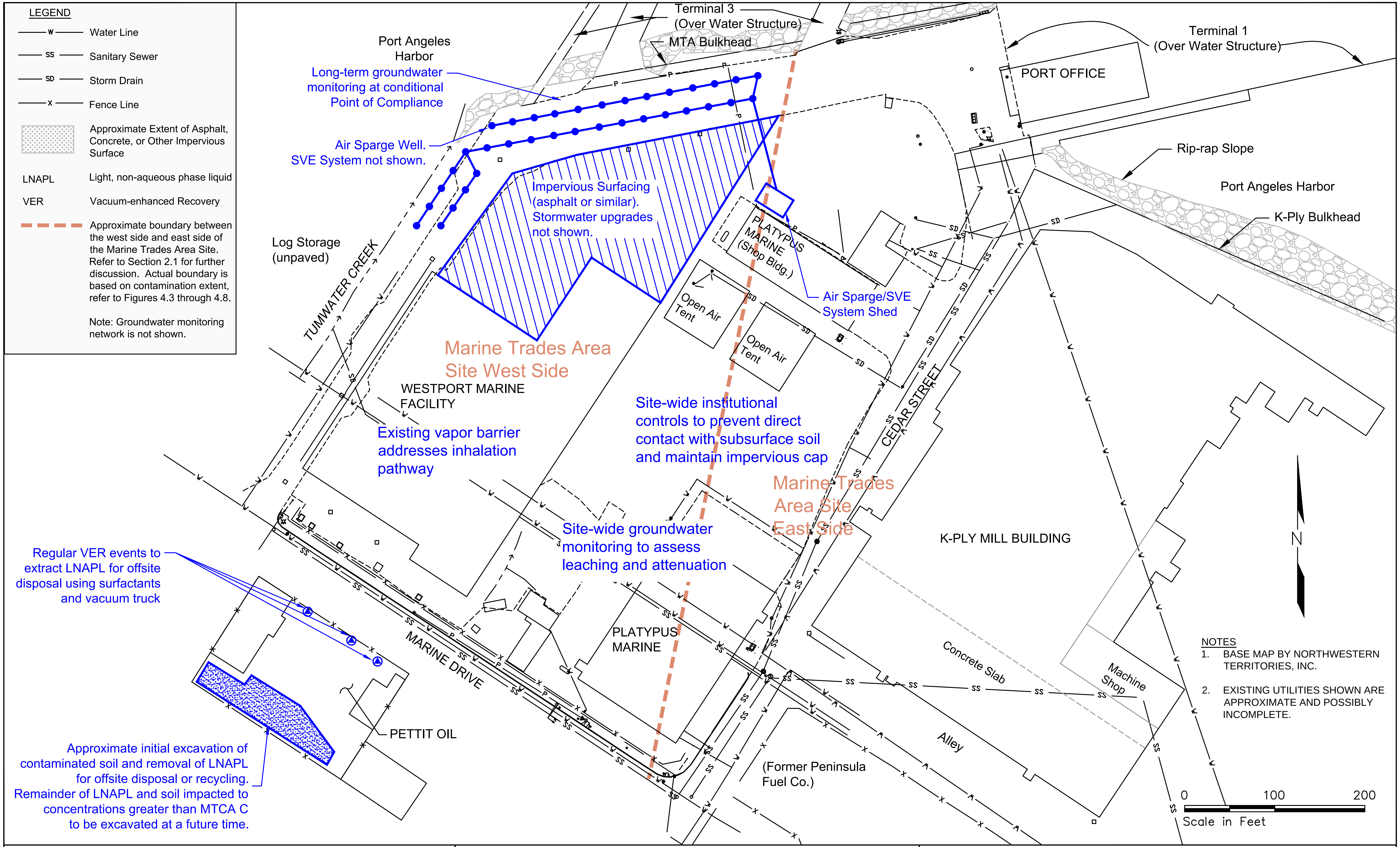

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Marine Trades Area Site
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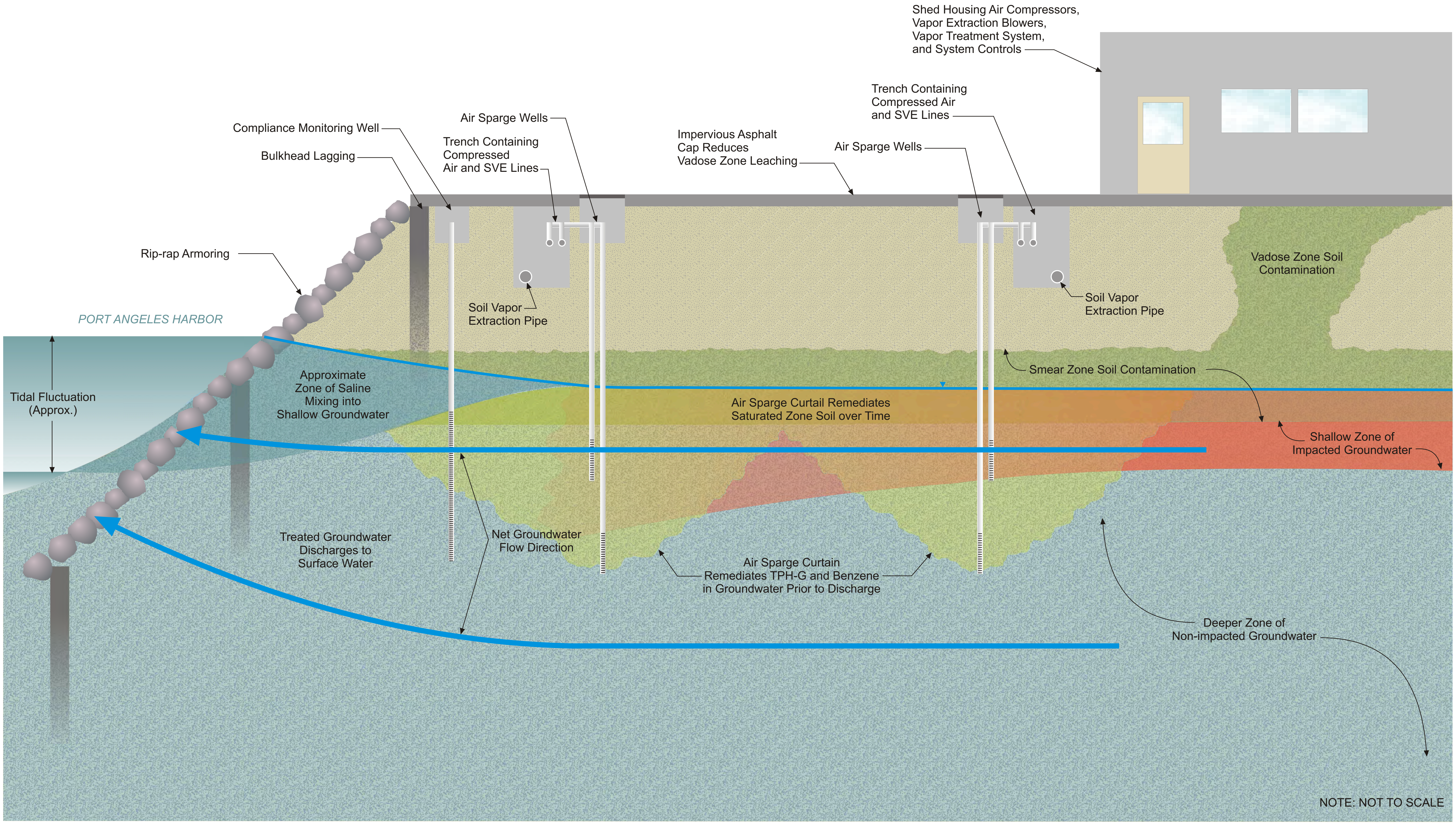
Figure 10.1
Preferred Cleanup Action
Conceptual Illustration

DWG NAME: K:\Project\clients\Floyd and Snider\PPA-OMW\ppa0088rev2012-05.dwg
DATE: 5/8/2012 8:51 PM



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Marine Trades Area Site
Port Angeles, WA

Figure 10.2
Conceptual Cross Section Illustrating
Preferred Bulkhead Remedy

G:Project\Clients\Floyd Snider\SJZ\

Marine Trades Area Site
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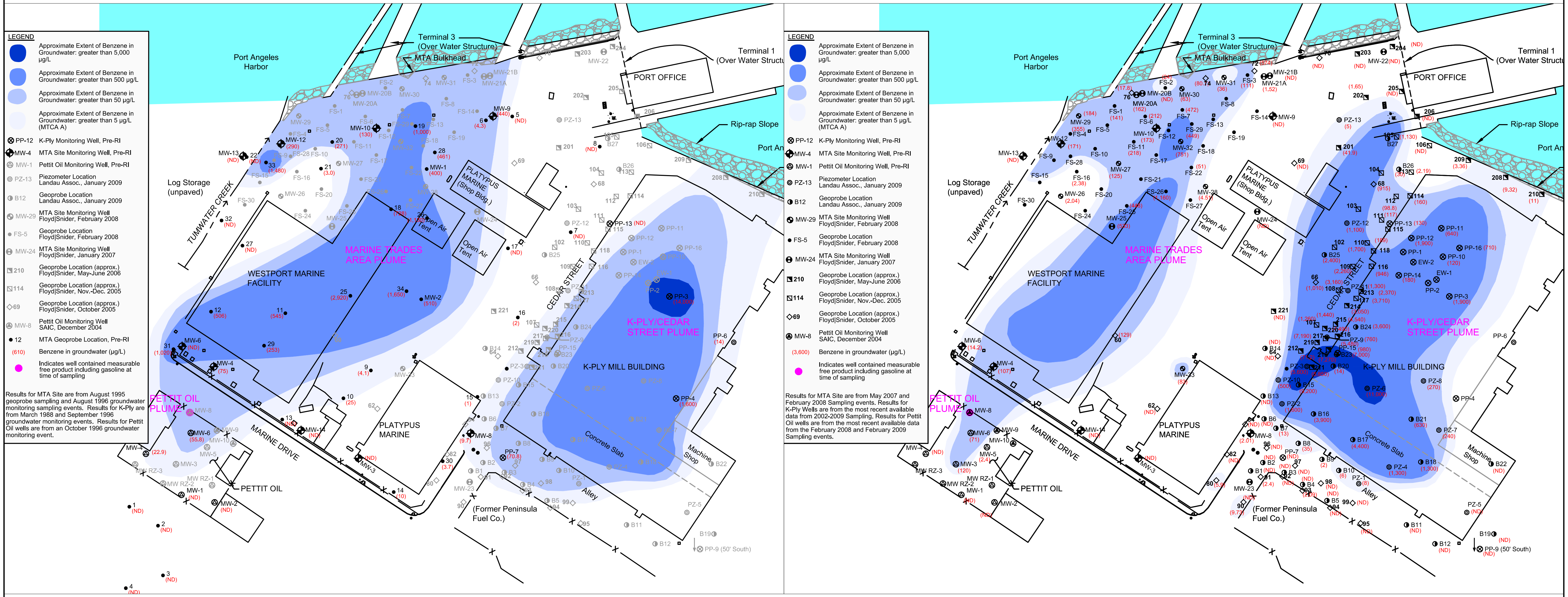
Appendix A
Comparison of Historic Versus Recent Groundwater Contamination Extent



Results for MTA Site are from August 1995 geoprobe sampling and August 1996 groundwater monitoring sampling events. Results for K-Ply are from March 1988 and September 1996 groundwater monitoring events. Results for Pettit Oil wells are from an October 1996 groundwater monitoring event.

Results for MTA Site are from May 2007 and February 2008 Sampling events. Results for K-Ply Wells are from the most recent available data from 2002-2009 Sampling. Results for Pettit Oil wells are from the most recent available data from the February 2008 and February 2009 Sampling events.

Historical

Recent

NOTES
1. BASE MAP BY NORTHWESTERN TERRITORIES, INC.
2. DUE TO LIMITED HISTORICAL DATA, CONTOURS ARE BASED ON CURRENT PLUME EXTENTS AND HISTORICAL SITE USE. PLUME EXTENTS ARE THEREFORE HIGHLY UNCERTAIN.

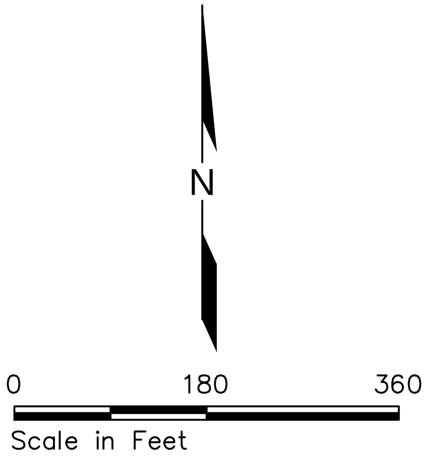


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Figure A.1
Historical Benzene in Groundwater

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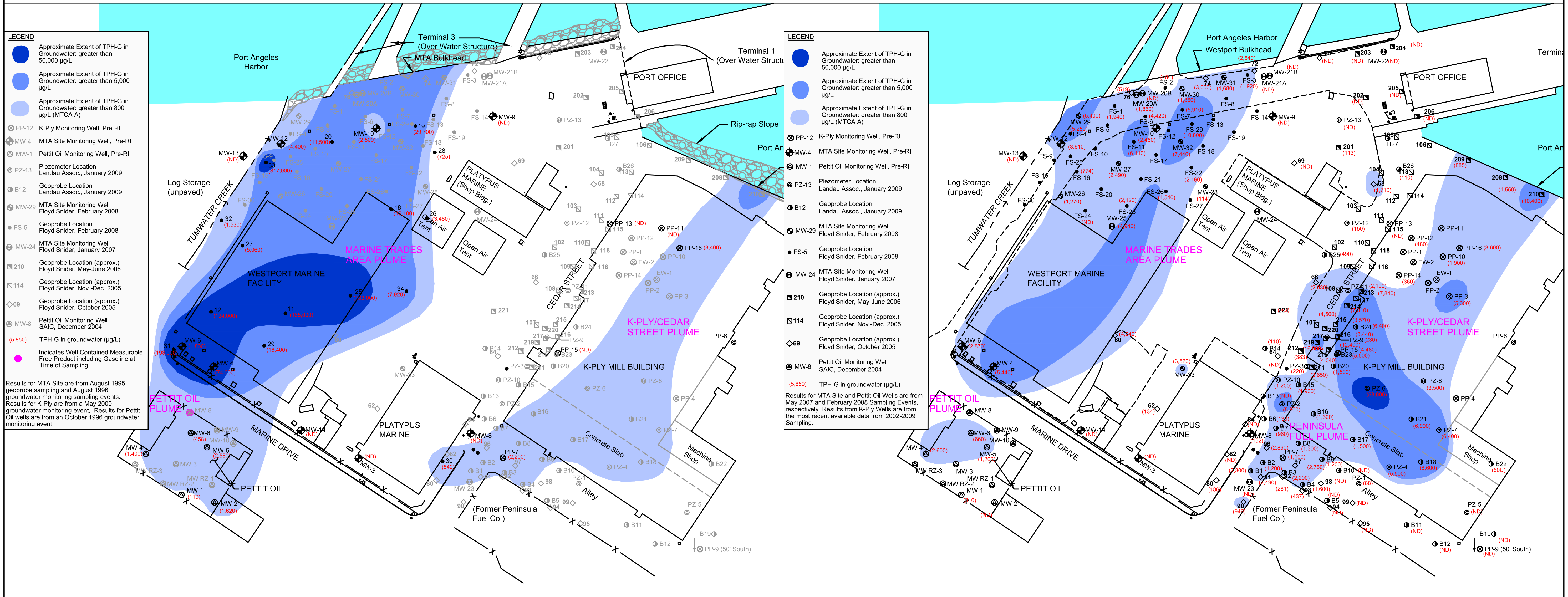
DATE: 3/27/2012 3:08 PM



Results for MTA Site are from August 1995 geoprobe sampling and August 1996 groundwater monitoring sampling events. Results for K-Ply are from a May 2000 groundwater monitoring event. Results for Pettit Oil wells are from an October 1996 groundwater monitoring event.

Results for MTA Site and Pettit Oil Wells are from May 2007 and February 2008 Sampling Events, respectively. Results from K-Ply Wells are from the most recent available data from 2002-2009 Sampling.

Historical

Recent

NOTES

1. BASE MAP BY NORTHWESTERN TERRITORIES, INC.
2. DUE TO LIMITED HISTORICAL DATA, CONTOURS ARE BASED ON CURRENT PLUME EXTENTS AND HISTORICAL SITE USE. PLUME EXTENTS ARE THEREFORE HIGHLY UNCERTAIN.

N

0 180 360

Scale in Feet

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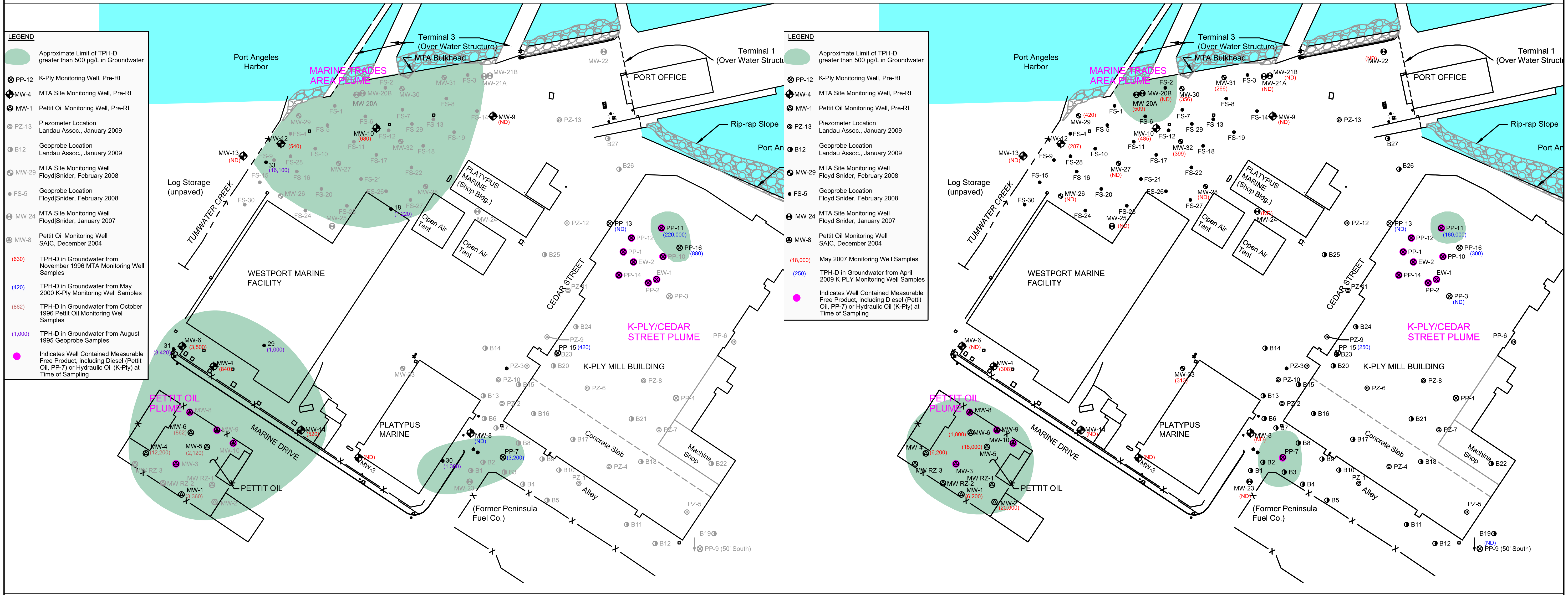
Figure A.2
Historical TPH-G in Groundwater

DWG NAME: K:\Project\clients\Floyd and Snider\PPA-OMW\ppa0091.dwg
DATE: 3/27/2012 3:08 PM



Historical

Recent

N

0 180 360
Scale in Feet

NOTES
1. BASE MAP BY NORTHWESTERN TERRITORIES, INC.

2. DUE TO LIMITED HISTORICAL DATA, CONTOURS ARE BASED ON CURRENT PLUME EXTENTS AND HISTORICAL SITE USE. PLUME EXTENTS ARE THEREFORE HIGHLY UNCERTAIN.

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Figure A.3
Historical TPH-D in Groundwater

DWG NAME: K:\Project\clients\Floyd and Snider\PPA-OMW\ppa0089.dwg
DATE: 3/27/2012 3:08 PM

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Appendix B
January 2003 Groundwater Sampling Results Table (Detects Only) and Pettit Oil Groundwater Sampling Summary Table

Table D.1
FSM January 2003 Groundwater Sampling Results
(Detects Only)

SAMPLE NAME	SAMPLE DATE	ANALYTICAL METHOD	ANALYTE	CONC	UNITS	DILUTION	DL	RL
MW1	1/10/2003 14:30	8260B VOA Full List	1,2,4-Trimethylbenzene	181	μg/L	5	2.96	5
MW1	1/10/2003 14:30	8260B VOA Full List	1,2,4-Trimethylbenzene	167	μg/L	100	59.2	100
MW10	1/9/2003 2:45	8260B VOA Full List	1,2,4-Trimethylbenzene	4.08	μg/L	4	2.37	4
MW1	1/10/2003 14:30	8260B VOA Full List	1,3,5-Trimethylbenzene	61.6	μg/L	5	2.22	5
MW10	1/9/2003 2:45	8260B VOA Full List	1,3,5-Trimethylbenzene	7.17	μg/L	4	1.78	4
MW11	1/10/2003 16:30	8260B VOA Full List	1,3,5-Trimethylbenzene	2.25	μg/L	1	0.444	1
MW1	1/10/2003 14:30	8270C SVOA Full List	2-Methylnaphthalene	70	μg/L	1	0.697	10
MW10	1/9/2003 2:45	8270C SVOA Full List	2-Methylnaphthalene	37.7	μg/L	1	0.697	10
MW17	1/9/2003 10:15	8270C SVOA Full List	2-Methylnaphthalene	16.1	μg/L	1	0.697	10
MW1	1/10/2003 14:30	8260B VOA Full List	Benzene	1210	μg/L	5	1.4	5
MW1	1/10/2003 14:30	8260B VOA Full List	Benzene	1470	μg/L	100	28.1	100
MW1	1/10/2003 14:30	NWTPH-G/BTEX MTBE	Benzene	1600	μg/L	50	4.65	25
MW1D	1/10/2003 14:30	NWTPH-G/BTEX MTBE	Benzene	1670	μg/L	20	1.86	10
MW2	1/11/2003 10:00	8260B VOA Full List	Benzene	49.3	μg/L	4	1.12	4
MW2	1/11/2003 10:00	NWTPH-G/BTEX MTBE	Benzene	47.6	μg/L	1	0.093	0.5
MW4	1/8/2003 23:30	NWTPH-G/BTEX MTBE	Benzene	218	μg/L	20	1.86	10
MW5	1/8/2003 18:47	NWTPH-G/BTEX MTBE	Benzene	1.69	μg/L	1	0.093	0.5
MW6	1/10/2003 18:00	NWTPH-G/BTEX MTBE	Benzene	23.4	μg/L	10	0.93	5
MW10	1/9/2003 2:45	8260B VOA Full List	Benzene	310	μg/L	8	2.25	8
MW10	1/9/2003 2:45	8260B VOA Full List	Benzene	325	μg/L	4	1.12	4

Table D.1
FSM January 2003 Groundwater Sampling Results
(Detects Only)

SAMPLE NAME	SAMPLE DATE	ANALYTICAL METHOD	ANALYTE	CONC	UNITS	DILUTION	DL	RL
MW10	1/9/2003 2:45	NWTPH-G/BTEX MTBE	Benzene	348	µg/L	10	0.93	5
MW10D	1/9/2003 2:45	NWTPH-G/BTEX MTBE	Benzene	310	µg/L	5	0.465	2.5
MW11	1/10/2003 16:30	8260B VOA Full List	Benzene	14.8	µg/L	1	0.281	1
MW11	1/10/2003 16:30	NWTPH-G/BTEX MTBE	Benzene	18.4	µg/L	1	0.093	0.5
MW12	1/9/2003 16:30	8260B VOA Full List	Benzene	121	µg/L	5	1.4	5
MW12	1/9/2003 16:30	NWTPH-G/BTEX MTBE	Benzene	144	µg/L	5	0.465	2.5
MW15	1/10/2003 12:00	NWTPH-G/BTEX MTBE	Benzene	1390	µg/L	50	4.65	25
MW17	1/9/2003 10:15	NWTPH-G/BTEX MTBE	Benzene	572	µg/L	10	0.93	5
MW12	1/9/2003 16:30	8270C SVOA Full List	Bis(2-ethylhexyl)phthalate	86.3	µg/L	1	1.6	50
MW1	1/10/2003 14:30	NWTPH-Dx w/SG	Diesel Range Hydrocarbons	0.516	mg/L	1	0.054	0.25
MW1D	1/10/2003 14:30	NWTPH-Dx w/SG	Diesel Range Hydrocarbons	0.528	mg/L	1	0.054	0.25
MW4	1/8/2003 23:30	NWTPH-Dx w/SG	Diesel Range Hydrocarbons	0.347	mg/L	1	0.054	0.25
MW6	1/10/2003 18:00	NWTPH-Dx w/SG	Diesel Range Hydrocarbons	0.307	mg/L	1	0.054	0.25
MW10	1/9/2003 2:45	NWTPH-Dx w/SG	Diesel Range Hydrocarbons	0.381	mg/L	1	0.054	0.25
MW10D	1/9/2003 2:45	NWTPH-Dx w/SG	Diesel Range Hydrocarbons	0.373	mg/L	1	0.054	0.25
MW11	1/10/2003 16:30	NWTPH-Dx w/SG	Diesel Range Hydrocarbons	0.311	mg/L	1	0.054	0.25
MW12	1/9/2003 16:30	NWTPH-Dx w/SG	Diesel Range Hydrocarbons	0.345	mg/L	1	0.054	0.25
MW15	1/10/2003 12:00	NWTPH-Dx w/SG	Diesel Range Hydrocarbons	0.426	mg/L	1	0.054	0.25
MW17	1/9/2003 10:15	NWTPH-Dx w/SG	Diesel Range Hydrocarbons	0.288	mg/L	1	0.054	0.25
MW1	1/10/2003 14:30	8260B VOA Full List	Ethylbenzene	346	µg/L	5	1.64	5

Table D.1
FSM January 2003 Groundwater Sampling Results
(Detects Only)

SAMPLE NAME	SAMPLE DATE	ANALYTICAL METHOD	ANALYTE	CONC	UNITS	DILUTION	DL	RL
MW1	1/10/2003 14:30	8260B VOA Full List	Ethylbenzene	317	µg/L	100	32.8	100
MW1	1/10/2003 14:30	NWTPH-G/BTEX MTBE	Ethylbenzene	357	µg/L	50	2.6	25
MW1D	1/10/2003 14:30	NWTPH-G/BTEX MTBE	Ethylbenzene	397	µg/L	20	1.04	10
MW2	1/11/2003 10:00	NWTPH-G/BTEX MTBE	Ethylbenzene	1.49	µg/L	1	0.052	0.5
MW4	1/8/2003 23:30	NWTPH-G/BTEX MTBE	Ethylbenzene	488	µg/L	20	1.04	10
MW5	1/8/2003 18:47	NWTPH-G/BTEX MTBE	Ethylbenzene	3.96	µg/L	1	0.052	0.5
MW6	1/10/2003 18:00	NWTPH-G/BTEX MTBE	Ethylbenzene	20.1	µg/L	10	0.52	5
MW10	1/9/2003 2:45	8260B VOA Full List	Ethylbenzene	83.4	µg/L	8	2.62	8
MW10	1/9/2003 2:45	8260B VOA Full List	Ethylbenzene	92.2	µg/L	4	1.31	4
MW10	1/9/2003 2:45	NWTPH-G/BTEX MTBE	Ethylbenzene	100	µg/L	10	0.52	5
MW10D	1/9/2003 2:45	NWTPH-G/BTEX MTBE	Ethylbenzene	68.9	µg/L	1	0.052	0.5
MW11	1/10/2003 16:30	8260B VOA Full List	Ethylbenzene	4.72	µg/L	1	0.328	1
MW11	1/10/2003 16:30	NWTPH-G/BTEX MTBE	Ethylbenzene	8.57	µg/L	1	0.052	0.5
MW12	1/9/2003 16:30	8260B VOA Full List	Ethylbenzene	104	µg/L	5	1.64	5
MW12	1/9/2003 16:30	NWTPH-G/BTEX MTBE	Ethylbenzene	129	µg/L	5	0.26	2.5
MW15	1/10/2003 12:00	NWTPH-G/BTEX MTBE	Ethylbenzene	2410	µg/L	50	2.6	25
MW17	1/9/2003 10:15	NWTPH-G/BTEX MTBE	Ethylbenzene	9.98	µg/L	5	0.26	2.5
MW1	1/10/2003 14:30	NWTPH-G/BTEX MTBE	Gasoline Range Hydrocarbons	9380	µg/L	50	525	2500
MW1D	1/10/2003 14:30	NWTPH-G/BTEX MTBE	Gasoline Range Hydrocarbons	9800	µg/L	20	210	1000
MW2	1/11/2003 10:00	NWTPH-G/BTEX MTBE	Gasoline Range Hydrocarbons	630	µg/L	1	10.5	50

Table D.1
FSM January 2003 Groundwater Sampling Results
(Detects Only)

SAMPLE NAME	SAMPLE DATE	ANALYTICAL METHOD	ANALYTE	CONC	UNITS	DILUTION	DL	RL
MW4	1/8/2003 23:30	NWTPH-G/BTEX MTBE	Gasoline Range Hydrocarbons	7990	µg/L	20	210	1000
MW5	1/8/2003 18:47	NWTPH-G/BTEX MTBE	Gasoline Range Hydrocarbons	853	µg/L	1	10.5	50
MW6	1/10/2003 18:00	NWTPH-G/BTEX MTBE	Gasoline Range Hydrocarbons	2530	µg/L	10	105	500
MW10	1/9/2003 2:45	NWTPH-G/BTEX MTBE	Gasoline Range Hydrocarbons	3180	µg/L	10	105	500
MW10D	1/9/2003 2:45	NWTPH-G/BTEX MTBE	Gasoline Range Hydrocarbons	2810	µg/L	1	10.5	50
MW11	1/10/2003 16:30	NWTPH-G/BTEX MTBE	Gasoline Range Hydrocarbons	1090	µg/L	1	10.5	50
MW12	1/9/2003 16:30	NWTPH-G/BTEX MTBE	Gasoline Range Hydrocarbons	1900	µg/L	5	52.5	250
MW15	1/10/2003 12:00	NWTPH-G/BTEX MTBE	Gasoline Range Hydrocarbons	24600	µg/L	50	525	2500
MW17	1/9/2003 10:15	NWTPH-G/BTEX MTBE	Gasoline Range Hydrocarbons	1740	µg/L	5	52.5	250
MW1	1/10/2003 14:30	8260B VOA Full List	Isopropylbenzene	40.8	µg/L	5	1.18	5
MW10	1/9/2003 2:45	8260B VOA Full List	Isopropylbenzene	32.3	µg/L	8	1.9	8
MW10	1/9/2003 2:45	8260B VOA Full List	Isopropylbenzene	36.9	µg/L	4	0.948	4
MW11	1/10/2003 16:30	8260B VOA Full List	Isopropylbenzene	11.2	µg/L	1	0.237	1
MW1	1/10/2003 14:30	Pb Diss ICPMS 6020	Lead	0.00202	mg/L	1	0.00006	0.001
MW4	1/8/2003 23:30	Pb Diss ICPMS 6020	Lead	0.00779	mg/L	1	0.00006	0.001
MW6	1/10/2003 18:00	Pb Diss ICPMS 6020	Lead	0.00222	mg/L	1	0.00006	0.001
MW12	1/9/2003 16:30	Pb Diss ICPMS 6020	Lead	0.00137	mg/L	1	0.00006	0.001
MW15	1/10/2003 12:00	Pb Diss ICPMS 6020	Lead	0.00445	mg/L	1	0.00006	0.001
MW1	1/10/2003 14:30	8260B VOA Full List	m,p-Xylene	712	µg/L	5	7.64	10
MW1	1/10/2003 14:30	8260B VOA Full List	m,p-Xylene	715	µg/L	100	153	200

Table D.1
FSM January 2003 Groundwater Sampling Results
(Detects Only)

SAMPLE NAME	SAMPLE DATE	ANALYTICAL METHOD	ANALYTE	CONC	UNITS	DILUTION	DL	RL
MW2	1/11/2003 10:00	8260B VOA Full List	m,p-Xylene	11.7	µg/L	4	6.12	8
MW10	1/9/2003 2:45	8260B VOA Full List	m,p-Xylene	71.1	µg/L	4	6.12	8
MW10	1/9/2003 2:45	8260B VOA Full List	m,p-Xylene	61.6	µg/L	8	12.2	16
MW11	1/10/2003 16:30	8260B VOA Full List	m,p-Xylene	9.42	µg/L	1	1.53	2
MW12	1/9/2003 16:30	8260B VOA Full List	m,p-Xylene	50.4	µg/L	5	7.64	10
MW1	1/10/2003 14:30	NWTPH-G/BTEX MTBE	Methyl tert-butyl ether	75.8	µg/L	50	4.7	50
MW1D	1/10/2003 14:30	NWTPH-G/BTEX MTBE	Methyl tert-butyl ether	68.9	µg/L	20	1.88	20
MW2	1/11/2003 10:00	NWTPH-G/BTEX MTBE	Methyl tert-butyl ether	5.45	µg/L	1	0.094	1
MW4	1/8/2003 23:30	NWTPH-G/BTEX MTBE	Methyl tert-butyl ether	159	µg/L	20	1.88	20
MW5	1/8/2003 18:47	NWTPH-G/BTEX MTBE	Methyl tert-butyl ether	1.14	µg/L	1	0.094	1
MW6	1/10/2003 18:00	NWTPH-G/BTEX MTBE	Methyl tert-butyl ether	32.4	µg/L	10	0.94	10
MW10	1/9/2003 2:45	NWTPH-G/BTEX MTBE	Methyl tert-butyl ether	41.6	µg/L	10	0.94	10
MW10D	1/9/2003 2:45	NWTPH-G/BTEX MTBE	Methyl tert-butyl ether	31.3	µg/L	1	0.094	1
MW11	1/10/2003 16:30	NWTPH-G/BTEX MTBE	Methyl tert-butyl ether	13.2	µg/L	1	0.094	1
MW12	1/9/2003 16:30	NWTPH-G/BTEX MTBE	Methyl tert-butyl ether	39.5	µg/L	5	0.47	5
MW15	1/10/2003 12:00	NWTPH-G/BTEX MTBE	Methyl tert-butyl ether	204	µg/L	50	4.7	50
MW17	1/9/2003 10:15	NWTPH-G/BTEX MTBE	Methyl tert-butyl ether	9.76	µg/L	5	0.47	5
MW1	1/10/2003 14:30	8260B VOA Full List	Naphthalene	60.1	µg/L	5	4.57	5
MW1	1/10/2003 14:30	8270C SVOA Full List	Naphthalene	56.1	µg/L	1	0.941	10
MW10	1/9/2003 2:45	8260B VOA Full List	Naphthalene	20	µg/L	4	3.66	4

Table D.1
FSM January 2003 Groundwater Sampling Results
(Detects Only)

SAMPLE NAME	SAMPLE DATE	ANALYTICAL METHOD	ANALYTE	CONC	UNITS	DILUTION	DL	RL
MW10	1/9/2003 2:45	8260B VOA Full List	Naphthalene	17.6	µg/L	8	7.31	8
MW10	1/9/2003 2:45	8270C SVOA Full List	Naphthalene	12.1	µg/L	1	0.941	10
MW12	1/9/2003 16:30	8260B VOA Full List	Naphthalene	31.5	µg/L	5	4.57	5
MW1	1/10/2003 14:30	8260B VOA Full List	n-Butylbenzene	10.8	µg/L	5	1.98	5
MW10	1/9/2003 2:45	8260B VOA Full List	n-Butylbenzene	6.02	µg/L	4	1.58	4
MW11	1/10/2003 16:30	8260B VOA Full List	n-Butylbenzene	3.28	µg/L	1	0.395	1
MW1	1/10/2003 14:30	8260B VOA Full List	n-Propylbenzene	105	µg/L	5	1.36	5
MW2	1/11/2003 10:00	8260B VOA Full List	n-Propylbenzene	4.64	µg/L	4	1.09	4
MW10	1/9/2003 2:45	8260B VOA Full List	n-Propylbenzene	74.2	µg/L	4	1.09	4
MW10	1/9/2003 2:45	8260B VOA Full List	n-Propylbenzene	65.8	µg/L	8	2.18	8
MW11	1/10/2003 16:30	8260B VOA Full List	n-Propylbenzene	22.5	µg/L	1	0.273	1
MW12	1/9/2003 16:30	8260B VOA Full List	n-Propylbenzene	8.84	µg/L	5	1.36	5
MW1	1/10/2003 14:30	8260B VOA Full List	o-Xylene	34.4	µg/L	5	2.32	5
MW10	1/9/2003 2:45	8260B VOA Full List	o-Xylene	8.1	µg/L	4	1.85	4
MW1	1/10/2003 14:30	8270C SVOA Full List	Phenol	29.2	µg/L	1	0.5	10
MW12	1/9/2003 16:30	8270C SVOA Full List	Phenol	22.8	µg/L	1	0.5	10
MW1	1/10/2003 14:30	Salinity-SM2520	Salinity	0.61	g/kg (ppt)	1		0.001
MW9	1/9/2003 17:00	Salinity-SM2520	Salinity	0.36	g/kg (ppt)	1		0.001
MW9H	1/10/2003 9:10	Salinity-SM2520	Salinity	0.35	g/kg (ppt)	1		0.001
MW10H	1/9/2003 8:30	Salinity-SM2520	Salinity	0.45	g/kg (ppt)	1		0.001

Table D.1
FSM January 2003 Groundwater Sampling Results
(Detects Only)

SAMPLE NAME	SAMPLE DATE	ANALYTICAL METHOD	ANALYTE	CONC	UNITS	DILUTION	DL	RL
MW12H	1/9/2003 9:45	Salinity-SM2520	Salinity	0.54	g/kg (ppt)	1		0.001
MW10	1/9/2003 2:45	8260B VOA Full List	sec-Butylbenzene	4.25	µg/L	4	0.892	4
MW11	1/10/2003 16:30	8260B VOA Full List	sec-Butylbenzene	3.02	µg/L	1	0.223	1
MW1	1/10/2003 14:30	8260B VOA Full List	Toluene	86.5	µg/L	5	4.91	5
MW1	1/10/2003 14:30	NWTPH-G/BTEX MTBE	Toluene	95.5	µg/L	50	6.7	25
MW1D	1/10/2003 14:30	NWTPH-G/BTEX MTBE	Toluene	91.3	µg/L	20	2.68	10
MW2	1/11/2003 10:00	8260B VOA Full List	Toluene	5.4	µg/L	4	3.93	4
MW2	1/11/2003 10:00	NWTPH-G/BTEX MTBE	Toluene	5.69	µg/L	1	0.134	0.5
MW4	1/8/2003 23:30	NWTPH-G/BTEX MTBE	Toluene	158	µg/L	20	2.68	10
MW5	1/8/2003 18:47	NWTPH-G/BTEX MTBE	Toluene	0.858	µg/L	1	0.134	0.5
MW6	1/10/2003 18:00	NWTPH-G/BTEX MTBE	Toluene	5.55	µg/L	10	1.34	5
MW10	1/9/2003 2:45	8260B VOA Full List	Toluene	42.5	µg/L	4	3.93	4
MW10	1/9/2003 2:45	8260B VOA Full List	Toluene	38.9	µg/L	8	7.86	8
MW10	1/9/2003 2:45	NWTPH-G/BTEX MTBE	Toluene	48.9	µg/L	10	1.34	5
MW10D	1/9/2003 2:45	NWTPH-G/BTEX MTBE	Toluene	39.7	µg/L	1	0.134	0.5
MW11	1/10/2003 16:30	8260B VOA Full List	Toluene	4.32	µg/L	1	0.982	1
MW11	1/10/2003 16:30	NWTPH-G/BTEX MTBE	Toluene	9.05	µg/L	1	0.134	0.5
MW12	1/9/2003 16:30	8260B VOA Full List	Toluene	16.6	µg/L	5	4.91	5
MW12	1/9/2003 16:30	NWTPH-G/BTEX MTBE	Toluene	20.1	µg/L	5	0.67	2.5
MW15	1/10/2003 12:00	NWTPH-G/BTEX MTBE	Toluene	981	µg/L	50	6.7	25

Table D.1
FSM January 2003 Groundwater Sampling Results
(Detects Only)

SAMPLE NAME	SAMPLE DATE	ANALYTICAL METHOD	ANALYTE	CONC	UNITS	DILUTION	DL	RL
MW17	1/9/2003 10:15	NWTPH-G/BTEX MTBE	Toluene	20.9	µg/L	5	0.67	2.5
MW9	1/9/2003 17:00	Solids, TDS-160.1	Total Dissolved Solids	340	mg/L	1		10
MW9H	1/10/2003 9:10	Solids, TDS-160.1	Total Dissolved Solids	320	mg/L	1		10
MW10H	1/9/2003 8:30	Solids, TDS-160.1	Total Dissolved Solids	490	mg/L	1		10
MW12H	1/9/2003 9:45	Solids, TDS-160.1	Total Dissolved Solids	540	mg/L	1		10
MW1	1/10/2003 14:30	NWTPH-G/BTEX MTBE	Xylenes (total)	838	µg/L	50	9.95	50
MW1D	1/10/2003 14:30	NWTPH-G/BTEX MTBE	Xylenes (total)	915	µg/L	20	3.98	20
MW2	1/11/2003 10:00	NWTPH-G/BTEX MTBE	Xylenes (total)	14.2	µg/L	1	0.199	1
MW4	1/8/2003 23:30	NWTPH-G/BTEX MTBE	Xylenes (total)	696	µg/L	20	3.98	20
MW5	1/8/2003 18:47	NWTPH-G/BTEX MTBE	Xylenes (total)	5.63	µg/L	1	0.199	1
MW6	1/10/2003 18:00	NWTPH-G/BTEX MTBE	Xylenes (total)	18.3	µg/L	10	1.99	10
MW10	1/9/2003 2:45	NWTPH-G/BTEX MTBE	Xylenes (total)	81.8	µg/L	10	1.99	10
MW10D	1/9/2003 2:45	NWTPH-G/BTEX MTBE	Xylenes (total)	66.1	µg/L	1	0.199	1
MW11	1/10/2003 16:30	NWTPH-G/BTEX MTBE	Xylenes (total)	16.9	µg/L	1	0.199	1
MW12	1/9/2003 16:30	NWTPH-G/BTEX MTBE	Xylenes (total)	75.3	µg/L	5	0.995	5
MW15	1/10/2003 12:00	NWTPH-G/BTEX MTBE	Xylenes (total)	4450	µg/L	50	9.95	50
MW17	1/9/2003 10:15	NWTPH-G/BTEX MTBE	Xylenes (total)	60.5	µg/L	5	0.995	5

Table 4

Groundwater Analytical Results - Oxygenate Compounds

Former Chevron Bulk Terminal #1001372
638 Marine Drive
Port Angeles, Washington

WELL ID	DATE	METHANOL *(ppb)*	ETHANOL *(ppb)*	TBA *(ppb)*	MTBE *(ppb)*	DIPE *(ppb)*	ETBE *(ppb)*	TAME *(ppb)*
MW-5	01/17/03	<1,000	<500	<100	<2	<2	<2	<2
MW-6	12/14/00	--	ND	ND	ND	ND	ND	ND
	01/17/03	<1,000	<500	<100	<2	<2	<2	<2
RZ-2	12/14/00	--	ND[1]	ND[1]	ND[1]	ND[1]	ND[1]	ND[1]

EXPLANATIONS:

TBA = Tertiary butyl alcohol
MTBE = Methyl tertiary butyl ether
DIPE = Di-isopropyl ether
ETBE = Ethyl tertiary butyl ether
TAME = Tertiary amyl methyl ether
(ppb) = Parts per billion
ND = Not Detected
-- = Not Analyzed

[1] Detection limit raised. Refer to analytical reports.

ANALYTICAL METHOD:

EPA Method 8260 for Oxygenate Compounds

Marine Trades Area Site
Port Angeles, Washington

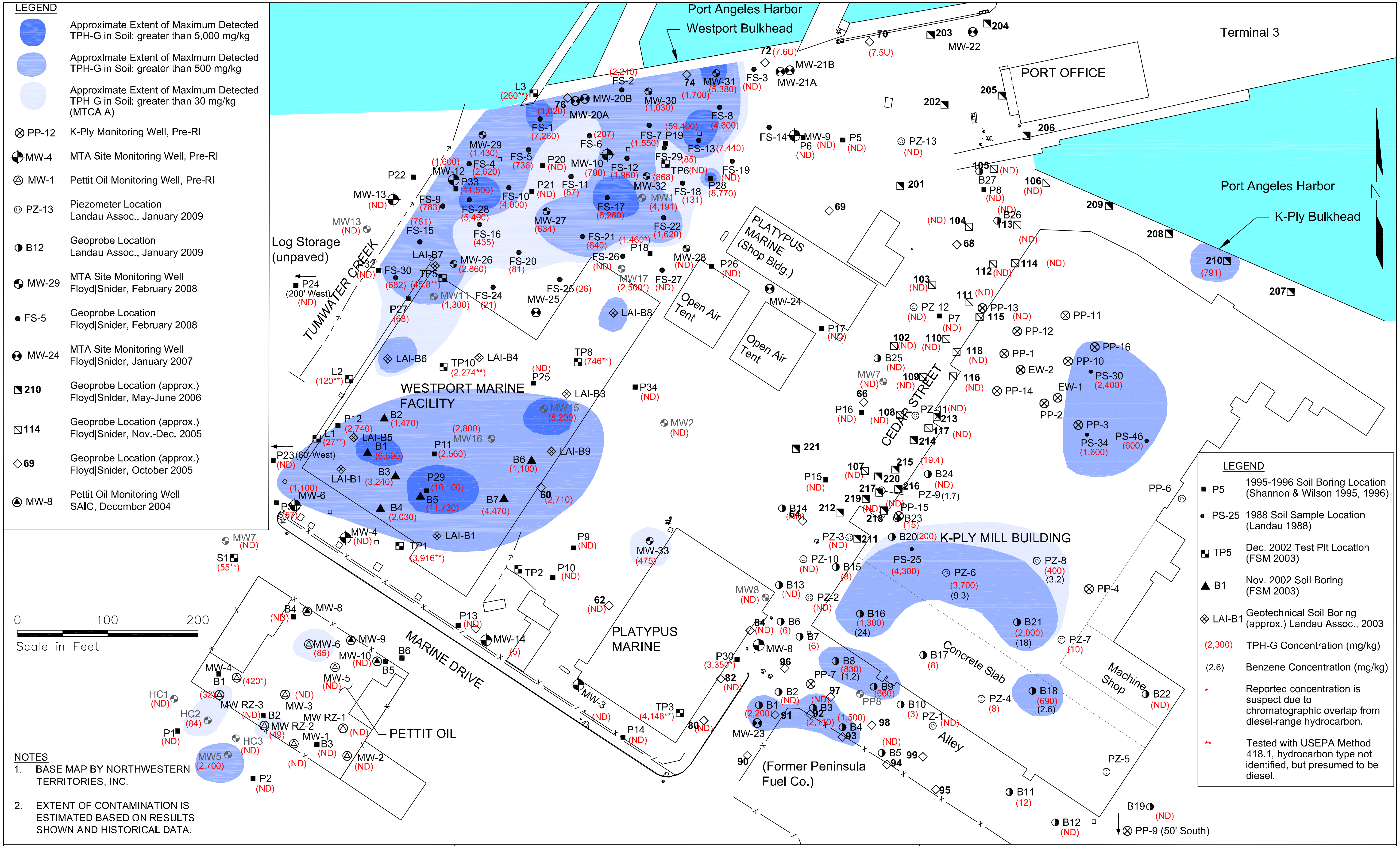
Final
Remedial Investigation/ Feasibility Study

Appendix C
RI Analytical Data Reports
(CD Attached)

Marine Trades Area Site
Port Angeles, Washington

Final
Remedial Investigation/ Feasibility Study

Appendix D
Monitoring Well and Soil Boring Logs



LEGEND

	Approximate Extent of Maximum Detected TPH-G in Soil: greater than 5,000 mg/kg
	Approximate Extent of Maximum Detected TPH-G in Soil: greater than 500 mg/kg
	Approximate Extent of Maximum Detected TPH-G in Soil: greater than 30 mg/kg (MTCA A)
⊗ PP-12	K-Ply Monitoring Well, Pre-RI
MW-4	MTA Site Monitoring Well, Pre-RI
MW-1	Petit Oil Monitoring Well, Pre-RI
◎ PZ-13	Piezometer Location Landau Assoc., January 2009
◑ B12	Geoprobe Location Landau Assoc., January 2009
MW-29	MTA Site Monitoring Well Floyd|Snider, February 2008
● FS-5	Geoprobe Location Floyd|Snider, February 2008
MW-24	MTA Site Monitoring Well Floyd|Snider, January 2007
210	Geoprobe Location (approx.) Floyd|Snider, May-June 2006
114	Geoprobe Location (approx.) Floyd|Snider, Nov.-Dec. 2005
◇**69**	Geoprobe Location (approx.) Floyd|Snider, October 2005
MW-8	Petit Oil Monitoring Well SAIC, December 2004

LEGEND

■ P5	1995-1996 Soil Boring Location (Shannon & Wilson 1995, 1996)
• PS-25	1988 Soil Sample Location (Landau 1988)
TP5	Dec. 2002 Test Pit Location (FSM 2003)
▲ B1	Nov. 2002 Soil Boring (FSM 2003)
LAI-B1	Geotechnical Soil Boring (approx.) Landau Assoc., 2003
(2,300)	TPH-G Concentration (mg/kg)
(2.6)	Benzene Concentration (mg/kg)
*	Reported concentration is suspect due to chromatographic overlap from diesel-range hydrocarbon.
**	Tested with USEPA Method 418.1, hydrocarbon type not identified, but presumed to be diesel.

NOTES

1. BASE MAP BY NORTHWESTERN TERRITORIES, INC.
2. EXTENT OF CONTAMINATION IS ESTIMATED BASED ON RESULTS SHOWN AND HISTORICAL DATA.

FLOYD | SNIDER
strategy ▪ science ▪ engineering

Remedial Investigation/Feasibility Study
Marine Trades Area Site
Port Angeles, Washington

Figure 4.3
Historical and Current Areas of Elevated TPH-G and Benzene in Soil

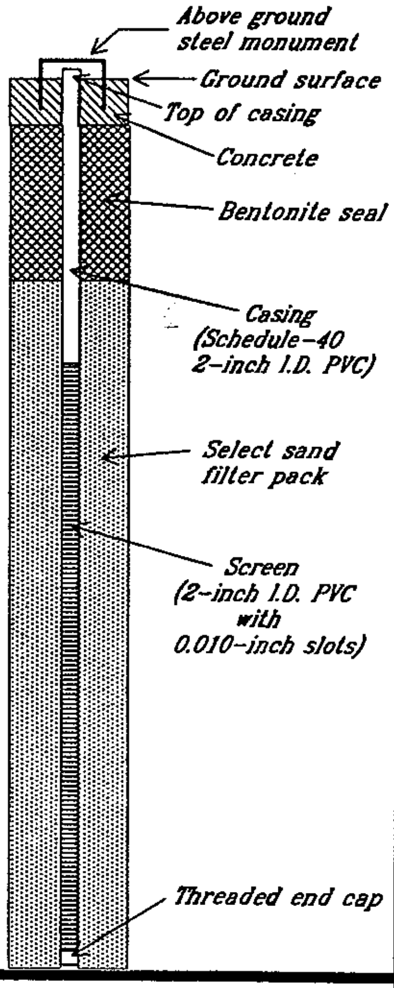
DWG NAME: G:\project\Clients\Floyd and Snider\PPA-OMW\ppa0078.dwg
DATE: 3/29/2010 4:54 PM

PROJECT *Port of Port Angeles* W.O. *W-7007-1* WELL NO. *MW-3*

Elevation reference: *17.56'*
Well completed: *8-28-90*
Ground surface elev: *16.43'*
Casing elevation: *16.97'*

DEPTH (feet)	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	BLOW COUNTS	HEAD SPACE	GROUND WATER
0	*Topsoil*					
	Medium dense, moist, brown, silty, fine to coorse SAND with some gravel.					
	Very dense, moist, blue-gray, silty fine to coarse SAND with some gravel.	I	*S-1*	*50/6"*	*0*	
5	*Medium dense, moist, blue-groy, silty fine SAND with some gravel.*	I	*S-2*	*13*	*0*	
	Loose, wet, blue-gray, silty, fine SAND with some gravel.	I	*S-3*	*7*	*0*	
10	*Medium dense to dense, wet to saturated, blue-groy, silty, fine to coorse SAND with some gravel.*	I	*S-4*	*29*	*0*	
						▼ ATD
	Interbedded lenses of GRAVEL.	I	*S-5*	*12*	*0*	
15						
		I	*S-6*	*20*	*0*	
20	*Boring terminoted at 20 feet.*					
25						
30						

AS-BUILT DESIGN



TESTING

PIT 000255

Well completed: *28 August 1990*

LEGEND

I 2-inch O.D. split-spoon sample

▼ ATD Observed groundwater level (ATD = at time of drilling)

RZA
RITTENHOUSE-ZEMAN & ASSOCIATES, INC.
Geotechnical & Environmental Consultants
1400 140th Ave NE
Bellevue, Washington 98005

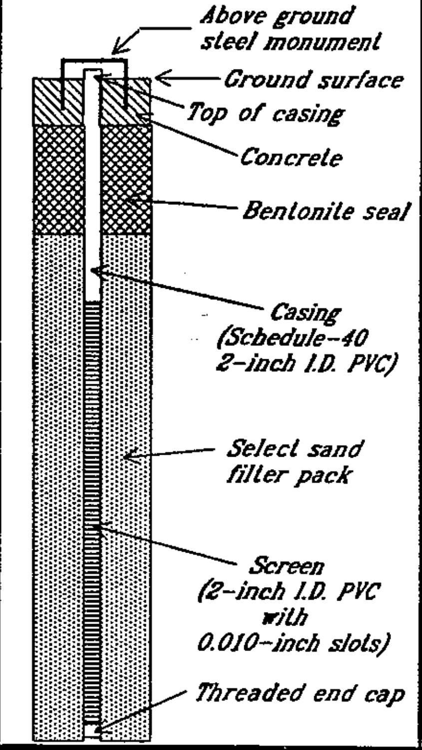
Drilling started: *28 August 1990* Drilling completed: *28 August 1990* Logged by: *JTC*

PROJECT *Port of Port Angeles* W.O. *W-7007-1* WELL NO. *MW-4*

Elevation reference: *17.56'*
Well completed: *8-28-90*
Ground surface elev: *12.41'*
Casing elevation: *13.89'*

DEPTH (feet)	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	BLOW COUNTS	HEAD SPACE	GROUND WATER	TESTING
0	*Medium dense, damp, brown, silty, fine SAND with some organics and gravel.*						
	Dense, moist, tan, silty, fine to medium SAND with some gravel.	I	*S-1*	*38*	*0*		
5	*Medium dense, moist, light brown grading to blue-gray, silty, fine to medium SAND with some gravel. Petroleum hydrocarbon odor detected.*	I	*S-2*	*66*	*190*		
	Dense to very dense, saturated, blue-gray, gravelly, coarse SAND with some fine sand and silt.	I	*S-3*	*60*	*310*	▼ ATD	
10	*Strong petroleum hydrocarbon odor and sheen observed on wet soil samples.*	I	*S-4*	*14*	*50*		
	Increasing SILT content.	I	*S-5*	*17*	*10*		
15	*Boring terminated at 15 feet.*						
20							
25							
30							

AS-BUILT DESIGN



Well completed: *28 August 1990*

LEGEND

I 2-inch O.D. split-spoon sample

▼ ATD Observed groundwater level (ATD = at time of drilling)

RZA
RITTENHOUSE-ZEMAN & ASSOCIATES, INC.
Geotechnical & Environmental Consultants
1400 140th Ave NE
Bellevue, Washington 98005

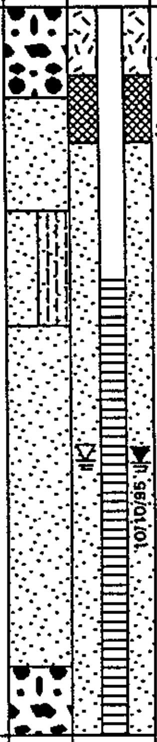
Drilling started: *28 August 1990* Drilling completed: *28 August 1990* Logged by: *JTC*

ENVLOG2 3/20/96

ENVIRONMENTAL BOREHOLE LOG

Date Started 10/2/95	Location Port Angeles, Washington	Depth Water First Encountered (Ft) 10.0
Date Completed 10/2/95	Drilling Company EDI	Drilling Method Hollow-Stem Auger
Total Depth (Ft) 16.0	Sampling Method Split-spoon	Hammer: Weight (lbs) 140 Drop (In) 30
Borehole Diam. (In) 8	Ground Elev. (ft) 16.16	Monument Elev. (ft)
		PVC Elev. (ft) 16.38

Depth (Ft)	Sample Number	Interval	Blow Counts/6 In	Recovery(%)	PID (ppm)	Time	Depth (Ft)	Lithologic Description	USCS* Symbol	Soil Log	Well Log	Depth (Ft)
								Ground Surface				
								Brown, sandy GRAVEL; moist.	GP			1.5
							2.0	Medium dense, brown, gravelly, medium SAND; dry.	SP			3.0
			6/8/9	20	0	1134						
							4.5	Medium dense, brown, gravelly, medium SAND and gray, fine sandy SILT; moist.	SP/ML			6.0
5			7/8/12	60	15	1139						
							7.0	Medium dense to dense, brownish black, gravelly, medium to coarse SAND; moist to wet; hydrocarbon sheen and odor from 10 to 11.5 feet.	SP			
	04		3/5/12	13	535	1144						
10	05		17/18/12	70	1477	1244						
	06		3/5/12	60	249	1258						
							14.5	Dense, black, coarse sandy GRAVEL; wet.	GP			
15			5/10/30	45		1305						
							16.0	BOTTOM OF BORING 16 FEET				16.0
20												



S&W 000378

Remarks: Refer to key for explanation of terminology and symbols.

* USC soil descriptions are based on visual classification, unless otherwise noted. Contacts between soil layers are approximate and may be gradual.

LEGEND

- ⌶ 2" O.D. Split-Spoon Sample
- Ⅲ 3" O.D. Split-Spoon Sample
- ▼ Water Level and Date Measured
- ▽ Water Level at Time of Drilling

Port of Port Angeles
Marine Terminal Log Yard

LOG OF BORING MW-6

October 1995 T-1396-06

Logged By ACT

Reviewed By

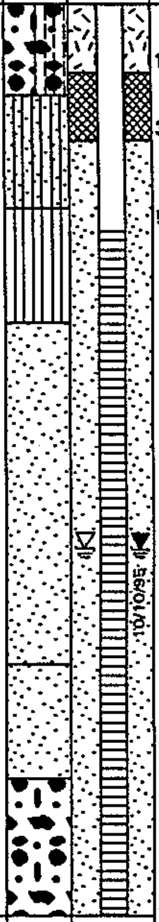
SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG.

ENVIRONMENTAL BOREHOLE LOG

Date Started 10/3/95	Location Port Angeles, Washington	Depth Water First Encountered (Ft) 12.0
Date Completed 10/3/95	Drilling Company EDI	Drilling Method Hollow-Stem Auger
Total Depth (Ft) 20.0	Sampling Method Split-spoon	Hammer: Weight (lbs) 140 Drop (In) 30
Borehole Diam. (In) 8	Ground Elev. (ft) 17.40	Monument Elev. (ft)
		PVC Elev. (ft) 17.92

Depth (Ft)	Sample Number	Interval	Blow Counts/6 In	Recovery(%)	PID (ppm)	Time	Depth (Ft)	Lithologic Description	USCS* Symbol	Soil Log	Well Log	Depth (Ft)
								Ground Surface				
								Brown, slightly silty, sandy GRAVEL; dry.	GP-GM			1.5
			6/7/11	80	4.5	0749	2.0	Medium dense, gray and brown, silty fine SAND; dry.	SM			3.0
5	10		1/1/3	90	12.8	0753	4.5	Very loose, light brown and gray, fine sandy SILT; dry.	ML			5.0
			6/10/19	70	7.9	0757	7.0	Medium dense, brown and gray, fine to medium SAND, trace gravel and silt; dry to wet; scattered shells.	SP			
10			10/12/ 14	90	5.2	0802						
	11		7/9/14	60	46.8	0807						
15	12		7/4/10	30	23.3	0811	14.5	Medium dense, gray, medium SAND and medium sandy GRAVEL; wet.	SP/GP			
			1/1/2	40		0815	17.0	Very loose, gray, sandy GRAVEL; wet.	GP			
20							20.0	BOTTOM OF BORING 20 FEET				20.0



Remarks: Refer to key for explanation of terminology and symbols.

* USC soil descriptions are based on visual classification, unless otherwise noted. Contacts between soil layers are approximate and may be gradual.

LEGEND

⌶ 2" O.D. Split-Spoon Sample

⌶ 3" O.D. Split-Spoon Sample

▼ Water Level and Date Measured

▽ Water Level at Time of Drilling

Port of Port Angeles
Marine Terminal Log Yard

LOG OF BORING MW-8

October 1995 T-1396-06

Logged By ACT

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SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

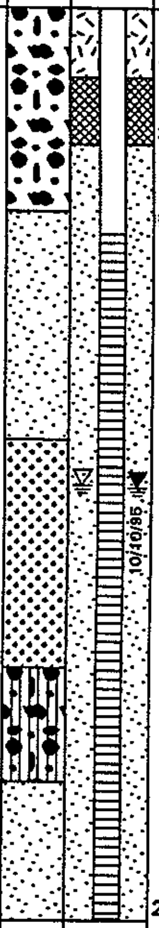
FIG.

ENVIRONMENTAL BOREHOLE LOG

Date Started 10/3/95	Location Port Angeles, Washington	Depth Water First Encountered (Ft) 10.5
Date Completed 10/3/95	Drilling Company EDI	Drilling Method Hollow-Stem Auger
Total Depth (Ft) 20.0	Sampling Method Split-spoon	Hammer: Weight (lbs) 140 Drop (In) 30
Borehole Diam. (In) 8	Ground Elev. (ft) 15.19	Monument Elev. (ft)
		PVC Elev. (ft) 15.58

Sample Number	Interval	Blow Counts/6 In	Recovery(%)	PID (ppm)	Time
		8/10/14	33	0.9	0937
		7/8/11	75	1.4	0940
		4/5/12	70	0.6	0944
14		4/12/16	60	1.6	0947
		6/10/7	45	2.4	0955
15		3/3/14	100	7.6	1000
16		1/6/14	100	3.1	1002

Depth (Ft)	Lithologic Description	USCS* Symbol
	Ground Surface	
	Medium dense, brown and gray, sandy GRAVEL and SAND; dry; scattered grasses and shells.	GP/SP
4.5	Medium dense, gray and brown, slightly gravelly, medium to coarse SAND, trace silt; moist; scattered shells.	SP
9.5	Medium dense, gray, gravelly SAND, trace silt; wet; scattered shells.	SW
14.5	Medium dense, gray, silty fine SAND and fine to medium sandy GRAVEL; wet; scattered shells.	SM/GP
17.0	Medium dense, gray, medium to coarse SAND and coarse sandy GRAVEL; wet; scattered shells.	SP/GP
20.0	BOTTOM OF BORING 20 FEET	



Depth (Ft)
1.5
3.0
5.0
20.0

Remarks: Refer to key for explanation of terminology and symbols.

* USC soil descriptions are based on visual classification, unless otherwise noted. Contacts between soil layers are approximate and may be gradual.

LEGEND

- ⌶ 2" O.D. Split-Spoon Sample
- Ⅲ 3" O.D. Split-Spoon Sample
- ▼ Water Level and Date Measured
- ▽ Water Level at Time of Drilling

Logged By ACT

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Port of Port Angeles
Marine Terminal Log Yard

LOG OF BORING MW-9

October 1995 T-1396-06

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG.

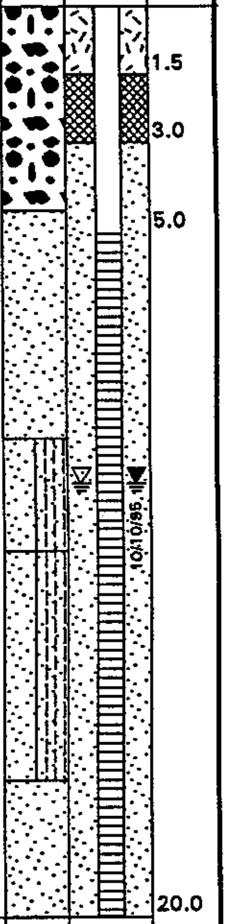
ENVLOG2 3/20/96

ENVIRONMENTAL BOREHOLE LOG

Date Started 10/3/95	Location Port Angeles, Washington	Depth Water First Encountered (Ft) 10.5
Date Completed 10/3/95	Drilling Company EDI	Drilling Method Hollow-Stem Auger
Total Depth (Ft) 20.0	Sampling Method Split-spoon	Hammer: Weight (lbs) 140 Drop (In) 30
Borehole Diam. (In) 8	Ground Elev. (ft) 15.23 / Monument Elev. (ft)	PVC Elev. (ft) 15.76

Sample Number	Blow Counts/6 In	Recovery(%)	PID (ppm)	Time
	9/12/22	50	23.2	1109
17	1/6/7	65	842	1113
18	6/15/29	50	1198	1117
19	12/14/ 14	80	1194	1122
	3/3/6	95	93.3	1126
	5/11/24	75	32.3	1131
	1/5/8	60		1135

Depth (Ft)	Lithologic Description	USCS* Symbol
	Ground Surface	
	Dense, brown and gray, fine to medium sandy GRAVEL, trace silt; wet; abundant wood fragments, scattered shells.	GP
4.5	Loose to dense, brown and gray, medium SAND, trace silt and gravel; moist; scattered shells and hydrocarbon odor.	SP
9.5	Medium dense, gray, slightly silty, fine SAND, trace gravel; wet; scattered shells; hydrocarbon odor.	SP-SM
12.0	Loose to dense, gray, slightly silty, fine SAND and sandy SILT, trace gravel; wet; scattered shells.	SP-SM
17.0	Medium dense, gray, gravelly, medium to coarse SAND, trace silt; wet.	SP
20.0	BOTTOM OF BORING 20 FEET	



Remarks: Refer to key for explanation of terminology and symbols.

* USC soil descriptions are based on visual classification, unless otherwise noted. Contacts between soil layers are approximate and may be gradual.

LEGEND

⌶	2" O.D. Split-Spoon Sample	▼	Water Level and Date Measured
⌶	3" O.D. Split-Spoon Sample	▽	Water Level at Time of Drilling

Port of Port Angeles
Marine Terminal Log Yard

LOG OF BORING MW-10

October 1995 T-1396-06

Logged By ACT

Reviewed By

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

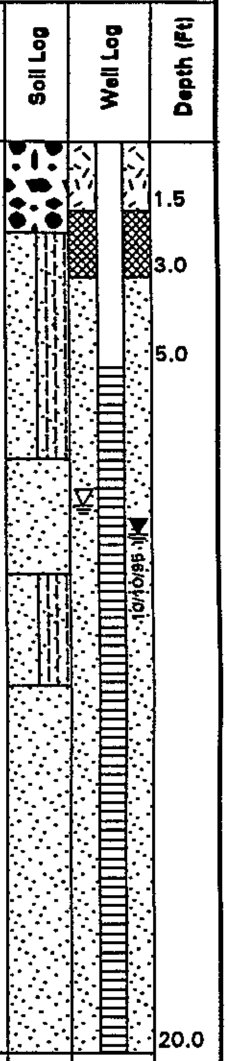
FIG.

ENVLOG2 3/20/96

ENVIRONMENTAL BOREHOLE LOG

Date Started 10/3/95	Location Port Angeles, Washington	Depth Water First Encountered (Ft) 8.0
Date Completed 10/4/95	Drilling Company EDI	Drilling Method Hollow-Stem Auger
Total Depth (Ft) 20.0	Sampling Method Split-spoon	Hammer: Weight (lbs) 140 Drop (In) 30
Borehole Diam. (In) 8	Ground Elev. (ft) 14.17 / Monument Elev. (ft)	PVC Elev. (ft) 14.28

Depth (Ft)	Sample Number	Interval	Blow Counts/6 In	Recovery(%)	PID (ppm)	Time	Depth (Ft)	Lithologic Description	USCS* Symbol
								Ground Surface	
								Black, sandy GRAVEL; dry; scattered grasses.	GP
							2.0	Medium dense, gray, slightly silty, gravelly SAND and fine sandy SILT; dry to moist; scattered shells.	SP-SM
	23		5/6/7	100	161	1606			
5			4/10/14	80	143	1610			
							7.0	Medium dense, gray, gravelly SAND; wet; scattered shells, hydrocarbon odor.	SP
	24		4/8/14	40	1889	1615			
							9.5	Medium dense, gray, slightly silty, fine SAND and fine sandy SILT; wet; hydrocarbon odor.	SP-SM
10	25		1/2/9	75	1310	1617			
							12.0	Loose to medium, dense, gray, gravelly SAND and sandy GRAVEL, trace silt; wet; scattered shells.	SP/GP
			6/12/12	80	259	0722			
15			1/4/6	60	12.9	0729			
			1/8/10	100	17.5	0733			
20							20.0	BOTTOM OF BORING 20 FEET	



Remarks: Refer to key for explanation of terminology and symbols.

* USC soil descriptions are based on visual classification, unless otherwise noted. Contacts between soil layers are approximate and may be gradual.

LEGEND

I	2" O.D. Split-Spoon Sample	▼	Water Level and Date Measured
III	3" O.D. Split-Spoon Sample	▽	Water Level at Time of Drilling

Port of Port Angeles
Marine Terminal Log Yard

LOG OF BORING MW-12

October 1995 T-1396-06

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Geotechnical and Environmental Consultants

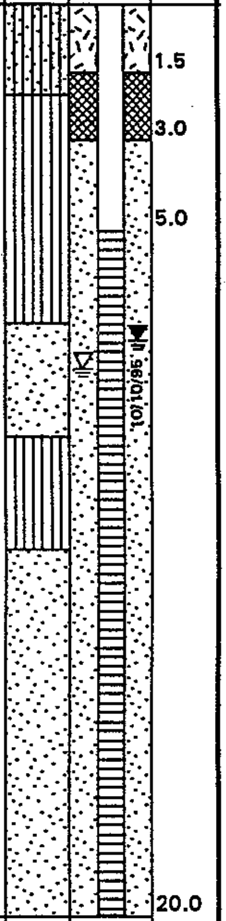
FIG.

ENVIRONMENTAL BOREHOLE LOG

Date Started 10/4/95
Location Port Angeles, Washington
Depth Water First Encountered (Ft) 8.0
Date Completed 10/4/95
Drilling Company EDI
Drilling Method Hollow-Stem Auger
Total Depth (Ft) 20.0
Sampling Method Split-spoon
Hammer: Weight (lbs) 140 Drop (In) 30
Borehole Diam. (In) 8
Ground Elev. (ft) 13.26
Monument Elev. (ft)
PVC Elev. (ft) 13.54

Sample Number	Interval	Blow Counts/6 In	Recovery(%)	PID (ppm)	Time
26	Ⅱ	3/4/4	80	44.1	0842
27	Ⅱ	1/3/7	33	26.5	0844
28	Ⅱ	2/2/2	80	0	0848
	Ⅱ	1/14/20	60	0	0851
	Ⅱ	2/3/10	1	0	0903
	Ⅱ	5/6/8	75		0907
	Ⅱ	3/7/11	100		0910

Depth (Ft)	Lithologic Description	USCS* Symbol
	Ground Surface	
	Brown, silty SAND; dry; scattered grasses.	SM
2.0	Loose, brown, sandy SILT, trace gravel; moist to wet; scattered wood.	ML
7.0	Very loose, brown and grey, fine to medium SAND; wet.	SP
9.5	Dense, brown and grey, fine sandy SILT; wet; scattered shells.	ML
12.0	Medium dense, grey, slightly gravelly, medium to coarse SAND; wet; scattered shells.	SP
20.0	BOTTOM OF BORING 20 FEET	



Remarks: Refer to key for explanation of terminology and symbols.

- USC soil descriptions are based on visual classification, unless otherwise noted. Contacts between soil layers are approximate and may be gradual.

LEGEND

Ⅰ 2" O.D. Split-Spoon Sample
Ⅱ 3" O.D. Split-Spoon Sample
▼ Water Level and Date Measured
▽ Water Level at Time of Drilling

Port of Port Angeles
Marine Terminal Log Yard

LOG OF BORING MW-13

October 1995 T-1396-06

Logged By ACT
Reviewed By

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

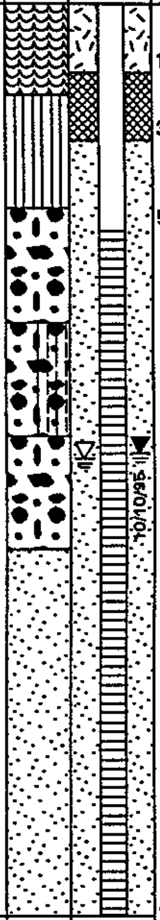
FIG.

ENVIRONMENTAL BOREHOLE LOG

Date Started 10/4/95	Location Port Angeles, Washington	Depth Water First Encountered (Ft) 10.0
Date Completed 10/4/95	Drilling Company EDI	Drilling Method Hollow-Stem Auger
Total Depth (Ft) 20.0	Sampling Method Split-spoon	Hammer: Weight (lbs) 140 Drop (In) 30
Borehole Diam. (In) 8	Ground Elev. (ft) 16.34	Monument Elev. (ft) PVC Elev. (ft) 16.19

Sample Number	Interval	Blow Counts/6 In	Recovery(%)	PID (ppm)	Time
29	⌶	4/4/6	100	117	1103
	⌶	5/10/6	33	1.2	1106
30	⌶	1/4/6	45	11.7	1110
31	⌶	4/7/7	70	16.3	1112
	⌶	7/12/12	50	6.2	1116
	⌶	4/10/12	25	0	1119
	⌶	5/8/10	30		1122

Depth (Ft)	Lithologic Description	USCS* Symbol
	Ground Surface	
	Brown, gray, gravelly PEAT (grass, moss, wood) and SAND; moist.	PT/SP
2.0	Loose, gray, sandy, gravelly SILT; dry; scattered wood.	ML
4.5	Medium dense, brownish gray, medium sandy GRAVEL, trace silt; dry; scattered wood.	GP
7.0	Loose, brownish gray, medium sandy GRAVEL and fine sandy SILT; moist.	GP/ML
9.5	Medium dense, brownish gray, fine to medium sandy GRAVEL, trace silt; wet; scattered shells.	GP
12.0	Medium dense, gray, gravelly, coarse SAND, trace silt; wet.	SP
20.0	BOTTOM OF BORING 20 FEET	



Remarks: Refer to key for explanation of terminology and symbols.

* USC soil descriptions are based on visual classification, unless otherwise noted. Contacts between soil layers are approximate and may be gradual.

LEGEND

⌶ 2" O.D. Split-Spoon Sample
Ⅲ 3" O.D. Split-Spoon Sample
▼ Water Level and Date Measured
▽ Water Level at Time of Drilling

Port of Port Angeles
Marine Terminal Log Yard

LOG OF BORING MW-14

October 1995 T-1396-06

Logged By ACT

Reviewed By

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG.

Log of Soil Boring and Well Construction MW-20A

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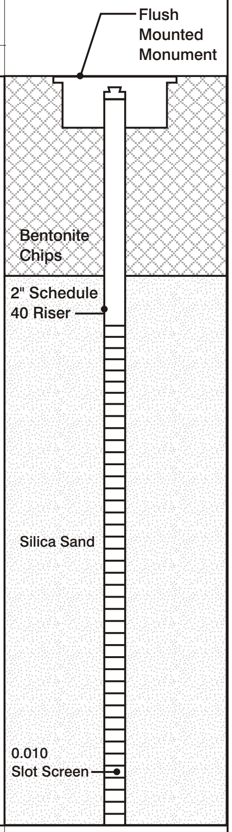
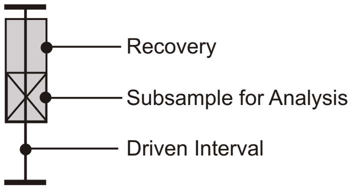
Floyd Snider
Boring MW-20A Date 1/15/07 Sheet 1 of 1
Job SJZ-MTA Job No. XX
Logged By Brett Beaulieu Weather 25 Degrees, Overcast
Drilled By Cascade Drilling
Drill Type/Method Hollow Stem Auger
Sampling Method 4” Split Spoon, 140 lb Hammer
Bottom of Boring 15.0’ BGS ATD Water Level Depth 10’ BGS
Ground Surface Elevation Approx 15’ NAVD 88

Obs. Well Install. ☒ Yes ☐ No

SAMPLE ID	Blow Count N/12"	RECOVERY From	RECOVERY To	GRAPHIC RECOVERY		USCS Symbol	DESCRIPTION: color, texture, moisture MAJOR CONSTITUENT. NON-SOIL SUBSTANCES: Odor, staining, sheen, scrap, slag, etc.
					0		
					1		No samples collected. Soil removed by Vactor to 5’ BGS. Refer to boring log for MW-20B for lithologic descriptions. Soil cuttings contain petroleum-contaminated soil and produce strong petroleum odors.
					2		
					3		
					4		
					5		
					6		
					7		
					8		
					9		
					10	▽	
					11		
					12		
					13		
					14		
					15		Bottom of boring at 15 feet. Note: Added approximately 3 to 4 gallons clean water to set well.
					16		
					17		
					18		
					19		
					20		
					21		
					22		
					23		
					24		
					25		

WELL CONSTRUCTION





▽ Groundwater Observed At Time of Drilling

Log of Soil Boring and Well Construction MW-20B

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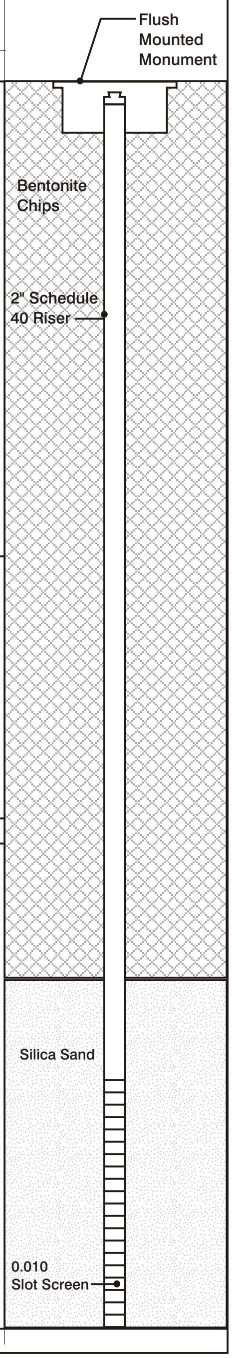
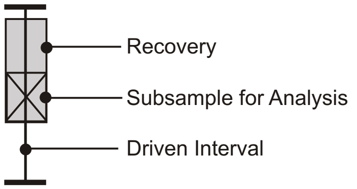
Obs. Well Install. ☒ Yes ☐ No

Floyd Snider
Boring MW-20B Date 1/15/07 Sheet 1 of 1
Job SJZ-MTA Job No. XX
Logged By Brett Beaulieu Weather 25 Degrees, Overcast
Drilled By Cascade Drilling
Drill Type/Method Hollow Stem Auger
Sampling Method 4” Split Spoon, 140 lb Hammer
Bottom of Boring 25.0’ BGS ATD Water Level Depth 10’ BGS
Ground Surface Elevation Approx 15’ NAVD 88

SAMPLE ID	Blow Count N/12”	RECOVERY From	RECOVERY To	GRAPHIC RECOVERY	Depth	USCS Symbol	DESCRIPTION: color, texture, moisture MAJOR CONSTITUENT. NON-SOIL SUBSTANCES: Odor, staining, sheen, scrap, slag, etc.
	4/4/5	5.0	6.5		6	SW	Light brown, fine to medium, dry SAND.
	7/8/5	9.0	10.5		10	▽	
					12	SM	Grey, fine to medium, wet, SILTY SAND with gravel. Cobbles. Petroleum contamination visible. Petroleum odors.
					14		Shell fragments
	4/7/7	14.0	15.5		15	ML	Grey to brown, moist, SILT with sand. Plastic. 4” lense.
	14/17/19	19.0	20.5		20	SM	Grey, fine to medium, wet, silty SAND with gravel.
	5/5/6	24.0	25.5		25		Bottom of boring at 25 feet.

WELL CONSTRUCTION





▽ Groundwater Observed At Time of Drilling

Log of Soil Boring and Well Construction MW-21A

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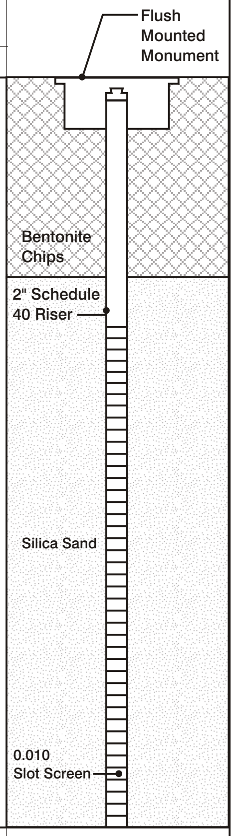
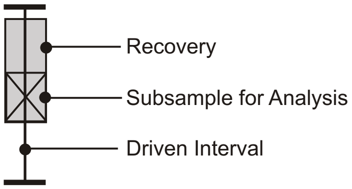
Obs. Well Install. ☒ Yes ☐ No

Floyd Snider
Boring MW-21A Date 1/16/07 Sheet 1 of 1
Job SJZ-MTA Job No. XX
Logged By Brett Beaulieu Weather 30s, cloudy
Drilled By Cascade Drilling
Drill Type/Method Hollow Stem Auger
Sampling Method 4" Split Spoon, 140 lb Hammer
Bottom of Boring 15.0' BGS ATD Water Level Depth 10' BGS
Ground Surface Elevation Approx 15' NAVD 88

SAMPLE ID	Blow Count N/12"	RECOVERY		GRAPHIC RECOVERY		USCS Symbol	DESCRIPTION: color, texture, moisture MAJOR CONSTITUENT. NON-SOIL SUBSTANCES: Odor, staining, sheen, scrap, slag, etc.
		From	To				
					0		
					1		No samples collected. Soil removed by Vactor to 5' BGS. Refer to boring log for MW-21B for litho soil descriptions. Soil cuttings produce petroleum odors.
					2		
					3		
					4		
					5		
					6		
					7		
					8		
					9		
					10	▽	
					11		
					12		
					13		
					14		
					15		Bottom of boring at 15 feet.
					16		
					17		
					18		
					19		
					20		
					21		
					22		
					23		
					24		
					25		

WELL CONSTRUCTION





▽ Groundwater Observed At Time of Drilling

Log of Soil Boring and Well Construction MW-21B

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Floyd Snider
Boring MW-21B Date 1/15/07 Sheet 1 of 1
Job SJZ-MTA Job No. XX
Logged By Brett Beaulieu Weather 30s, cloudy
Drilled By Cascade Drilling
Drill Type/Method Hollow Stem Auger
Sampling Method 4" Split Spoon, 140 lb Hammer
Bottom of Boring 25.0' BGS ATD Water Level Depth 10' BGS
Ground Surface Elevation Approx 15' NAVD 88

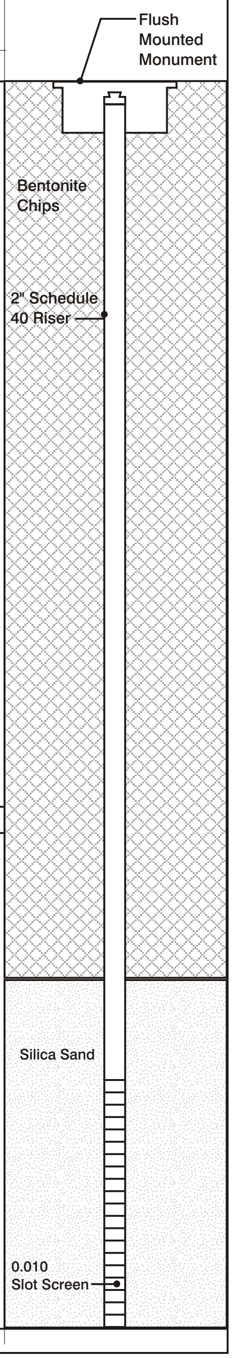
Obs. Well Install. [✓ Yes] No

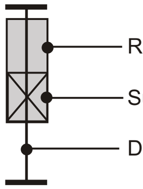
SAMPLE ID	Blow Count N/12"	RECOVERY From	RECOVERY To	USCS Symbol	DESCRIPTION: color, texture, moisture MAJOR CONSTITUENT. NON-SOIL SUBSTANCES: Odor, staining, sheen, scrap, slag, etc.
					No samples collected. Soil removed by Vactor to 5' BGS.
	3/4/5	5.0	6.5	SW	Light brown, fine to medium, moist, SAND.
	3/4/3	9.0	10.5	SW ∇	Brown to grey, moist to wet, SAND with gravel. Shell fragments. No apparent odor or visual signs of petroleum.
	4/5/3	14.0	15.5	SM	Grey, fine, wet, SILTY SAND. Petroleum odor from soil porewater
				ML	4" silt lense.
				SM	Grey, fine, wet, SILTY SAND. Petroleum odor from soil porewater
	6/7/7	19.0	20.5	SM	Grey, fine to coarse, wet, silty SAND with gravel. Shell fragments. Faint petroleum odor.
	6/7/7	24.0	25.5	SW-SM	Grey, well-graded SAND with silt. Shell fragments.
					Bottom of boring at 25 feet.

GRAPHIC RECOVERY

0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25

WELL CONSTRUCTION





∇ Groundwater Observed At Time of Drilling

Log of Soil Boring and Well Construction MW-22

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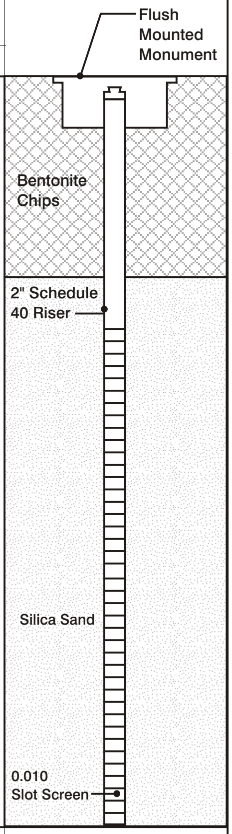
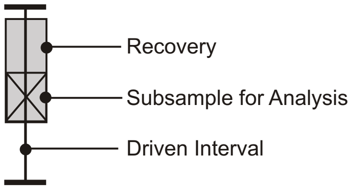
Obs. Well Install. ☒ Yes ☐ No

Floyd Snider
Boring MW-22 Date 1/16/07 Sheet 1 of 1
Job SJZ-MTA Job No. XX
Logged By Brett Beaulieu Weather 30s, cloudy
Drilled By Cascade Drilling
Drill Type/Method Hollow Stem Auger
Sampling Method 4" Split Spoon, 140 lb Hammer
Bottom of Boring 15.0' BGS ATD Water Level Depth 9.5' BGS
Ground Surface Elevation Approx 16' NAVD 88

	SAMPLE ID	Blow Count N/12"	RECOVERY		GRAPHIC RECOVERY	USCS Symbol	DESCRIPTION: color, texture, moisture MAJOR CONSTITUENT. NON-SOIL SUBSTANCES: Odor, staining, sheen, scrap, slag, etc.
			From	To			
0							
1							No samples collected. Soil removed by Vactor to 5' BGS.
2							
3							
4							
5					▨		
6		3/4/5	5.0	6.5	▨	SW	Brown, well-graded, fine to medium SAND.
7							
8							
9					▨	▽	
10		2/2/2	9.0	10.5	▨	SW	Grey, well-graded, fine to medium, wet, SAND.
11							
12							
13							
14					▨		
15		3/2/3	14.0	15.5	▨	SM	Greyish-brown, wet, SILTY SAND.
16							Bottom of boring at 15 feet.
17							
18							
19							
20							
21							
22							
23							
24							
25							

WELL CONSTRUCTION





▽ Groundwater Observed At Time of Drilling

Log of Soil Boring and Well Construction MW-23

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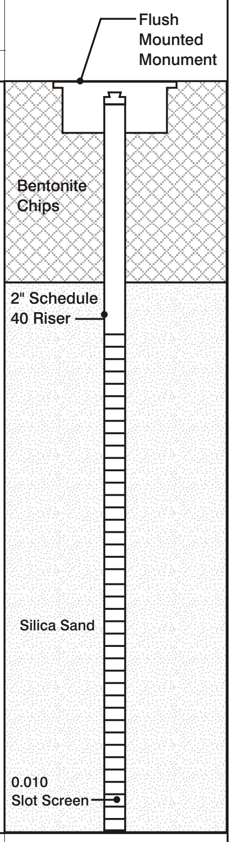
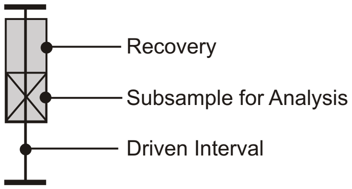
Floyd Snider
Boring MW-23 Date 1/16/07 Sheet 1 of 1
Job SJZ-MTA Job No. XX
Logged By Brett Beaulieu Weather 30s, cloudy
Drilled By Cascade Drilling
Drill Type/Method Hollow Stem Auger
Sampling Method 4" Split Spoon, 140 lb Hammer
Bottom of Boring 15.0' BGS ATD Water Level Depth 10.5' BGS
Ground Surface Elevation Approx 17' NAVD 88

Obs. Well Install. ☒ Yes ☐ No

SAMPLE ID	Blow Count N/12"	RECOVERY		GRAPHIC RECOVERY		USCS Symbol	DESCRIPTION: color, texture, moisture MAJOR CONSTITUENT. NON-SOIL SUBSTANCES: Odor, staining, sheen, scrap, slag, etc.
		From	To				
					0		
					1		No samples collected. Soil removed by Vactor to 5' BGS.
					2		
					3		
					4		
					5		
	2/3/4	5.0	6.5		6	ML	Light brown, slightly plastic, dry to moist, SILT. No odors.
					7		
					8		
					9		
	5/7/5	9.0	10.5		10	SM ∇	Grey, fine, moist, SILTY SAND with gravel. Black staining for 1.5" at water table. No odors.
					11		
					12		
					13		
	6/6/6	14.0	15.5		14	SW	Grey, well-graded, fine to medium, wet, SAND. Faint petroleum odor apparently from soil porewater.
					15		Bottom of boring at 15 feet.
					16		
					17		
					18		
					19		
					20		
					21		
					22		
					23		
					24		
					25		

WELL CONSTRUCTION





∇ Groundwater Observed
At Time of Drilling

Log of Soil Boring and Well Construction MW-24

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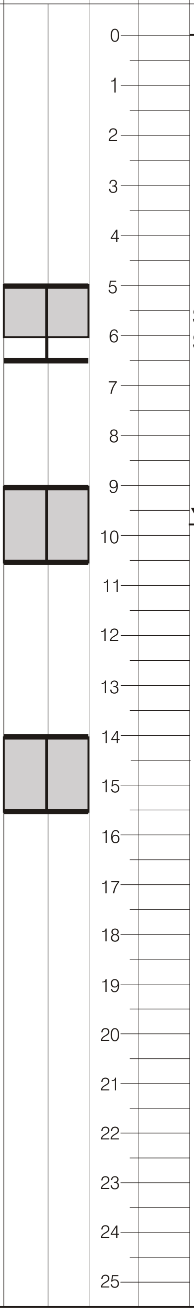
Floyd Snider
Boring MW-24 Date 1/16/07 Sheet 1 of 1
Job SJZ-MTA Job No. XX
Logged By Brett Beaulieu Weather 40s, partly cloudy
Drilled By Cascade Drilling
Drill Type/Method Hollow Stem Auger
Sampling Method 4" Split Spoon, 140 lb Hammer
Bottom of Boring 15.0' BGS ATD Water Level Depth 9.75' BGS
Ground Surface Elevation Approx 16' NAVD 88

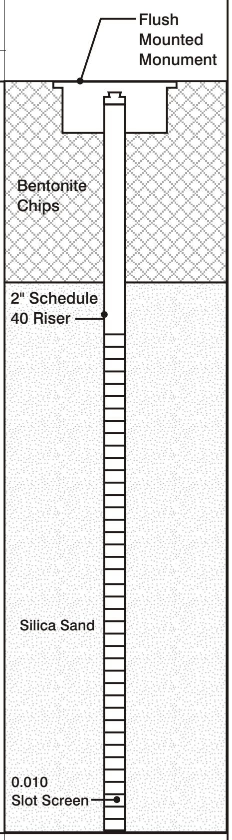
Obs. Well Install. ☒ Yes ☐ No

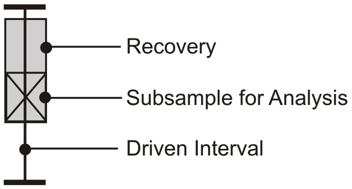
SAMPLE ID	Blow Count N/12"	RECOVERY From	RECOVERY To	USCS Symbol	DESCRIPTION: color, texture, moisture MAJOR CONSTITUENT. NON-SOIL SUBSTANCES: Odor, staining, sheen, scrap, slag, etc.
					No samples collected. Soil removed by Vactor to 5' BGS.
	4/3/5	5.0	6.5	SW-SM	Brown, well-graded, fine to medium, moist, SAND with silt and gravel. Shell fragments. No odors.
	4/4/4	9.0	10.5	▽ SM	Brown, fine, moist, SILTY SAND with gravel. Black staining for 1.5" at water table. Grey at 10 ft BGS. No odors.
	6/7/6	14.0	15.5	SW	Grey, well-graded, fine, wet, SAND.
					Bottom of boring at 15 feet.
					Note: Added approximately 10 gallons clean water to set well.

GRAPHIC RECOVERY



WELL CONSTRUCTION





▽ Groundwater Observed At Time of Drilling

Log of Soil Boring and Well Construction MW-25

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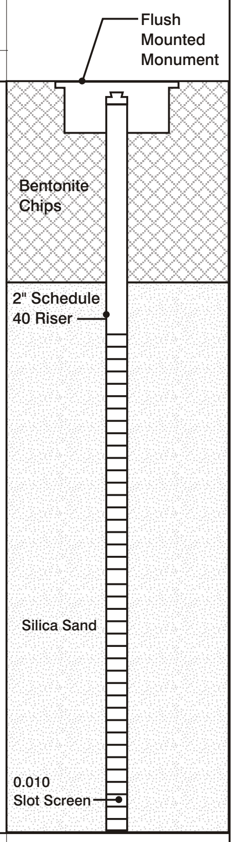
Floyd Snider
Boring MW-25 Date 1/16/07 Sheet 1 of 1
Job SJZ-MTA Job No. XX
Logged By Brett Beaulieu Weather 40s, partly cloudy
Drilled By Cascade Drilling
Drill Type/Method Hollow Stem Auger
Sampling Method 4" Split Spoon, 140 lb Hammer
Bottom of Boring 15.0' BGS ATD Water Level Depth 9.5' BGS
Ground Surface Elevation Approx 16' NAVD 88

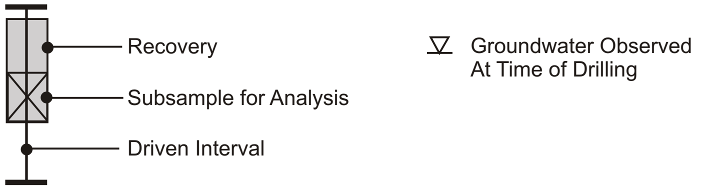
Obs. Well Install. ☒ Yes ☐ No

SAMPLE ID	Blow Count N/12"	RECOVERY		GRAPHIC RECOVERY	USCS Symbol	DESCRIPTION: color, texture, moisture MAJOR CONSTITUENT. NON-SOIL SUBSTANCES: Odor, staining, sheen, scrap, slag, etc.
		From	To			
						No samples collected. Soil removed by Vactor to 5' BGS.
	3/4/3	5.0	6.5		SW-SM	Brown, well-graded, fine to coarse, moist, SAND with silt and gravel. No odors.
	7/9/9	9.0	10.5		∇ SW	Grey, well-graded, fine to coarse, moist, SAND with gravel. Shell fragments. Faint petroleum odors.
	5/7/6	14.0	15.5		SW	Grey, well-graded, fine to coarse, moist, SAND with gravel. Shell fragments. Faint petroleum odors.
						Bottom of boring at 15 feet.

Depth scale: 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25

WELL CONSTRUCTION





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Monitoring Well ID: MW-26

Drill Date: February 6, 2008
Logged By: Megan King
Drilled By: Scott K / Cascade Drilling Inc.

Ground Surf Elev. & Datum: 15.34' (NAVD88)
Coordinate System: NAV83
Latitude/Northing: 420782.538N
Longitude/Easting: 1002585.65E
Casing Elevation: 14.75'

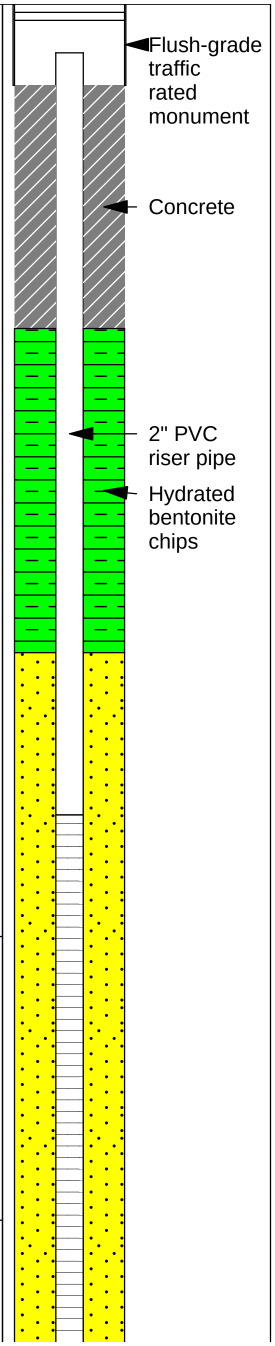
Drill Type: Hollow Stem Auger
Sample Method: 2" x 18" D&M
Boring Diameter: 8-inches
Boring Depth (ft bgs): 16.5'
Groundwater ATD (ft bgs): 10.0'

Client: MTA Group
Project: Marine Trades Area
Task Number: SJZ-MTA T.6
Site Location: 638 Marine Drive
Port Angeles, WA

Remarks: Ground surface compacted angular gravel, located within Westport Marine parking area, off the NW corner of the Westport Building. Weather overcast and cold. Drilling began at 13:30.

PID (ppm)	SHEEN TEST	SAMPLE ID	BLOW COUNT	DRIVEN / RECOVERED	DEPTH FT BGS	USCS SYMBOL	SOIL DESCRIPTION AND OBSERVATIONS
					0	SW-SM	Compact silty SAND with angular gravel.
					1		
					2		
			50				Medium brown silty sand with rounded and angular gravel, dense. Damp, slight odor.
			50/5"		3		
0.7	Slight						
			-				
					4		
			10		5		Same as above with wood fragments and broken shell fragments. Damp, slight odor.
27.9	Moderate		28				
						SW	Light gray medium to coarse SAND with few small rounded gravels. Medium gray CLAY layer 1" thick at 5.9'. Damp.
770	Heavy		35		6		
0.7	Slight						
					7		
			25			SP	Poor recovery due to rock blocking sampler. Light gray fine SAND with silt and well graded rounded gravel and small broken shell fragments. Damp, no odor.
49.9	Slight		18		8		

MONITORING WELL COMPLETION DETAIL



Notes:
FT BGS = feet below ground surface
ppm = parts per million
USCS = Unified Soil Classification System
▼ = denotes groundwater table

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Monitoring Well ID: MW-26

Drill Date: February 6, 2008
Logged By: Megan King
Drilled By: Scott K / Cascade Drilling Inc.

Ground Surf Elev. & Datum: 15.34' (NAVD88)
Coordinate System: NAV83
Latitude/Northing: 420782.538N
Longitude/Easting: 1002585.65E
Casing Elevation: 14.75'

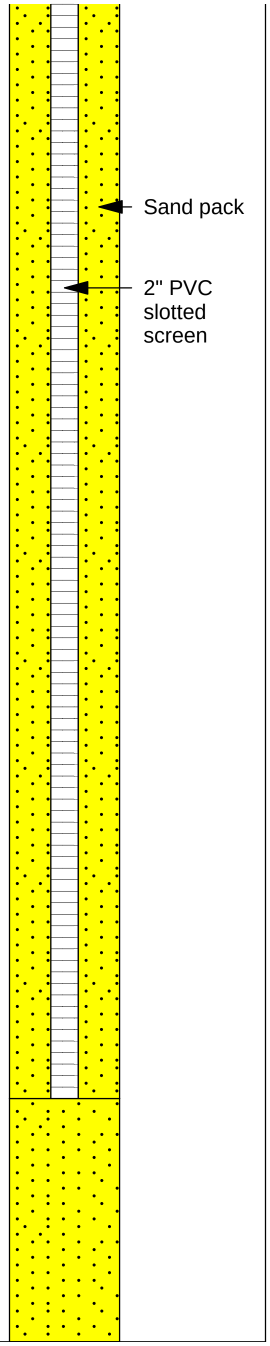
Drill Type: Hollow Stem Auger
Sample Method: 2" x 18" D&M
Boring Diameter: 8-inches
Boring Depth (ft bgs): 16.5'
Groundwater ATD (ft bgs): 10.0'

Client: MTA Group
Project: Marine Trades Area
Task Number: SJZ-MTA T.6
Site Location: 638 Marine Drive
Port Angeles, WA

Remarks: Ground surface compacted angular gravel, located within Westport Marine parking area, off the NW corner of the Westport Building. Weather overcast and cold. Drilling began at 13:30.

PID (ppm)	SHEEN TEST	SAMPLE ID	BLOW COUNT	DRIVEN / RECOVERED	DEPTH FT BGS	USCS SYMBOL	SOIL DESCRIPTION AND OBSERVATIONS
			12		9		
2226	Heavy	MW-26 10-11.5'	10 7		10	SW	Medium gray well graded SAND with <10% well graded rounded gravel and scattered broken shell fragments. Strong hydrocarbon odor.
	Slight		7		11	SP	Medium gray very fine SAND with wood debris. Wet, no odor.
					12		
			12 10 10		13 14		Rock in sampler - no sample collected.
3	None		7		15	GP	Very coarse gravelly SAND with shell fragments. Wet, slight odor.
			8			SM	Medium gray fine silty SAND with few small rounded gravels. Wet, no odor.
2.5	None		10		16		

MONITORING WELL COMPLETION DETAIL



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Monitoring Well ID: MW-27

Drill Date: February 5, 2008
Logged By: Megan King
Drilled By: Scott K / Cascade Drilling Inc.

Ground Surf Elev. & Datum: 15.25' (NAVD88)
Coordinate System: NAV83(91)
Latitude/Northing: 420840.927
Longitude/Easting: 1002688.779
Casing Elevation: 14.76'

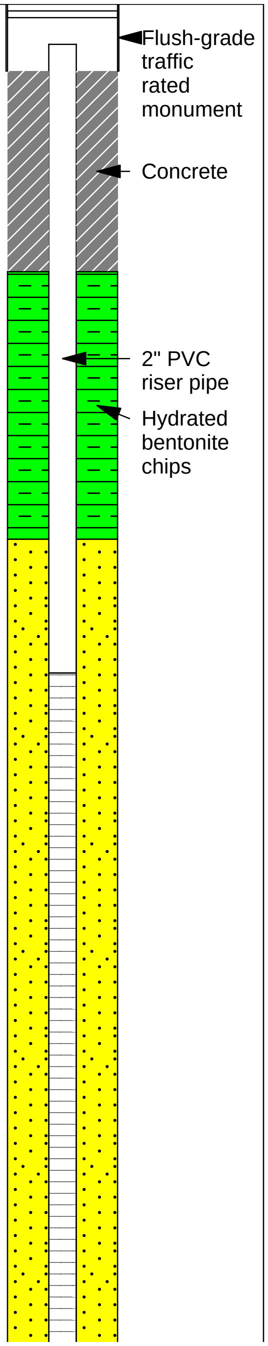
Drill Type: 8"-dia Hollow Stem Auger
Sample Method: 2"x18" D&M Sampler
Boring Diameter: 8-inch
Boring Depth (ft bgs): 20'
Groundwater ATD (ft bgs): 10'

Client: MTA Group
Project: Marine Trades Area
Task Number: SJZ-MTA T.6
Site Location: 638 Marine Drive
Port Angeles, WA

Remarks: Well located in Westport Marine parking lot, approx. 125' North of building.
Surface conditions: compacted angular gravel. Monument set 2" below grade.

PID (ppm)	SHEEN TEST	SAMPLE ID	BLOW COUNT	DRIVEN / RECOVERED	DEPTH FT BGS	USCS SYMBOL	SOIL DESCRIPTION AND OBSERVATIONS
					0	SW	Light brown well graded SAND with ~25% angular gravels. Damp, no odor.
					1		
					2		
			50			SW-SM	Light brown silty SAND with rounded, well graded gravels. Damp, no odor.
			50/4"		3		
			-				
					4		
			15		5	SP	Light brownish gray medium SAND with some gravel and trace silt, sand becomes finer with depth. Damp, slight to moderate hydrocarbon odor at 5.5'.
233			18			SP-SM	Dark gray very fine SAND with silt lense 1" thick. Damp, strong odor.
	Heavy		23		6	SP	Same as unit above SP-SM lense.
		MW-27 6.5-7'					
					7		
			9			SW	Light gray fine to medium SAND with broken shell fragments. Damp, slight odor.
10.5	Slight to Mod.		15		8		
0.8			16			SP	Light gray medium SAND with broken shell fragments. No odor.
					9		
					▼ 10		

MONITORING WELL COMPLETION DETAIL



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Monitoring Well ID: MW-27

Drill Date: February 5, 2008
Logged By: Megan King
Drilled By: Scott K / Cascade Drilling Inc.

Ground Surf Elev. & Datum: 15.25' (NAVD88)
Coordinate System: NAV83(91)
Latitude/Northing: 420840.927
Longitude/Easting: 1002688.779
Casing Elevation: 14.76'

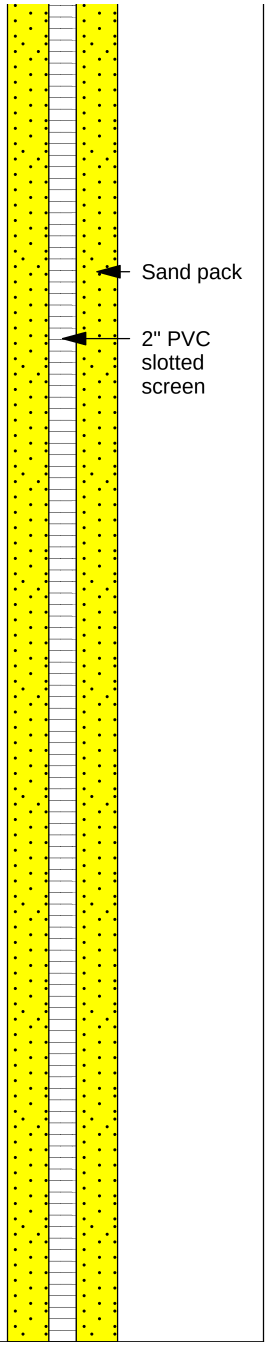
Drill Type: 8"-dia Hollow Stem Auger
Sample Method: 2"x18" D&M Sampler
Boring Diameter: 8-inch
Boring Depth (ft bgs): 20'
Groundwater ATD (ft bgs): 10'

Client: MTA Group
Project: Marine Trades Area
Task Number: SJZ-MTA T.6
Site Location: 638 Marine Drive
Port Angeles, WA

Remarks: Well located in Westport Marine parking lot, approx. 125' North of building.
Surface conditions: compacted angular gravel. Monument set 2" below grade.

PID (ppm)	SHEEN TEST	SAMPLE ID	BLOW COUNT	DRIVEN / RECOVERED	DEPTH FT BGS	USCS SYMBOL	SOIL DESCRIPTION AND OBSERVATIONS
5.9 9.0	None		8 7 7	▨	10	SW	Medium gray fine to medium SAND with rounded gravel and broken shell fragments. Moderate hydrocarbon odor.
					11	SP	1.5" lense of Medium gray very fine SAND. Damp, moderate hydrocarbon odor.
						SW	Medium gray fine to medium SAND with trace silt and small rounded gravels. Broken shell fragments from 13.5'. Slight odor.
					12		
5.4	None		12 13 15	▨	13		
					14		
15.3	None		? ? ?	▨	15		SAA. Slight odor.
					16	SP	Dark gray very fine SAND with ~10% rounded gravel.
					17		
			8 10 15	▨	18		SAA.
1.1	None		8 13	▨	19		SAA with no gravel, and small broken shell fragments. No odor.
					20		

MONITORING WELL COMPLETION DETAIL



Notes:
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Monitoring Well ID: MW-28

Drill Date: February 6, 2008
Logged By: Megan King
Drilled By: Scott K. / Cascade Drilling Inc.

Ground Surf Elev. & Datum: 16.11' (NAVD88)
Coordinate System: NAV83(91)
Latitude/Northing: 420799.679
Longitude/Easting: 1002843.84
Casing Elevation: 15.62'

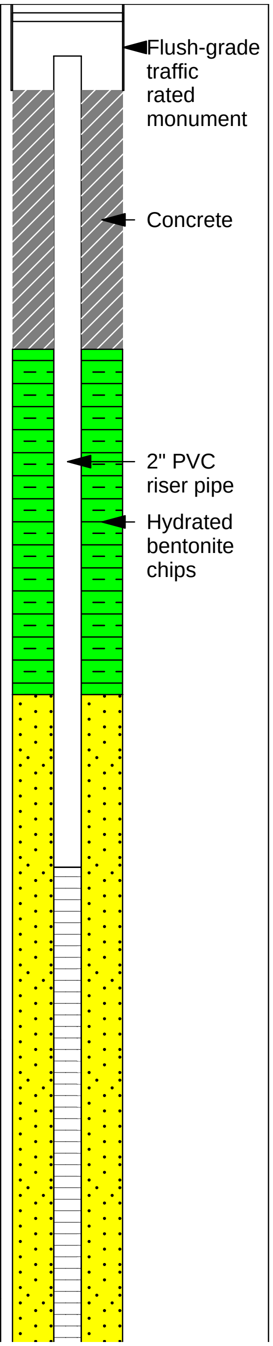
Drill Type: 8"-dia Hollow Stem Auger
Sample Method: 2"x18" D&M Sampler
Boring Diameter: 8-inch
Boring Depth (ft bgs): 15.5
Groundwater ATD (ft bgs): 9.5'

Client: MTA Group
Project: Marine Trades Area
Task Number: SJZ-MTA T.6
Site Location: 638 Marine Drive
Port Angeles, WA

Remarks: Ground surface conditions: compacted angular gravel. Well located N. of Westport building NE corner. Drilling began at 15:30

PID (ppm)	SHEEN TEST	SAMPLE ID	BLOW COUNT	DRIVEN / RECOVERED	DEPTH FT BGS	USCS SYMBOL	SOIL DESCRIPTION AND OBSERVATIONS
					0	SW-SM	Brown compact silty SAND with angular gravel.
					1		
					2		
			35				Light brown silty SAND with rounded gravel, well graded, largest gravel 2" diameter. Damp, no odor.
			35		3		
2.6	Slight						
			40				
					4		
			18		5		SAA. No odor.
3.1	Slight		21				
			25		6	SP	Light brown (with more orange color than above) Medium SAND with trace silt and ~10% rounded gravel. Damp, no odor.
0.3	Slight						
					7		
			10			SW	Light gray medium to coarse SAND with no fines and few rounded gravel. Small

MONITORING WELL COMPLETION DETAIL



Notes:
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Monitoring Well ID: MW-28

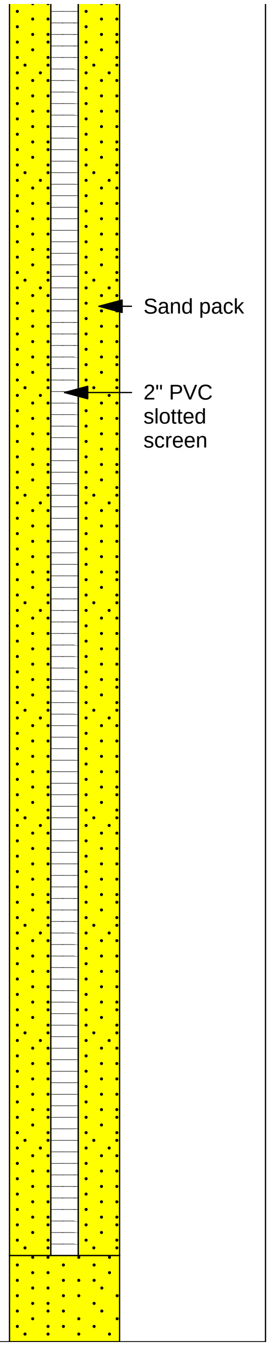
Drill Date: February 6, 2008
Logged By: Megan King
Drilled By: Scott K. / Cascade Drilling Inc.

Ground Surf Elev. & Datum: 16.11' (NAVD88)
Coordinate System: NAV83(91)
Latitude/Northing: 420799.679
Longitude/Easting: 1002843.84
Casing Elevation: 15.62'

Drill Type: 8"-dia Hollow Stem Auger
Sample Method: 2"x18" D&M Sampler
Boring Diameter: 8-inch
Boring Depth (ft bgs): 15.5
Groundwater ATD (ft bgs): 9.5'

Client: MTA Group
Project: Marine Trades Area
Task Number: SJZ-MTA T.6
Site Location: 638 Marine Drive
Port Angeles, WA

Remarks: Ground surface conditions: compacted angular gravel. Well located N. of Westport building NE corner. Drilling began at 15:30

PID (ppm)	SHEEN TEST	SAMPLE ID	BLOW COUNT	DRIVEN / RECOVERED	DEPTH FT BGS	USCS SYMBOL	SOIL DESCRIPTION AND OBSERVATIONS	MONITORING WELL COMPLETION DETAIL
0.4	None		15		8		broken shell fragments. Damp, slight hydrocarbon odor.	
			14					
					9			
					▼			
		MW-28 10-11.5'	8		10		SAA with no gravel, few scattered broken shell fragments. Wet, slight hydrocarbon odor.	
			11					
1.1	None							
					11			
			12					
					12			
			8			SP	Medium to dark gray fine SAND with small (<1cm) rounded gravel and small broken shell fragments throughout. Wet, no odor.	
					13			
			10					
0.2	None							
			10					
			7		14		SAA. No odor.	
			8					
1.1	None							
			9		15	SP-SM	Medium gray very fine SAND with SILT layers and wood debris. Wet, no odor.	

Notes:
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Monitoring Well ID: MW-29

Drill Date: February 5, 2008
Logged By: Megan King
Drilled By: Scott K. / Cascade Drilling Inc.

Ground Surf Elev. & Datum: 14.48' (NAVD88)
Coordinate System: NAV83(91)
Latitude/Northing: 420925.699(N)
Longitude/Easting: 1002617.713(E)
Casing Elevation: 13.96'

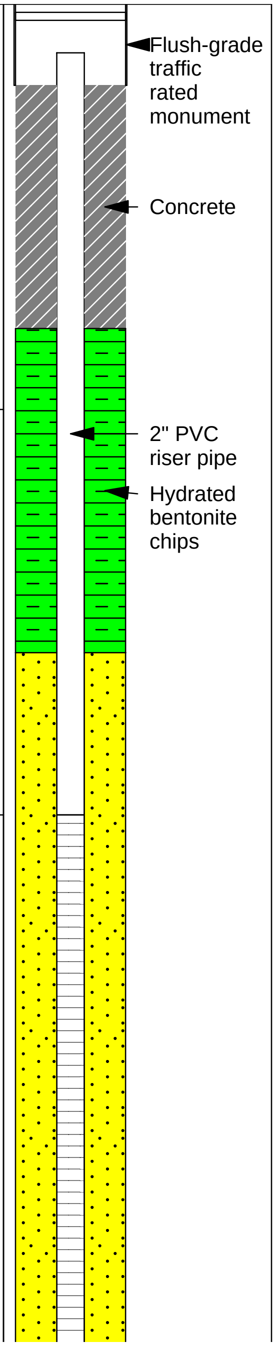
Drill Type: 8"-dia Hollow Stem Auger
Sample Method: 2"x18" D&M Sampler
Boring Diameter: 8-inch
Boring Depth (ft bgs): 16.5'
Groundwater ATD (ft bgs): 8.0'

Client: MTA Group
Project: Marine Trades Area
Task Number: SJZ-MTA T.6
Site Location: 638 Marine Dr.
Port Angeles, WA

Remarks: Ground surface conditions: vegetated soil, and gravel. Well located along east bank of Tumwater creek at outfall to Harbor. Drilling began at 11:30.

PID (ppm)	SHEEN TEST	SAMPLE ID	BLOW COUNT	DRIVEN / RECOVERED	DEPTH FT BGS	USCS SYMBOL	SOIL DESCRIPTION AND OBSERVATIONS
						SM	Light brown silty SAND with rounded and angular gravel. Damp, No odor.
0.3	None		2 2 2			ML	Light brownish gray SILT with very fine sand and small rounded gravel. Few red oxide staining. Damp, no odor.
0.4	None		3 3 4			SW	Gray fine to medium SAND with rounded gravel. Damp, no odor
1.0	Slight		9 9				Gray fine to coarse well graded SAND with rounded gravel, and some silt. Large cobble blocked sampler, poor recovery. Noticable pepper-like odor, wet.

MONITORING WELL COMPLETION DETAIL



Notes:
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ppm = parts per million
USCS = Unified Soil Classification System
▼ = denotes groundwater table

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Monitoring Well ID: MW-29

Drill Date: February 5, 2008
Logged By: Megan King
Drilled By: Scott K. / Cascade Drilling Inc.

Ground Surf Elev. & Datum: 14.48' (NAVD88)
Coordinate System: NAV83(91)
Latitude/Northing: 420925.699(N)
Longitude/Easting: 1002617.713(E)
Casing Elevation: 13.96'

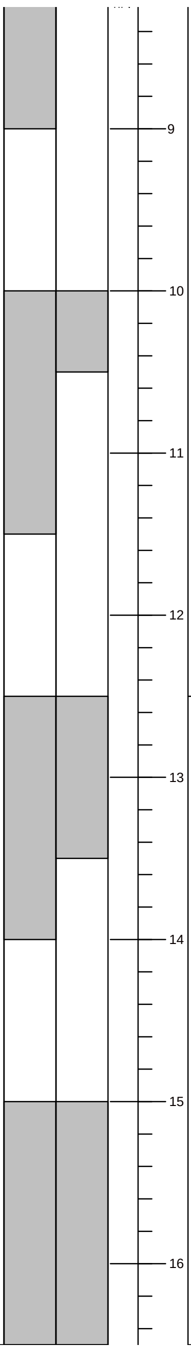
Drill Type: 8"-dia Hollow Stem Auger
Sample Method: 2"x18" D&M Sampler
Boring Diameter: 8-inch
Boring Depth (ft bgs): 16.5'
Groundwater ATD (ft bgs): 8.0'

Client: MTA Group
Project: Marine Trades Area
Task Number: SJZ-MTA T.6
Site Location: 638 Marine Dr.
Port Angeles, WA

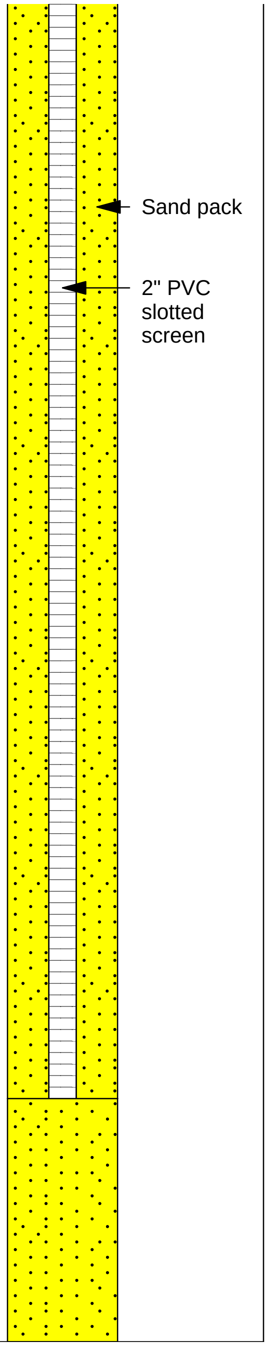
Remarks: Ground surface conditions: vegetated soil, and gravel. Well located along east bank of Tumwater creek at outfall to Harbor. Drilling began at 11:30.

PID (ppm)	SHEEN TEST	SAMPLE ID	BLOW COUNT	USCS SYMBOL	SOIL DESCRIPTION AND OBSERVATIONS
			10		
197	Heavy	MW-29 10'	6 5 4		Gray fine to medium SAND with small rounded gravel, and silt. Poor recovery. Wet, strong odor.
214	Heavy		18 25 30	SP	Fine SAND with few large rounded gravel, and trace silt. Wet, strong hydrocarbon odor, Heavy sheen visible on sample.
1.5	None		15 20 23		Gray fine SAND (grades to coarse with depth) clean, no silt or gravel. wet, no odor.

DRIVEN / RECOVERED — DEPTH FT BGS



MONITORING WELL COMPLETION DETAIL



Notes:
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Monitoring Well ID: MW-30

Drill Date: February 5, 2008
Logged By: Megan King
Drilled By: Scott K./ Cascade Drilling Inc.
Drill Type: 8"-dia Hollow Stem Auger
Sample Method: 2"x18" D&M Sampler
Boring Diameter: 8-inch
Boring Depth (ft bgs): 15'
Groundwater ATD (ft bgs): 8.5'

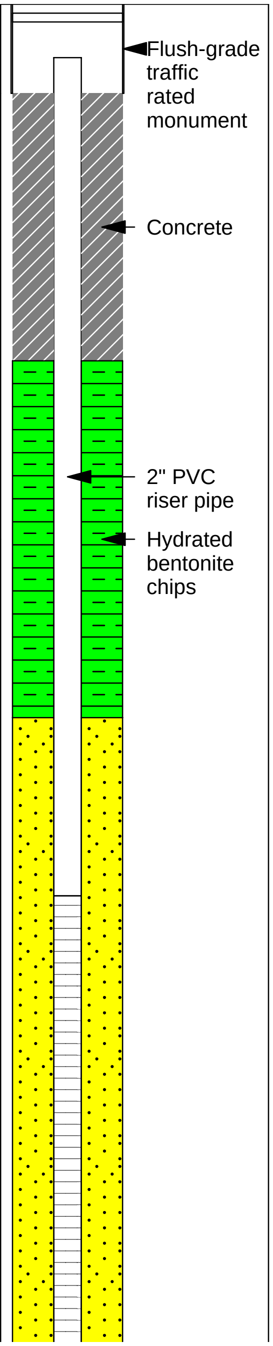
Ground Surf Elev. & Datum: 14.67' (NAVD88)
Coordinate System: NAV83
Latitude/Northing: 420974.166N
Longitude/Easting: 1002801.73E
Casing Elevation: 14.18'

Client: MTA Group
Project: Marine Trades Area
Task Number: SJZ-MTA T.6
Site Location: 638 Marine Drive
Port Angeles, WA

Remarks: Ground surface paved, well installed between existing wells MW-20B and MW-21A. Drilling began at 14:30.

PID (ppm)	SHEEN TEST	SAMPLE ID	BLOW COUNT	DRIVEN / RECOVERED	DEPTH FT BGS	USCS SYMBOL	SOIL DESCRIPTION AND OBSERVATIONS
					0	Asphalt	Asphalt, 6" thick.
						SW-SM	Light brown SILTY SAND with rounded and angular gravels, damp, no odor.
					1		
					2		
			15				
					3	SW	Light brown well graded SAND with well-graded rounded gravels and trace silt. damp, no odor.
0.3			25				
			27				
					4		
			10		5		SAA.
0.3			11				
			12		6		
					7		

MONITORING WELL COMPLETION DETAIL



Notes:
FT BGS = feet below ground surface
ppm = parts per million
USCS = Unified Soil Classification System
▼ = denotes groundwater table

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Monitoring Well ID: MW-30

Drill Date: February 5, 2008
Logged By: Megan King
Drilled By: Scott K./ Cascade Drilling Inc.

Ground Surf Elev. & Datum: 14.67' (NAVD88)
Coordinate System: NAV83
Latitude/Northing: 420974.166N
Longitude/Easting: 1002801.73E
Casing Elevation: 14.18'

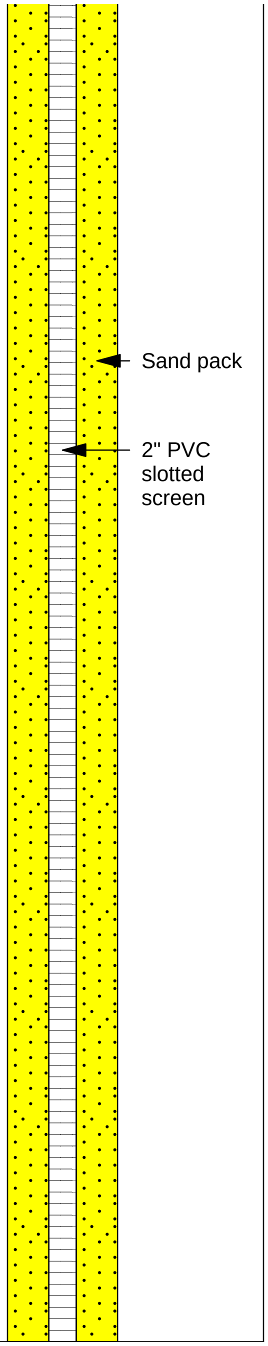
Drill Type: 8"-dia Hollow Stem Auger
Sample Method: 2"x18" D&M Sampler
Boring Diameter: 8-inch
Boring Depth (ft bgs): 15'
Groundwater ATD (ft bgs): 8.5'

Client: MTA Group
Project: Marine Trades Area
Task Number: SJZ-MTA T.6
Site Location: 638 Marine Drive
Port Angeles, WA

Remarks: Ground surface paved, well installed between existing wells MW-20B and MW-21A. Drilling began at 14:30.

PID (ppm)	SHEEN TEST	SAMPLE ID	BLOW COUNT	DEPTH FT BGS	USCS SYMBOL	SOIL DESCRIPTION AND OBSERVATIONS
0.4			16			SAA with small broken shell fragments. no odor.
		MW-30 8-9'	9	8	SP	@ 8.0', 1"-thick lense of light brown very fine sand.
125.9			8	▼		Medium gray fine SAND with thin SILT lenses, wet, very strong odor.
				9		
279		MW-30 10'	18	10	SW-SM	Poor recovery, large rock in sampler, 4" material recovered. Med. gray SILTY SAND with rounded gravels, very strong odor.
	NAPL		20			
			23	11		
56.6			12			
41.6	Heavy				ML	Medium gray SILT, wet, very strong organic sulfur-like odor.
			9	12	SP	Medium gray fine SAND with thin silt lenses and shell fragments, wet, strong organic sulfur-like odor.
8.2	Heavy		8			
				13		
35.0	Moderate		6		SW	Medium gray well graded SAND with silt and small rounded gravels, and small shell fragements, wet, slight odor.
		MW-30 15'	7	14		Medium gray fine to medium SAND, wet, no odor.
	Slight		8			
2.6	None			15	CL	Medium gray fat CLAY, medium plasticity, wet, no odor.

MONITORING WELL COMPLETION DETAIL



Notes:
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Monitoring Well ID: MW-31

Drill Date: February 6, 2008
Logged By: Megan King
Drilled By: Scott K./ Cascade Drilling Inc.

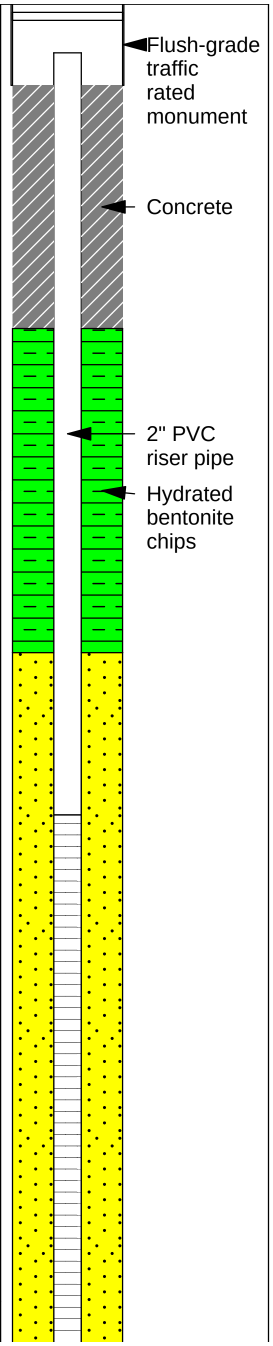
Ground Surf Elev. & Datum: 14.55' (NAVD88)
Coordinate System: NAV83
Latitude/Northing: 420994.181N
Longitude/Easting: 1002876.827E
Casing Elevation: 13.92'

Drill Type: 8"-dia Hollow Stem Auger
Sample Method: 2"x18" D&M Sampler
Boring Diameter: 8-inch
Boring Depth (ft bgs): 16.5'
Groundwater ATD (ft bgs): 8.0'

Client: MTA Group
Project: Marine Trades Area
Task Number: SJZ-MTA T.6
Site Location: 638 Marine Drive
Port Angeles, WA

Remarks: Ground surface compacted gravel, well located between bulkhead and paved roadway. Purge water from developing turned black while sitting exposed. Water removed from the well was clear and colorless.

PID (ppm)	SHEEN TEST	SAMPLE ID	BLOW COUNT	DRIVEN / RECOVERED	DEPTH FT BGS	USCS SYMBOL	SOIL DESCRIPTION AND OBSERVATIONS	MONITORING WELL COMPLETION DETAIL
					0	SW-SM	Medium brown silty sand with rounded and angular gravels, damp, no odor.	
					1			
					2			
			10					
			10		3	SW	Light brown, medium to coarse SAND, one small broken shell fragment, damp, no odor.	
0.1	None		11					
					4			
			7		5		SAA with small rounded gravels and broken shell fragments at 5.25', damp, slight odor at 6.5'.	
			8					
			10		6			
0.7	None							
					7			
			7				SAA.	
0.3	None							
		MW-31 8.0-9.0'	9		8	SP	Light brown fine sand, wet, slight odor. Distinct color contact at 8.25'.	



Notes:
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ppm = parts per million
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▼ = denotes groundwater table

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Monitoring Well ID: MW-31

Drill Date: February 6, 2008
Logged By: Megan King
Drilled By: Scott K./ Cascade Drilling Inc.

Ground Surf Elev. & Datum: 14.55' (NAVD88)
Coordinate System: NAV83
Latitude/Northing: 420994.181N
Longitude/Easting: 1002876.827E
Casing Elevation: 13.92'

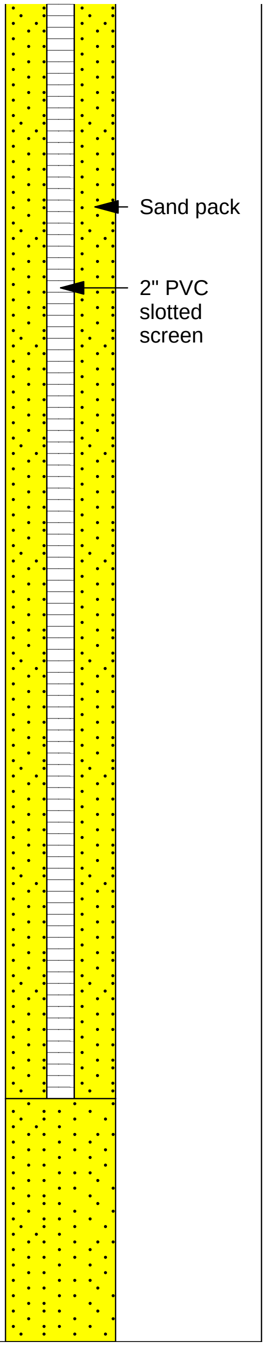
Drill Type: 8"-dia Hollow Stem Auger
Sample Method: 2"x18" D&M Sampler
Boring Diameter: 8-inch
Boring Depth (ft bgs): 16.5'
Groundwater ATD (ft bgs): 8.0'

Client: MTA Group
Project: Marine Trades Area
Task Number: SJZ-MTA T.6
Site Location: 638 Marine Drive
Port Angeles, WA

Remarks: Ground surface compacted gravel, well located between bulkhead and paved roadway. Purge water from developing turned black while sitting exposed. Water removed from the well was clear and colorless.

PID (ppm)	SHEEN TEST	SAMPLE ID	BLOW COUNT	DRIVEN / RECOVERED	DEPTH FT BGS	USCS SYMBOL	SOIL DESCRIPTION AND OBSERVATIONS
1051	NAPL		12			SW	Gray, fine to medium SAND, wet, strong hydrocarbon odor.
						SM	Gray, very fine silty SAND, plastic, wet, strong hydrocarbon odor.
					9	SW	Medium gray well graded SAND with rounded gravels (25%), wet, strong hydrocarbon odor.
			10		10	SP	Medium gray fine SAND, wet, strong hydrocarbon odor.
1442	NAPL		10				
997	NAPL		15		11	GP	4" lense of medium gray well graded gravel with sand (GP) at 11.2'
					12		
			12			SW	Medium gray fine to coarse SAND with broken shell fragments (increasing with depth) and rounded gravels (5%), wet, strong odor (dissapates with depth).
137	Moderate		13		13		
1.7	Light		13				
					14		
			8		15		
19.6	Light						
			10			SP	Medium gray very fine sand with some silt, wood debris at 16.5', and one broken shell fragment at 16.5'. 1" thick clay layer at 16', wet, strong organic sulfur-like odor.
0.6	None		10		16	CL	
						SP	

MONITORING WELL COMPLETION DETAIL



Notes:
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Monitoring Well ID: MW-32

Drill Date: February 6, 2008
Logged By: Megan King
Drilled By: Scott K./ Cascade Drilling Inc.
Drill Type: 8"-dia Hollow Stem Auger
Sample Method: 2"x18" D&M Sampler
Boring Diameter: 8-inch
Boring Depth (ft bgs): 16.5'
Groundwater ATD (ft bgs): 10.25'

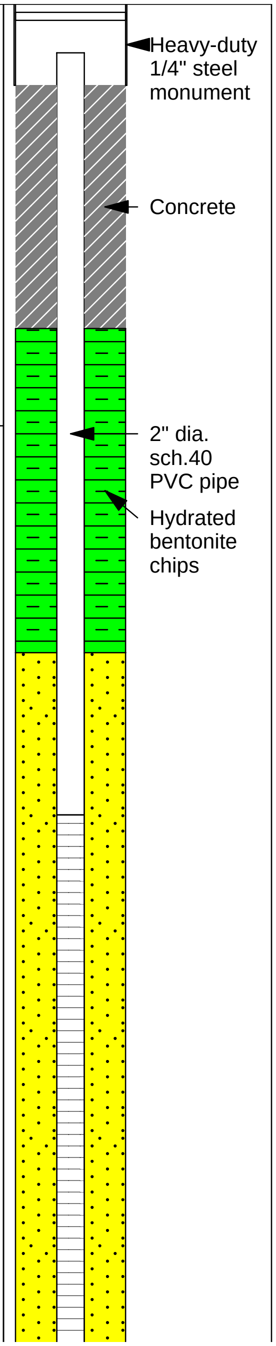
Ground Surf Elev. & Datum: 14.98' (NAVD88)
Coordinate System: NAV83
Latitude/Northing: 420880.17N
Longitude/Easting: 1002799.57E
Casing Elevation: 14.64'

Client: MTA Group
Project: Marine Trades Area
Task Number: SJZ-MTA T.6
Site Location: 638 Marine Drive
Port Angeles, WA

Remarks: Ground surface compacted gravel, well located south of roadway in machine storage area. Completed with heavy-duty monument sunk 2" below grade.

PID (ppm)	SHEEN TEST	SAMPLE ID	BLOW COUNT	DRIVEN / RECOVERED	DEPTH FT BGS	USCS SYMBOL	SOIL DESCRIPTION AND OBSERVATIONS
					0	SW-SM	Medium brown silty SAND with angular gravel, damp, no odor.
					1		
					2		
			15				
						SW	Light gray medium to coarse SAND with rounded gravel (<10%) and broken shell fragments, damp, moderate odor.
			18		3		
	Slight						
			18				
16.1							
					4		
			8		5		
243							SAA, damp, strong odor, NAPL coating soil particles at 6.5', produced NAPL in sheen test.
	Heavy to NAPL		9				
			9		6		
1666							
					7		
			10				SAA with fewer gravels and shell fragments (<1%), damp, strong odor.
1804	Heavy to		10		8		

MONITORING WELL COMPLETION DETAIL



Notes:
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ppm = parts per million
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Monitoring Well ID: MW-32

Drill Date: February 6, 2008
Logged By: Megan King
Drilled By: Scott K./ Cascade Drilling Inc.

Ground Surf Elev. & Datum: 14.98' (NAVD88)
Coordinate System: NAV83
Latitude/Northing: 420880.17N
Longitude/Easting: 1002799.57E
Casing Elevation: 14.64'

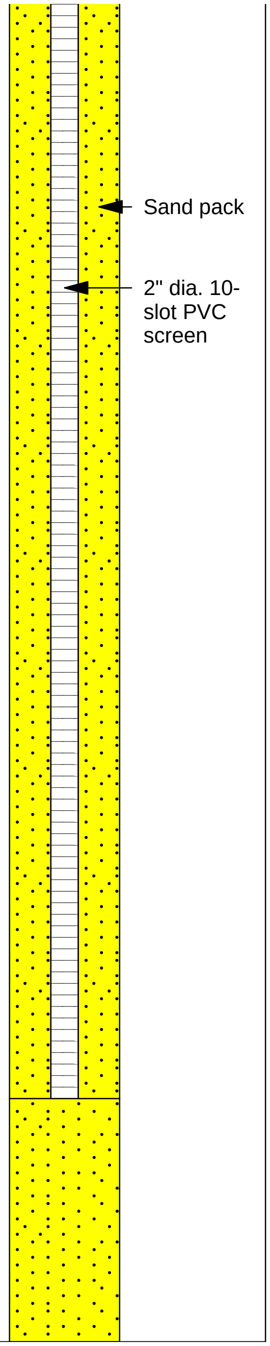
Drill Type: 8"-dia Hollow Stem Auger
Sample Method: 2"x18" D&M Sampler
Boring Diameter: 8-inch
Boring Depth (ft bgs): 16.5'
Groundwater ATD (ft bgs): 10.25'

Client: MTA Group
Project: Marine Trades Area
Task Number: SJZ-MTA T.6
Site Location: 638 Marine Drive
Port Angeles, WA

Remarks: Ground surface compacted gravel, well located south of roadway in machine storage area. Completed with heavy-duty monument sunk 2" below grade.

PID (ppm)	SHEEN TEST	SAMPLE ID	BLOW COUNT	DRIVEN / RECOVERED	DEPTH FT BGS	USCS SYMBOL	SOIL DESCRIPTION AND OBSERVATIONS
	NAPL		10				
					9		
		MW-32 10-11.5'	8		10 ▼		SAA, gray, wet, very strong odor. Light orange colored NAPL in sheen test, and stained sample gloves and equipment.
			6				
1495	NAPL						
			5		11		
					12		
			7				SAA, gray medium to coarse SAND with few rounded gravels and broken shell fragments, wet, moderate odor. Medium gray fine clean SAND lense (3" thick) at 13.5'. Odor slight at 14'.
748	Slight to Moderate		8		13		
			9				
16.0	Slight				14		
			7		15		
290	Heavy		8				
		MW-32 16-16.5'	9		16	SW	Dark gray fine to medium SAND with rounded gravel and broken shell fragments, wet, strong odor.
6.3	None						

MONITORING WELL COMPLETION DETAIL



Notes:
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Monitoring Well ID: MW-33

Drill Date: February 7, 2008
Logged By: Megan King
Drilled By: Scott K./ Cascade Drilling Inc.

Ground Surf Elev. & Datum: 17.47' (NAVD88)
Coordinate System: NAV83
Latitude/Northing: 420475.105N
Longitude/Easting: 1002803.052E
Casing Elevation: 17.07'

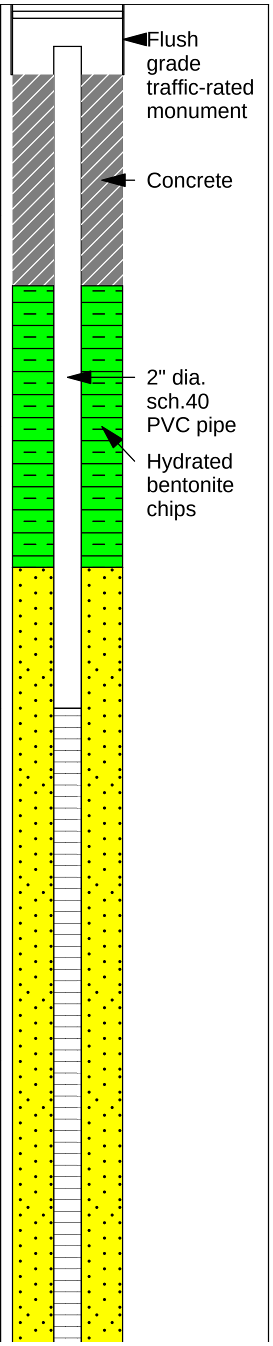
Drill Type: 8"-dia Hollow Stem Auger
Sample Method: 2"x18" D&M Sampler
Boring Diameter: 8-inch
Boring Depth (ft bgs): 19.0'
Groundwater ATD (ft bgs): 10'

Client: MTA Group
Project: Marine Trades Area
Task Number: SJZ-MTA T.6
Site Location: 638 Marine Drive
Port Angeles, WA

Remarks: Ground surface compacted angular gravel. Completed with traffic rated monument. Well located near NW corner entry to Platypus Marine Shop.

PID (ppm)	SHEEN TEST	SAMPLE ID	BLOW COUNT	DEPTH FT BGS	USCS SYMBOL	SOIL DESCRIPTION AND OBSERVATIONS
				0	SW-SM	Medium brown, silty SAND with gravel, rounded and angular gravels, well graded, damp, no hydrocarbon odor.
2.7	None					
				1		
					OL/OH	Dark brown sandy organic soil with gravel. Contains wood particles/chips, with fine silty sand, and 5% large rounded gravels, damp, no hydrocarbon odor. One piece of wood debris stained bright red color.
				2		
			16			
			35	3	SP	Light gray very fine SAND with no gravel or debris, damp, no odor
1.3	None		40			
				4		
			8	5	ML	Light gray dense SILT, damp, slight hydrocarbon odor.
0.6	Slt-Org?					
10.7	Slt-Org?		15			
0.7	Slt-Org?		15	6	SP	Light gray fine SAND, with no gravel or debris, dense, damp, moderate hydrocarbon odor.
		MW-33 6.5'				
				7		
			14		SW	Light gray medium to coarse SAND with few broken shell fragments and small rounded gravels, damp, slight odor.
2.3	None		16	8		
2.2	None		17			
		MW-33 9.0'		9		

MONITORING WELL COMPLETION DETAIL



Notes:
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ppm = parts per million
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Monitoring Well ID: MW-33

Drill Date: February 7, 2008
Logged By: Megan King
Drilled By: Scott K./ Cascade Drilling Inc.

Ground Surf Elev. & Datum: 17.47' (NAVD88)
Coordinate System: NAV83
Latitude/Northing: 420475.105N
Longitude/Easting: 1002803.052E
Casing Elevation: 17.07'

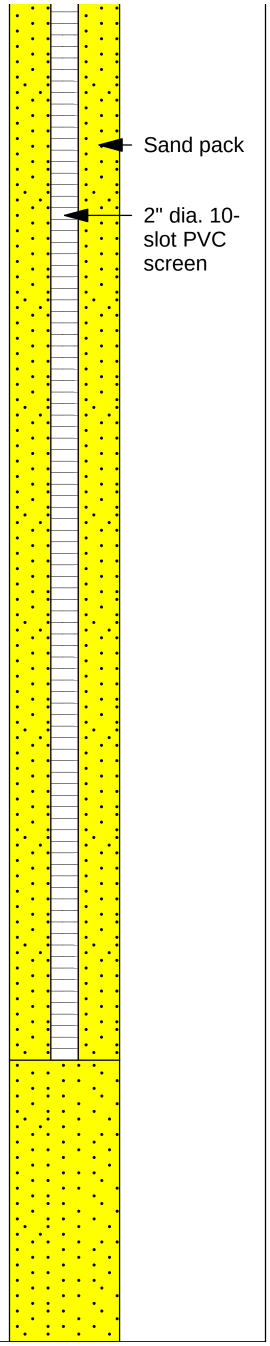
Drill Type: 8"-dia Hollow Stem Auger
Sample Method: 2"x18" D&M Sampler
Boring Diameter: 8-inch
Boring Depth (ft bgs): 19.0'
Groundwater ATD (ft bgs): 10'

Client: MTA Group
Project: Marine Trades Area
Task Number: SJZ-MTA T.6
Site Location: 638 Marine Drive
Port Angeles, WA

Remarks: Ground surface compacted angular gravel. Completed with traffic rated monument. Well located near NW corner entry to Platypus Marine Shop.

PID (ppm)	SHEEN TEST	SAMPLE ID	BLOW COUNT	DRIVEN / RECOVERED	DEPTH FT BGS	USCS SYMBOL	SOIL DESCRIPTION AND OBSERVATIONS
57.8	None	MW-33 11.5'	12 16 18		10 11 12		SAA with 20% rounded gravel, matrix coarser with depth, wet, moderate odor at 11.5'.
2.5	None	MW-33 13'	12 14 17		13 14	SW-SM	Light gray well graded sand with silt and gravel, wet, strong hydrocarbon odor
2.2	None		- - -		15 16 17	SP	Medium to light gray coarse sand with with well graded rounded gravels, wet, moderate hydrocarbon odor.
4.2	None	MW-33 18'	6 7		18	SW	Light gray well graded SAND wtih trace silt and rounded gravel, wet, no odor.
0.5	None		7		19	SP	Light gray fine SAND with trace silt and rounded gravel, wet, no odor.

MONITORING WELL COMPLETION DETAIL



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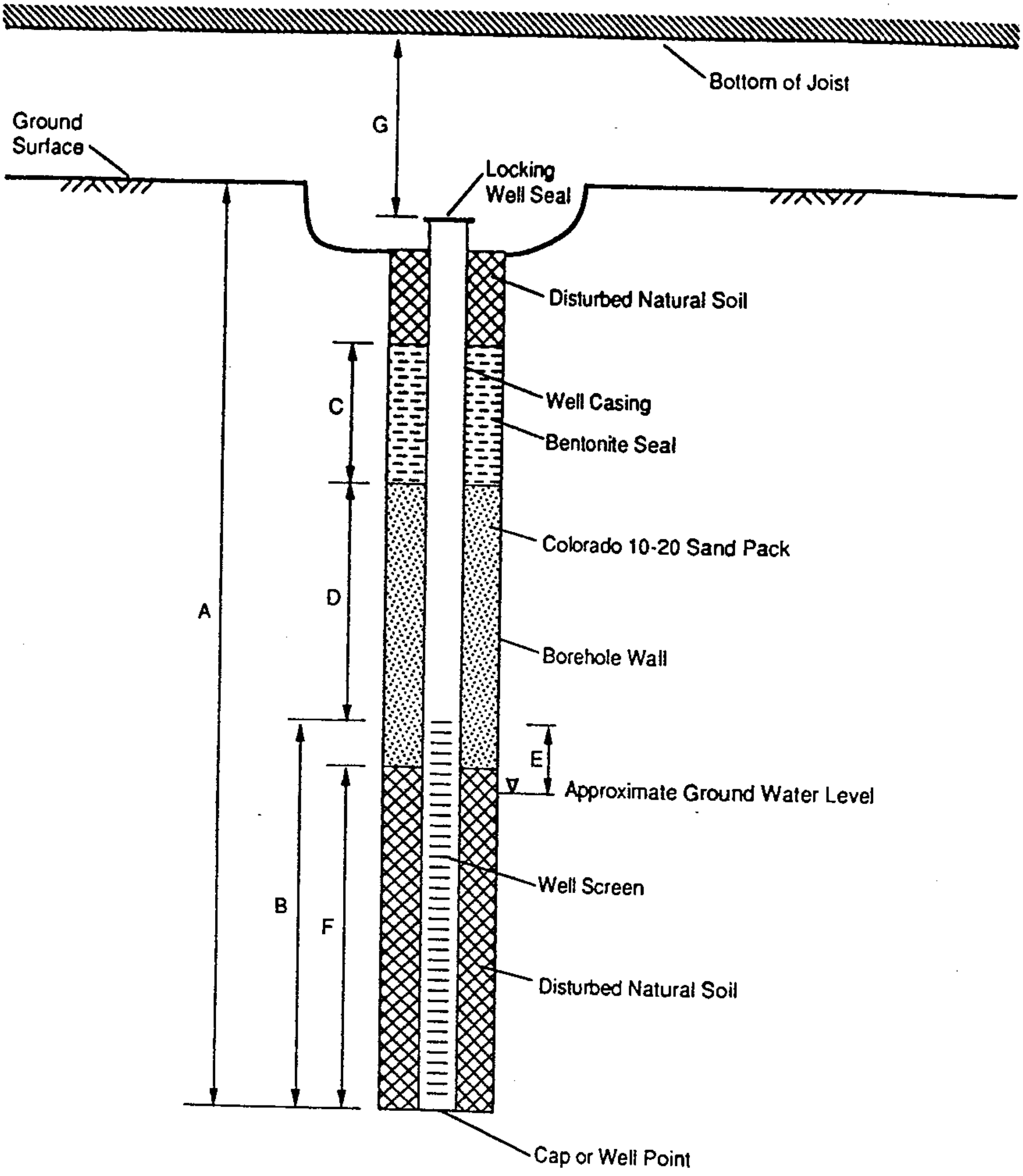
APPENDIX A

Well Construction Details

Figures A-1 and A-2 depict typical as-built well construction details. Specific dimensions and variances from the illustrations are summarized in Table A-1.

The monitoring wells were installed by digging a hole to the ground water surface with hand tools (such as shovel, posthole digger, and hand auger). The well screen and casing were inserted in the hole and jetted or driven into place. The wells constructed of PVC were jetted with tap water. The jetting equipment was washed with soap and hot water prior to use. The wells constructed of steel were driven into place with a hammer.

All wells were installed under the supervision of a licensed well driller and were constructed in accordance with the intent of the Washington State regulation, Minimum Standards for Construction and Maintenance of Wells (WAC 173-160). The start card for these wells was submitted to the Southwest Regional Office of the Washington Department of Ecology on January 19, 1989. The well record will be submitted within the 30 day period following well completion.

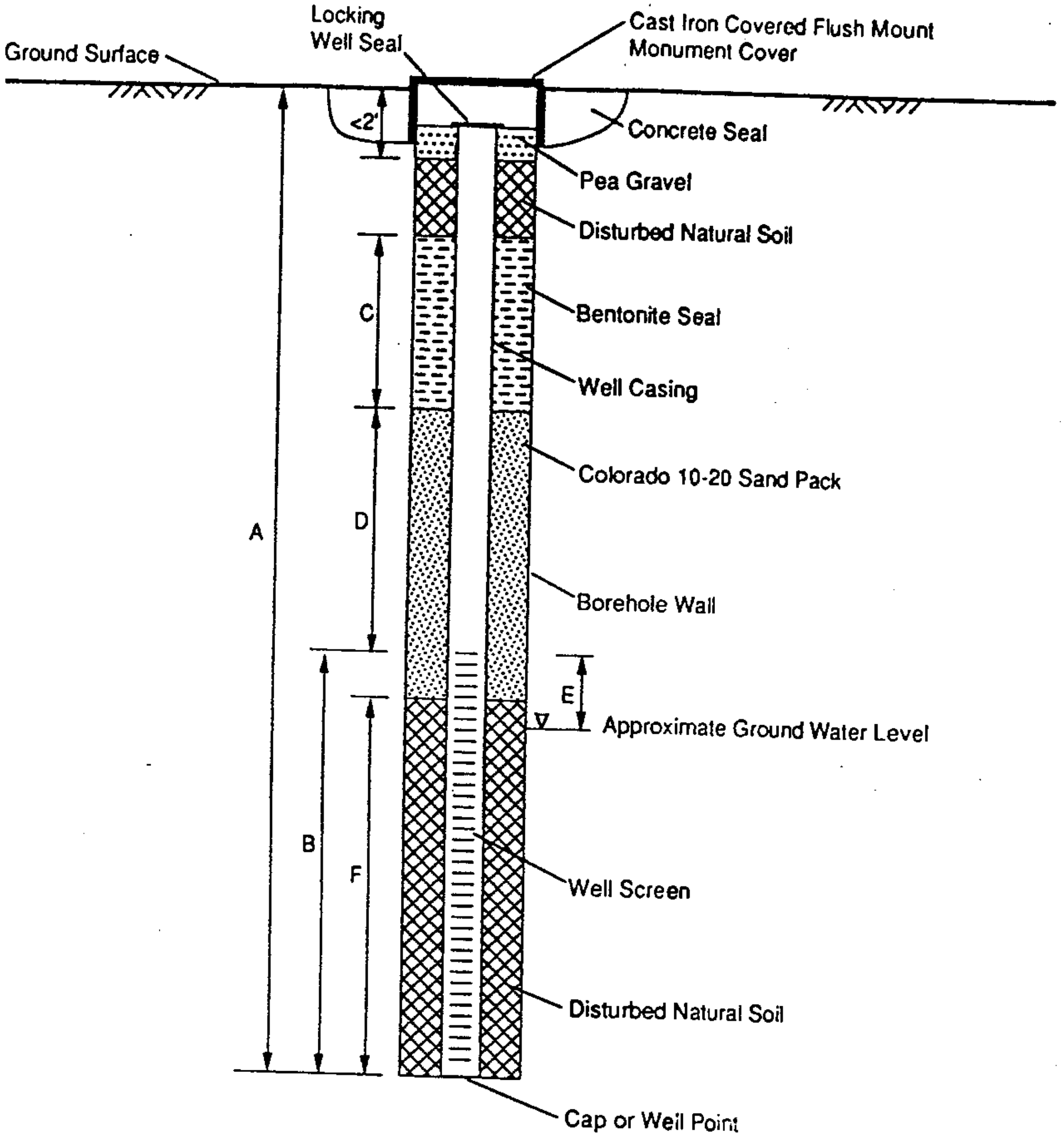


Notes:
1) Not to scale.
2) Refer to Table A-1 for dimensions.

LANDAU ASSOCIATES, INC.

Typical Inside Monitoring Well

igure A-1



Notes:

1) Not to scale.
2) Refer to Table A-1 for dimensions.

LANDAU ASSOCIATES, INC.

Typical Outside Monitoring Well

Figure A-2

TABLE A-1

WELL CONSTRUCTION DETAILS

		A	B	C	D	E	F	G			
Well	Figure	Total Depth (ft.)	Screen Length (ft.)	Seal Thickness (ft.)	Bottom of Seal to Top of Screen (ft.)	Top of Screen to Water Level(1) (ft.)	Bottom of Sandpack to Bottom of Well (ft.)	Overhead Clearance (ft.)	Casing Description	Screen Description	Monument Description
PP-1	A-1	12.5	5.0	5.3	0.8	3.3	4.0	5.2	2 in. Sch. 40 PVC	2 in. Sch. 40 PVC, 0.010 in. slot	No monument(3)
PP-2(2)	A-1	15.9	5.2	3.0	5.0	1.5	7.2	4.2	1.25 in. Sch. 80 Steel inside 2 in. Sch. 40 PVC	1.25 in. diameter, 60 mesh steel screen	8-inch diameter concrete
PP-3	A-1	12.5	5.0	2.4	2.1	3.3	6.5	3.8	2 in. Sch. 40 PVC	2 in. Sch. 40 PVC, 0.010 in. slot	No monument(3)
PP-4	A-1	12.5	5.0	2.8	1.3	2.5	3.0	4.5	2 in. Sch. 40 PVC	2 in. Sch. 40 PVC, 0.010 in. slot	No monument(3)
PP-5	A-1	13.5	5.0	2.8	0.9	2.5	4.5	3.9	2 in. Sch. 40 PVC	2 in. Sch. 40 PVC, 0.010 in. slot	No monument(3)
PP-6	A-2	13.1	5.0	1.5	1.3	2.8	3.5	NA	2 in. Sch. 40 PVC	2 in. Sch. 40 PVC, 0.010 in. slot	Flush mounted cast iron
PP-7	A-2	13.3	5.2	3.8	1.0	2.1	3.6	NA	1.25 in. Sch. 80 steel	1.25 in. diameter, 60 mesh steel screen	Flush mounted cast iron
PP-8	A-2	12.2	3.3	5.0	2.5	1.3	2.5	NA	1.25 in. Sch. 80 steel	1.25 in. diameter, 60 mesh steel screen	Flush mounted cast iron
PP-9(2)	A-2	14.0	5.2	4.1	1.1	2.4	3.1	NA	1.25 in. Sch. 80 steel inside 2 in. Sch. 40 PVC	1.25 in. diameter, 60 mesh steel screen	Flush mounted cast iron
PP-10	A-1	12.5	5.0	3.4	1.3	2.7	3.0	4.7	2 in. Sch. 40 PVC	2 in. Sch. 40 PVC,	No monument(3)

NOTES:

NA Not Applicable

(1) At time of installation.

(2) These wells, initially constructed by jetting a 2-inch PVC casing, were subsequently deepened by driving a 1.25-inch steel well point down through the PVC casing. The addition of the steel insert left the bentonite seal intact. The dimensions are given relative to the steel well screen.

(3) Protective monuments were not installed on wells in low-traffic, non-public locations.

APPENDIX B

Soil Sample Descriptions and Locations

Listed below are the identifications of all soil samples collected and a brief description of each sample. The depths given refer to the depth beneath the ground surface. Note that the ground surface beneath the mill floor may not be level or at the same elevation as the ground surface outside the mill. Sample locations can be determined from the text below and by reference to Figure 1.

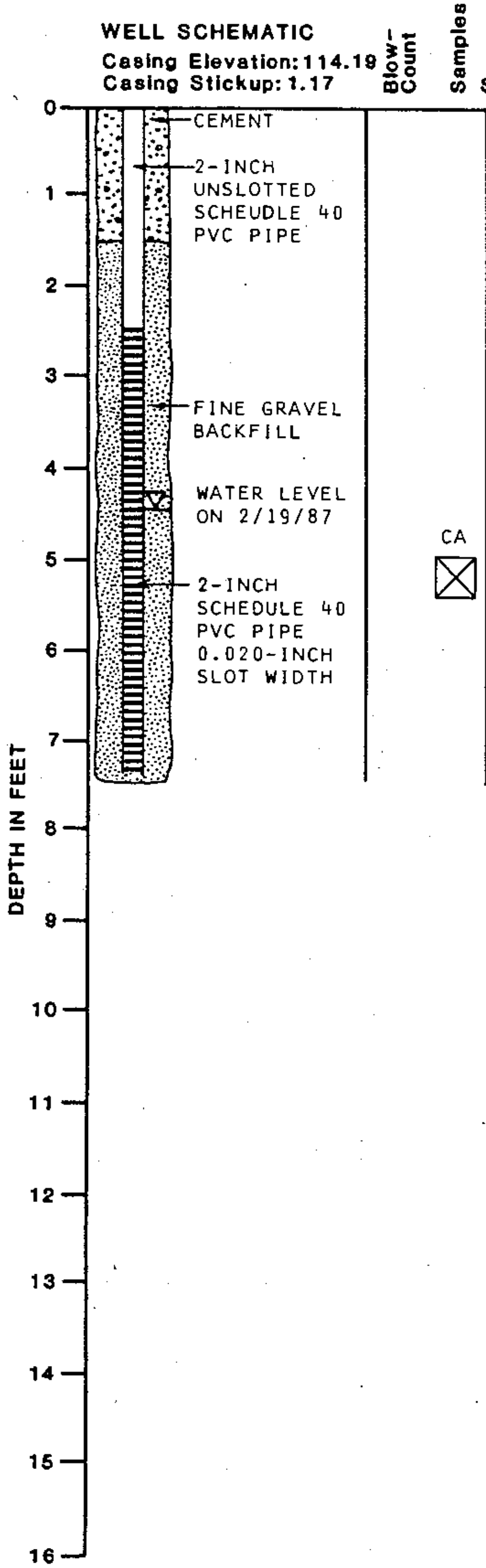
Soil samples were analyzed by Analytical Resources, Inc. of Seattle under subcontract to Landau Associates, Inc. The analytical results are presented in Appendix C.

Sample I.D.	Description and Location
PS-49	Gray, fine to medium sand with some gravel. Abundant shell fragments. Very oily. Sample collected at location of Well PP-2 from 8.0 to 8.2 foot depth.
PS-50	Gray, fine to medium sand with shell fragments. Wet. Faint gasoline odor. Sample collected at location of Well PP-4 from 9.8 to 9.9 foot depth.
PS-51	Gray, fine to medium sand with fine and coarse gravel and shell fragments. No petroleum odors. Wet. Sample collected at location of Well PP-6 from 10.5 to 10.6 foot depth.
PS-52	Gray, gravelly fine to medium sand. Apparently wet with fuel oil. Sample collected at location of Well PP-7 from 10.2 to 10.3 foot depth.
PS-53	Gray, gravelly fine to medium sand. Apparently wet with fuel oil. Sample collected at location of Well PP-8 from 10.9 to 11.0 foot depth.
PS-54	Brownish gray, gravelly, fine to coarse sand. Wet. No petroleum odors. Sample collected at location of Well PP-9 from 11.4 to 11.5 foot depth.
PS-55	Gray, fine to medium sand with trace of gravel. Very oily with gasoline odor. Sample collected at location of Well PP-10 from 10.7 to 10.8 foot depth.

MONITOR WELL NO. MW-1

WELL SCHEMATIC
Casing Elevation: 114.19
Casing Stickup: 1.17

Surface Elevation: 113.02



Group Symbol	DESCRIPTION
SM	BROWN SILTY FINE TO COARSE GRAVEL WITH SAND (DENSE, MOIST) (FILL)
SP-SM	GRAY FINE TO MEDIUM SAND WITH SILT (MEDIUM DENSE, MOIST) MODERATE HYDROCARBON ODOR AT 2 FEET
SM	GRAY SILTY FINE SAND (LOOSE, MOIST) STRONG HYDROCARBON ODOR FROM 4 TO 7½ FEET BECOMES WET AT 5 FEET
SW-SM	GRAY FINE TO COARSE SAND WITH SILT AND GRAVEL (MEDIUM DENSE, WET)
	BORING COMPLETED AT 7½ FEET ON 2/4/87

Note: See Figure A-2 for Explanation of Symbols

GeoEngineers Incorporated

LOG OF MONITOR WELL

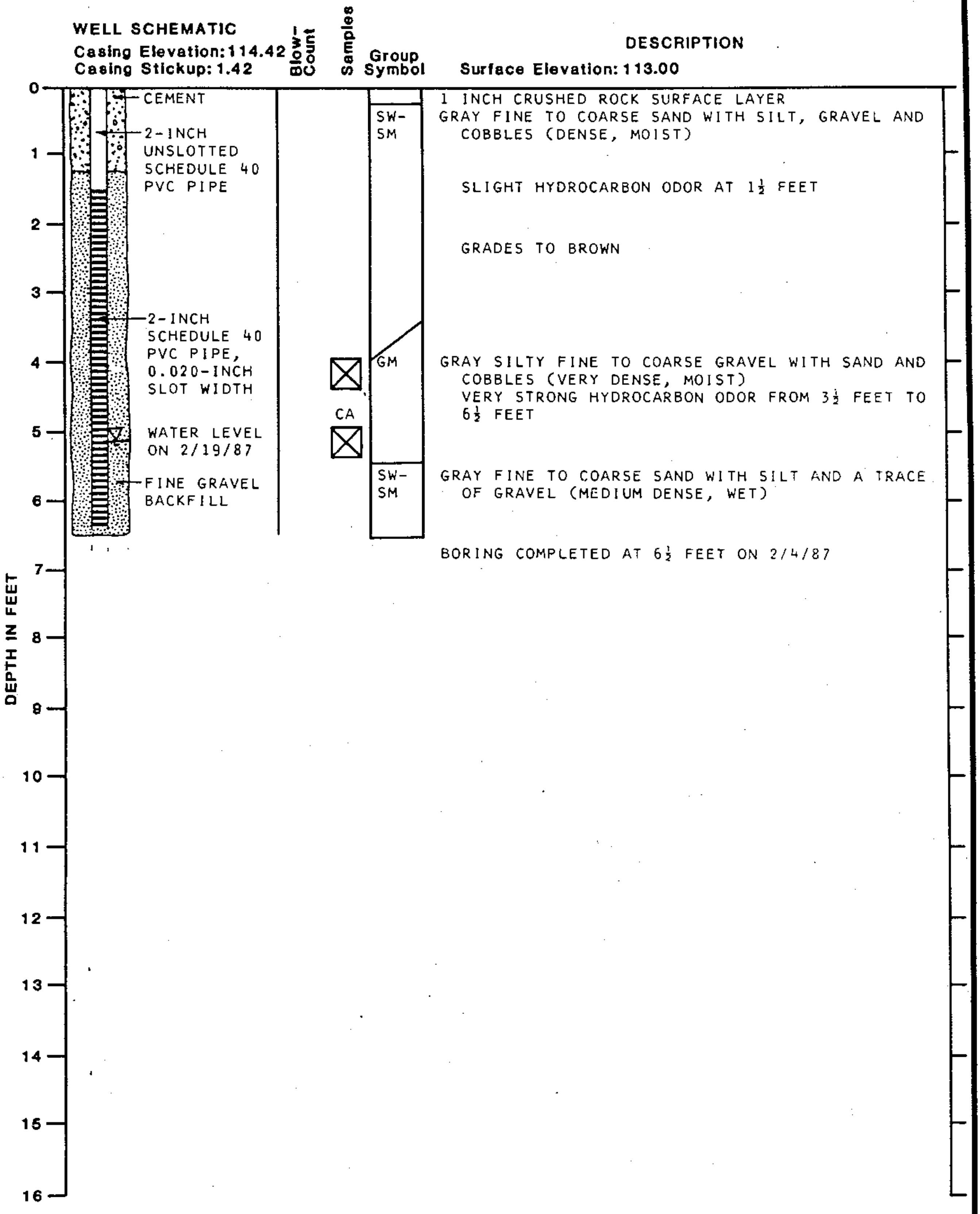
FIGURE A-3

372-23 JF:DMP:EL 2/13/87

MONITOR WELL NO. MW-2

WELL SCHEMATIC
Casing Elevation: 114.42
Casing Stickup: 1.42

DESCRIPTION
Surface Elevation: 113.00



1 INCH CRUSHED ROCK SURFACE LAYER

GRAY FINE TO COARSE SAND WITH SILT, GRAVEL AND COBBLES (DENSE, MOIST)

SLIGHT HYDROCARBON ODOR AT 1½ FEET

GRADES TO BROWN

GRAY SILTY FINE TO COARSE GRAVEL WITH SAND AND COBBLES (VERY DENSE, MOIST)
VERY STRONG HYDROCARBON ODOR FROM 3½ FEET TO 6½ FEET

GRAY FINE TO COARSE SAND WITH SILT AND A TRACE OF GRAVEL (MEDIUM DENSE, WET)

BORING COMPLETED AT 6½ FEET ON 2/4/87

JF:DMP:EL 2/13/87 372-23

GeoEngineers Incorporated

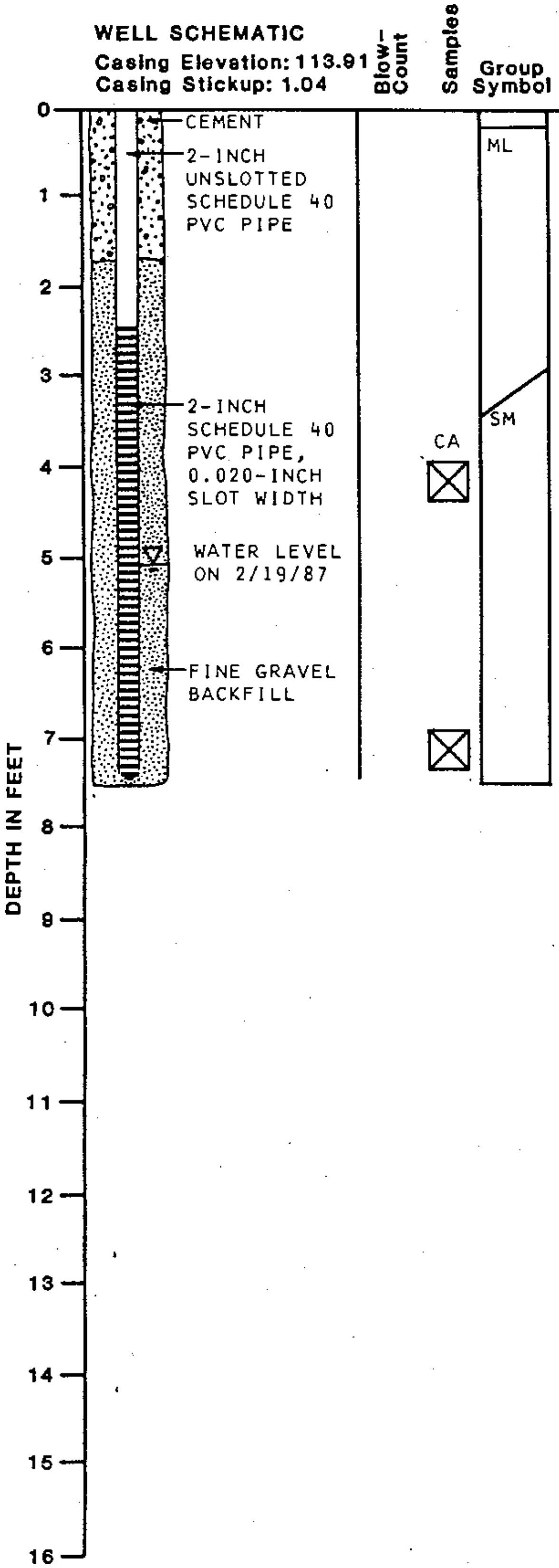
LOG OF MONITOR WELL

FIGURE A-4

MONITOR WELL NO. MW-3

WELL SCHEMATIC
Casing Elevation: 113.91
Casing Stickup: 1.04

DESCRIPTION
Surface Elevation: 112.87



2 INCHES CRUSHED ROCK SURFACE LAYER

GRAY SANDY SILT (MEDIUM STIFF, MOIST)

MODERATE HYDROCARBON ODOR FROM 1½ TO 7½ FEET

GRAY SILTY FINE SAND (MEDIUM DENSE, MOIST)

BECOMES WET AT 4½ FEET

LENSES OF SILT AT 5 FEET

OCCASIONAL GRAVEL AND A TRACE OF ORGANICS AT 7 FEET

BORING COMPLETED AT 7½ FEET ON 2/5/87

GeoEngineers Incorporated

LOG OF MONITOR WELL

FIGURE A-5

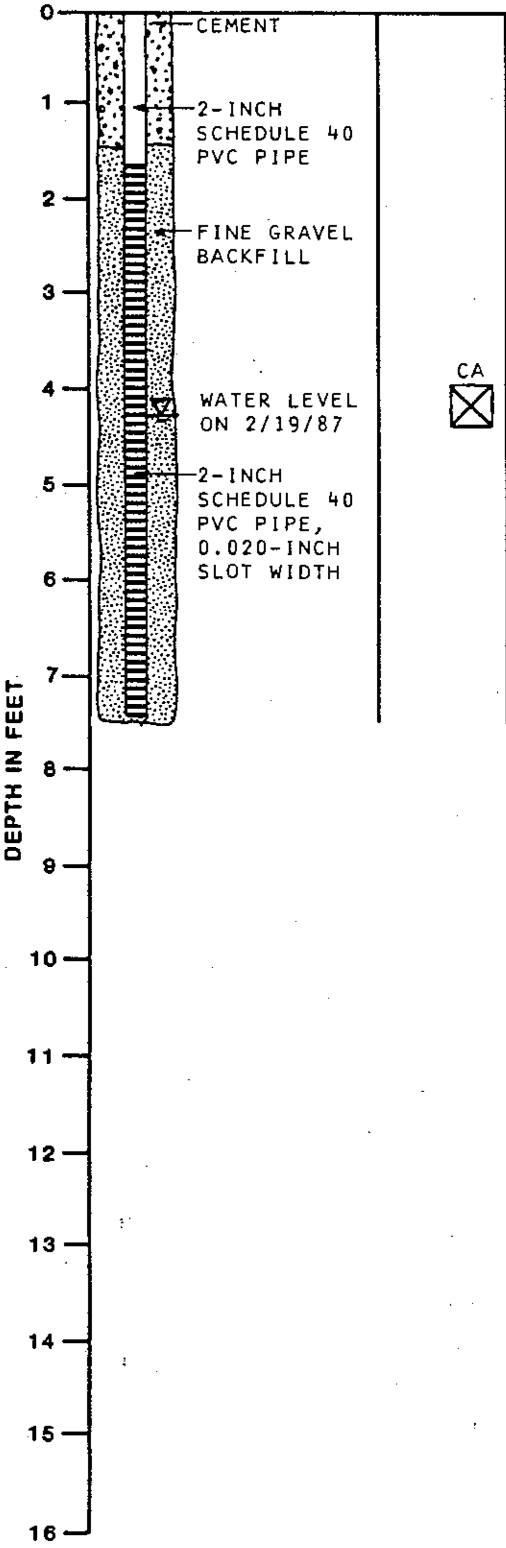
372-23 JF:DMP:EL 2/13/87

MONITOR WELL NO. MW-4

WELL SCHEMATIC
Casing Elevation: 114.41
Casing Stickup: 1.30

Blow-Count **Samples**

Surface Elevation: 113.11



Group Symbol	DESCRIPTION
	2 INCHES CRUSHED ROCK SURFACE LAYER
SM	BROWN SILTY FINE TO COARSE SAND WITH GRAVEL (MEDIUM DENSE, MOIST)
SP-SM	GRAY FINE TO MEDIUM SAND WITH SILT AND OCCASIONAL GRAVEL (LOOSE, MOIST) STRONG HYDROCARBON ODOR AT 4 FEET BECOMES WET AT 4½ FEET
ML	BROWN SANDY SILT WITH A TRACE OF GRAVEL (MEDIUM STIFF, WET)

BORING COMPLETED AT 7½ FEET ON 2/5/87

GeoEngineers Incorporated

LOG OF MONITOR WELL

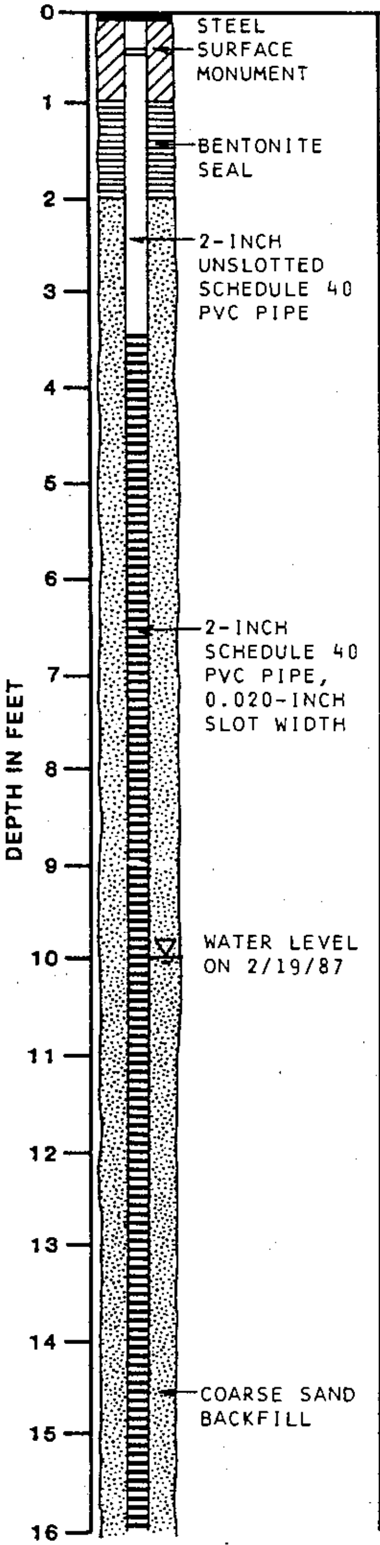
FIGURE A-6

372-23 JF:DMP:EL 2/13/87

MONITOR WELL NO. MW-5

WELL SCHEMATIC
Casing Elevation: 116.74
Casing Stickup: -0.44

Surface Elevation: 117.18



Blow-Count	Samples	Group Symbol	DESCRIPTION
			3 INCH ASPHALTIC CONCRETE PAVEMENT
		SM	GRAY SILTY FINE TO COARSE SAND WITH OCCASIONAL GRAVEL AND A TRACE OF ORGANICS (LOOSE, MOIST)
6	■		SLIGHT HYDROCARBON ODOR FROM 3½ FEET TO 19½ FEET
2	CA ■		GRAVEL NO LONGER PRESENT GRADES TO VERY LOOSE
		GW-GM	GRAY SANDY FINE TO COARSE GRAVEL WITH SILT AND OCCASIONAL COBBLES AND WITH A TRACE OF ORGANICS (MEDIUM DENSE, WET)
19	■		

372-23 JF:DMP:EL 2/13/87

GeoEngineers Incorporated

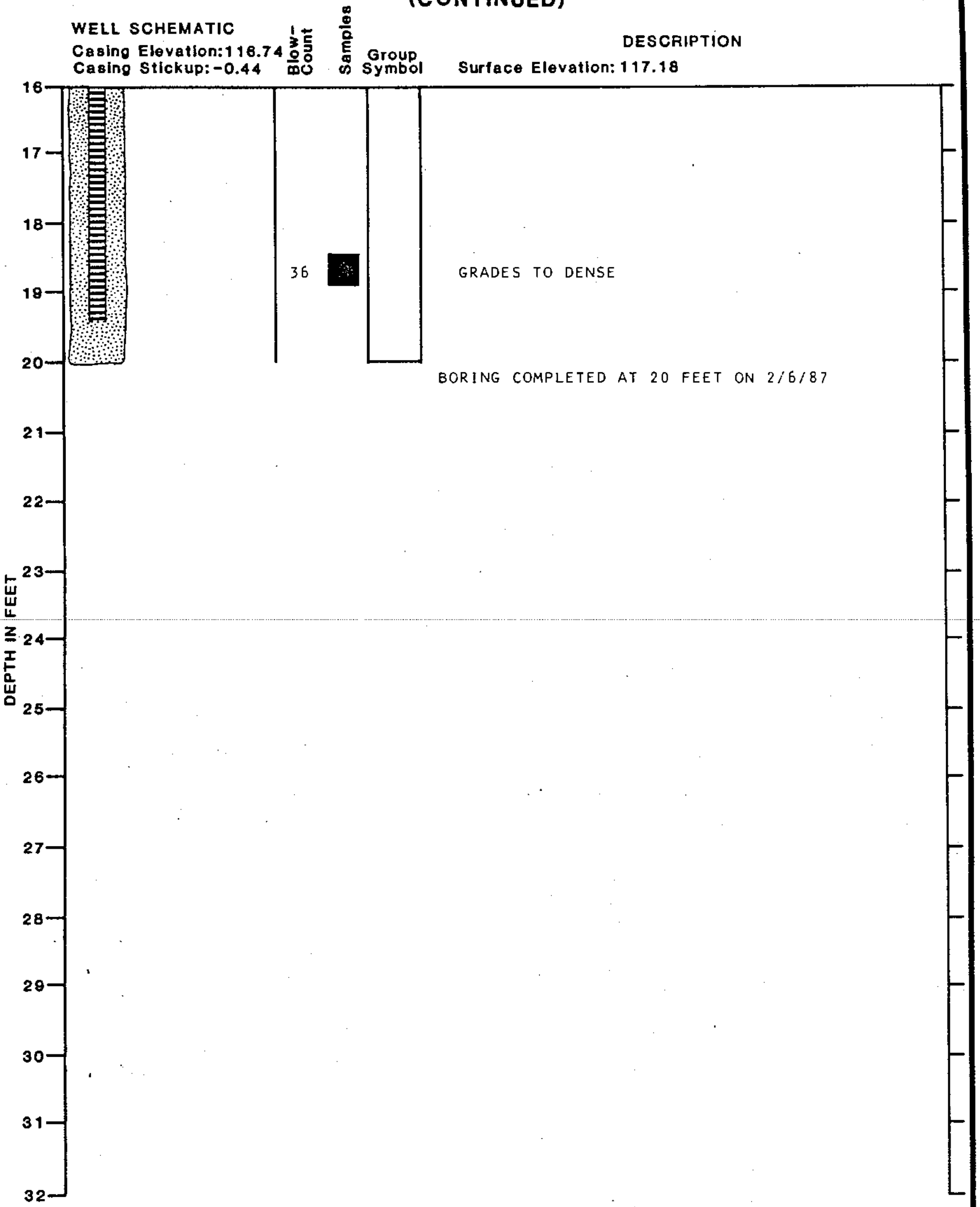
LOG OF MONITOR WELL

FIGURE A-7A

MONITOR WELL NO.MW-5
(CONTINUED)

WELL SCHEMATIC
Casing Elevation:116.74
Casing Stickup:-0.44

DESCRIPTION
Surface Elevation: 117.18



GRADES TO DENSE

BORING COMPLETED AT 20 FEET ON 2/6/87

372-23 JF:DMP:EL 2/13/87

GeoEngineers Incorporated

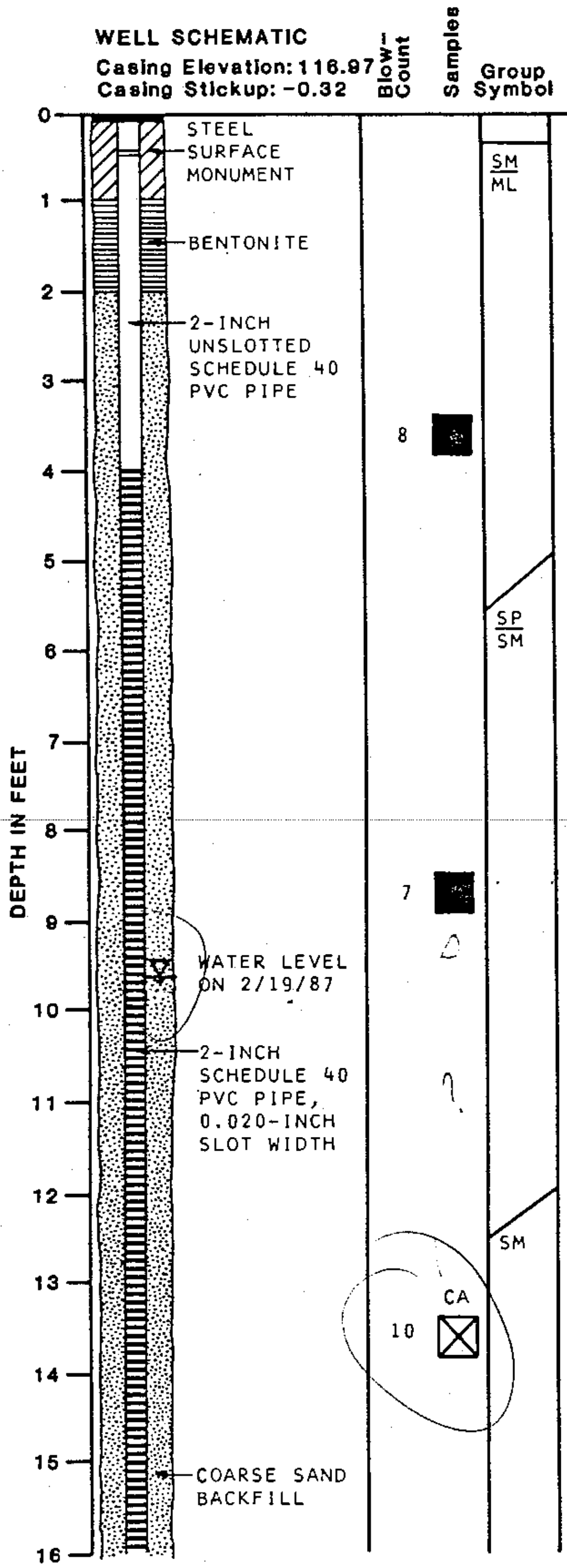
LOG OF MONITOR WELL

FIGURE A-7B

MONITOR WELL NO. MW-6

WELL SCHEMATIC
Casing Elevation: 116.97
Casing Stickup: -0.32

DESCRIPTION
Surface Elevation: 117.29



3 INCHES ASPHALTIC CONCRETE PAVEMENT

GRAY SILTY FINE TO MEDIUM SAND WITH LENSES OF SANDY SILT AND OCCASIONAL GRAVEL (LOOSE AND MEDIUM STIFF, MOIST)

SLIGHT HYDROCARBON ODOR AT 3½ FEET

GRAY FINE TO MEDIUM SAND WITH LENSES OF SANDY SILT AND OCCASIONAL GRAVEL (LOOSE, MOIST)

STRONG HYDROCARBON ODOR AT 8½ AND 13½ FEET

GRAY SILTY FINE TO MEDIUM SAND (LOOSE TO MEDIUM DENSE, WET)

GeoEngineers Incorporated

LOG OF MONITOR WELL

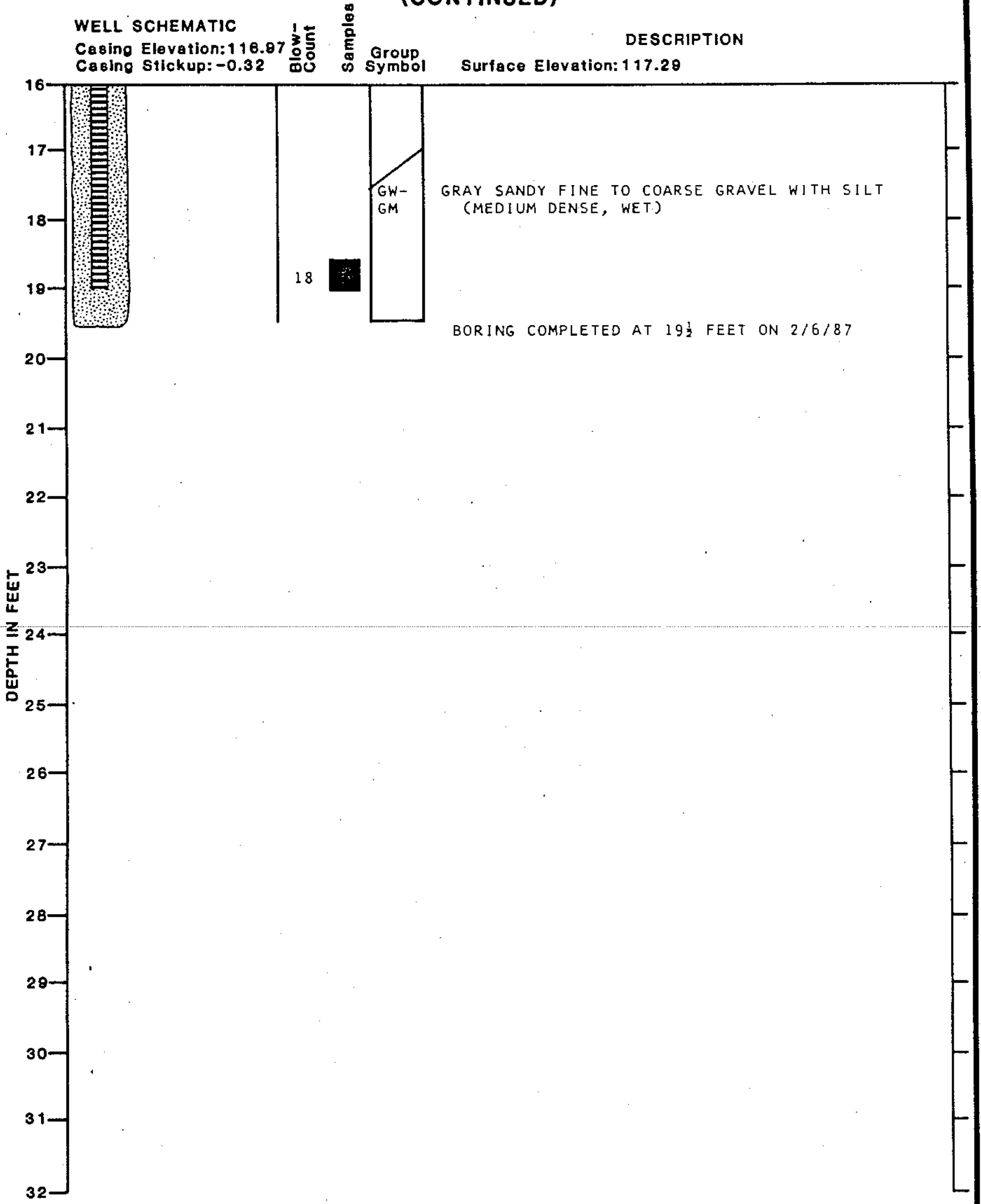
FIGURE A-8A

372-23 JF:DMP:EL 2/13/87

MONITOR WELL NO. MW-6
(CONTINUED)

WELL SCHEMATIC
Casing Elevation: 116.97
Casing Stickup: -0.32

DESCRIPTION
Surface Elevation: 117.29



GRAY SANDY FINE TO COARSE GRAVEL WITH SILT (MEDIUM DENSE, WET)

BORING COMPLETED AT 19½ FEET ON 2/6/87

372-23 JF:DMP:EL 2/13/87

GeoEngineers Incorporated

LOG OF MONITOR WELL

FIGURE A-8B

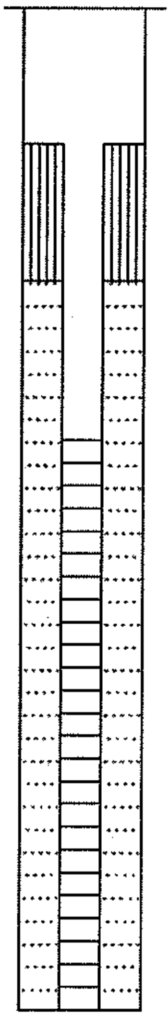
BORING LOG Page 1 of 2

An Employee-Owned Company

Site:	1001372
Boring No:	MW-8
Diameter:	
Date:	12/15/2004

Northing:	NA	Driller:	Andy Flagan (Cascade Drilling, Inc.)		Total Depth:
Easting:	NA	Method:	Hollow Stem		20.25 Ft
Elevation:	NA	Consultant:	Christopher Houck (SAIC)		GW Depth:
Datum:	Unknown	Project No:		Field Book No:	12.0 Ft

Depth Ft	Recov.	Solid Sample ID	Blow Count	VOC (ppm)	Soil Code	Soil Symbol	Soil Description	MW-8 Construction
0							Asphalt	
					SW		Medium brown SAND. Fine to coarse sand; encountered large wood timber at 1 foot; loose; moist. Fill	
		--	--	0	ML		Dark brown to black SILT. Some organic debris; little cohesion; very loose; moist. No odor.	
5		--	--	0	ML		Olive green sandy SILT. Heterogeneous; coarse to fine sand; trace fine gravel; slight cohesion; loose; very moist to wet at 8 feet. No odor.	
		MW-8-8	--	0				
10					SW		Gray SAND. Fine to coarse sand; some gravel; minor silt; loose; wet. Moderate odor.	
		MW-8-10	23 50/6	4220	OL		Dark brown organic SILT. Trace fine sand; cohesive; stiff; moist. Moderate odor.	
11								



Locus

BORING LOG Page 2 of 2

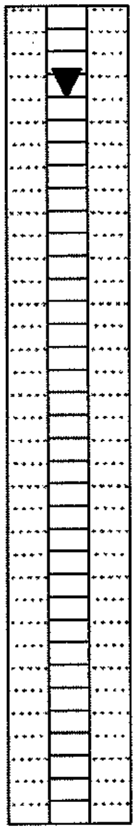
An Employee-Owned Company

Site:	1001372
Boring No:	MW-8
Diameter:	
Date:	12/15/2004

Northing:	NA	**Driller:**	Andy Flagan (Cascade Drilling, Inc.)	**Total Depth:**	20.25 Ft
Easting:	NA	**Method:**	Hollow Stem	**GW Depth:**	12.0 Ft
Elevation:	NA	**Consultant:**	Christopher Houck (SAIC)		
Datum:	Unknown	**Project No:**	**Field Book No:**		

Depth Ft	Recov.	Solid Sample ID	Blow Count	VOC (ppm)	Soil Code	Soil Symbol	Soil Description
11					OL		Dark brown organic SILT. Trace fine sand; cohesive; stiff; moist. Moderate odor.
▼		MW-8-12.5	26 26 29	53.1	SP		Dark gray to olive green SAND. Medium to fine sand; trace coarse sand; medium dense; wet. Very weak odor.
15		MW-8-15	3 50/6	0	SW		Dark gray to olive SAND grading to gravelley SAND or GRAVEL. Fine to coarse sand; fine to coarse subrounded gravel; dense; wet. Very weak to no odor.
20		--	50/3	--			

MW-8 Construction



BORING LOG Page 1 of 2

SAIC

An Employee-Owned Company

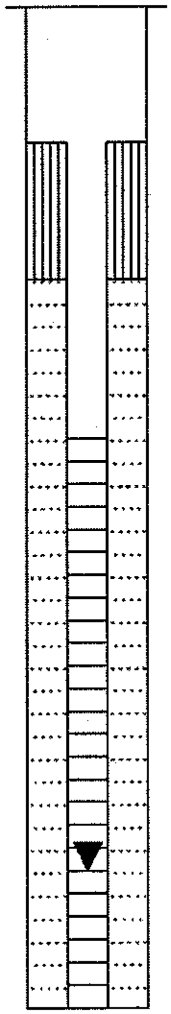
Site: 1001372
Boring No: MW-9
Diameter:
Date: 12/15/2004

Northing: NA
Easting: NA
Elevation: NA
Datum: Unknown

Driller: Andy Flagan (Cascade Drilling, Inc.)
Method: Hollow Stem
Consultant: Christopher Houck (SAIC)
Project No: **Field Book No:**

Total Depth: 20.5 Ft
GW Depth: 9.5 Ft

Depth Ft	Recov.	Solid Sample ID	Blow Count	VOC (ppm)	Soil Code	Soil Symbol	Soil Description	MW-9 Construction
0							Asphalt	
5					SM		Dark olive green silty SAND. Fine sand; trace coarse to medium sand; trace fine to coarse gravel; stratified with organic silt at 12 to 14 feet; loose; moist to wet at 9 feet. Moderate to weak odor from 8 to 14 feet.	
		MW-9-8	1 5 9	2182				
10		MW-9-10	14 9 10	2390				
11								



▼ Boring GW Depth

Locus

BORING LOG Page 2 of 2

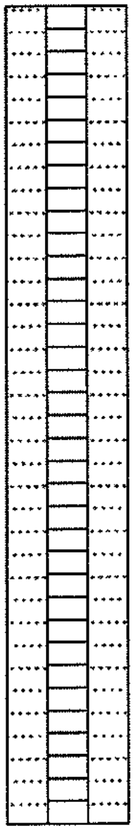
An Employee-Owned Company

Site:	1001372
Boring No:	MW-9
Diameter:	
Date:	12/15/2004

Northing:	NA	Driller:	Andy Flagan (Cascade Drilling, Inc.)	Total Depth:	20.5 Ft
Easting:	NA	Method:	Hollow Stem	GW Depth:	9.5 Ft
Elevation:	NA	Consultant:	Christopher Houck (SAIC)		
Datum:	Unknown	Project No:	Field Book No:		

Depth Ft	Recov.	Solid Sample ID	Blow Count	VOC (ppm)	Soil Code	Soil Symbol	Soil Description
11		MW-9-10	14 9 10	2390	SM		Dark olive green silty SAND. Fine sand; trace coarse to medium sand; trace fine to coarse gravel; stratified with organic silt at 12 to 14 feet; loose; moist to wet at 9 feet. Moderate to weak odor from 8 to 14 feet.
		MW-9-12.5	9 10 9	2046			
15		MW-9-15	26 50/6	--	SW		Dark gray to olive gravelley SAND grading to GRAVEL. Alternating grading pattern; fine to coarse sand; fine to coarse, subrounded gravel; minor silt; trace wood fragments; wet. Very weak odor; very slight sheen on soil water
20		--	50/6	39.3			

MW-9 Construction



Locus

htt

BORING LOG Page 1 of 2

SAIC®

An Employee-Owned Company

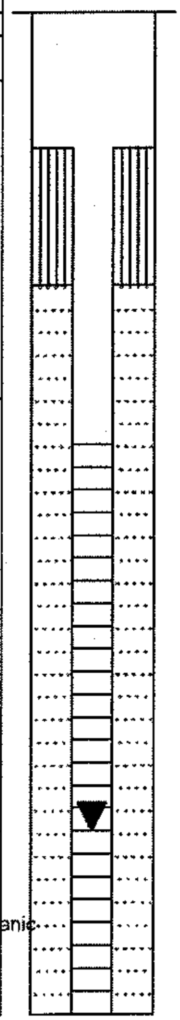
Site: 1001372
Boring No: MW-10
Diameter:
Date: 12/15/2004

Northing: NA
Easting: NA
Elevation: NA
Datum: Unknown

Driller: Andy Flagan (Cascade Drilling, Inc.)
Method: Hollow Stem
Consultant: Christopher Houck (SAIC)
Project No:
Field Book No:

Total Depth: 21.0 Ft
GW Depth: 9.0 Ft

Depth Ft	Recov.	Solid Sample ID	Blow Count	VOC (ppm)	Soil Code	Soil Symbol	Soil Description	MW-10 Construction
0							Asphalt	
					SP		Gray gravelly SAND. Fill, fine to coarse sand; loose; moist. No odor.	
		MW-10-2.5	--	83.2	SM		Olive green silty SAND. Fine sand; very loose; very moist. Moderate odor.	
5		--	--	0	ML		Olive green SILT. Trace very fine sand; some wood fragments; large wood timbers at 6 feet; cohesive; very moist. No odor.	
		MW-10-8	13 11 12	765				
10		MW-10-10	7 6 9	0	SP		Dark gray, well-graded SAND grading to gray poorly-graded SAND interlayered with organic SILT. Fine to very fine sand; wet; loose. Strong odor in relatively coarse sand at 9 feet; very weak odor detected at 15.5 feet.	
11								



▼ Boring GW Depth

Locus

BORING LOG Page 2 of 2

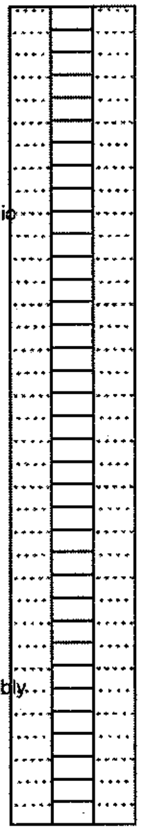
An Employee-Owned Company

Site: 1001372
Boring No: MW-10
Diameter:
Date: 12/15/2004

Northing: NA
Easting: NA
Elevation: NA
Datum: Unknown

Driller: Andy Flagan (Cascade Drilling, Inc.)
Method: Hollow Stem
Consultant: Christopher Houck (SAIC)
Project No:
Field Book No:

Total Depth: 21.0 Ft
GW Depth: 9.0 Ft

Depth Ft	Recov.	Solid Sample ID	Blow Count	VOC (ppm)	Soil Code	Soil Symbol	Soil Description	MW-10 Construction
11		MW-10-10	7 6 9	0	SP		Dark gray, well-graded SAND grading to gray poorly-graded SAND interlayered with organic SILT. Fine to very fine sand; wet; loose. Strong odor in relatively coarse sand at 9 feet; very weak odor detected at 15.5 feet.	
15		MW-10-15	24 50/6	24.4	SW		Dark gray to olive gravelly SAND grading to GRAVEL. Fine to coarse sand; fine to coarse, subrounded gravel; dense; wet. Very weak (possibly water borne) odor.	
20		–	22 50/6	0				
21								

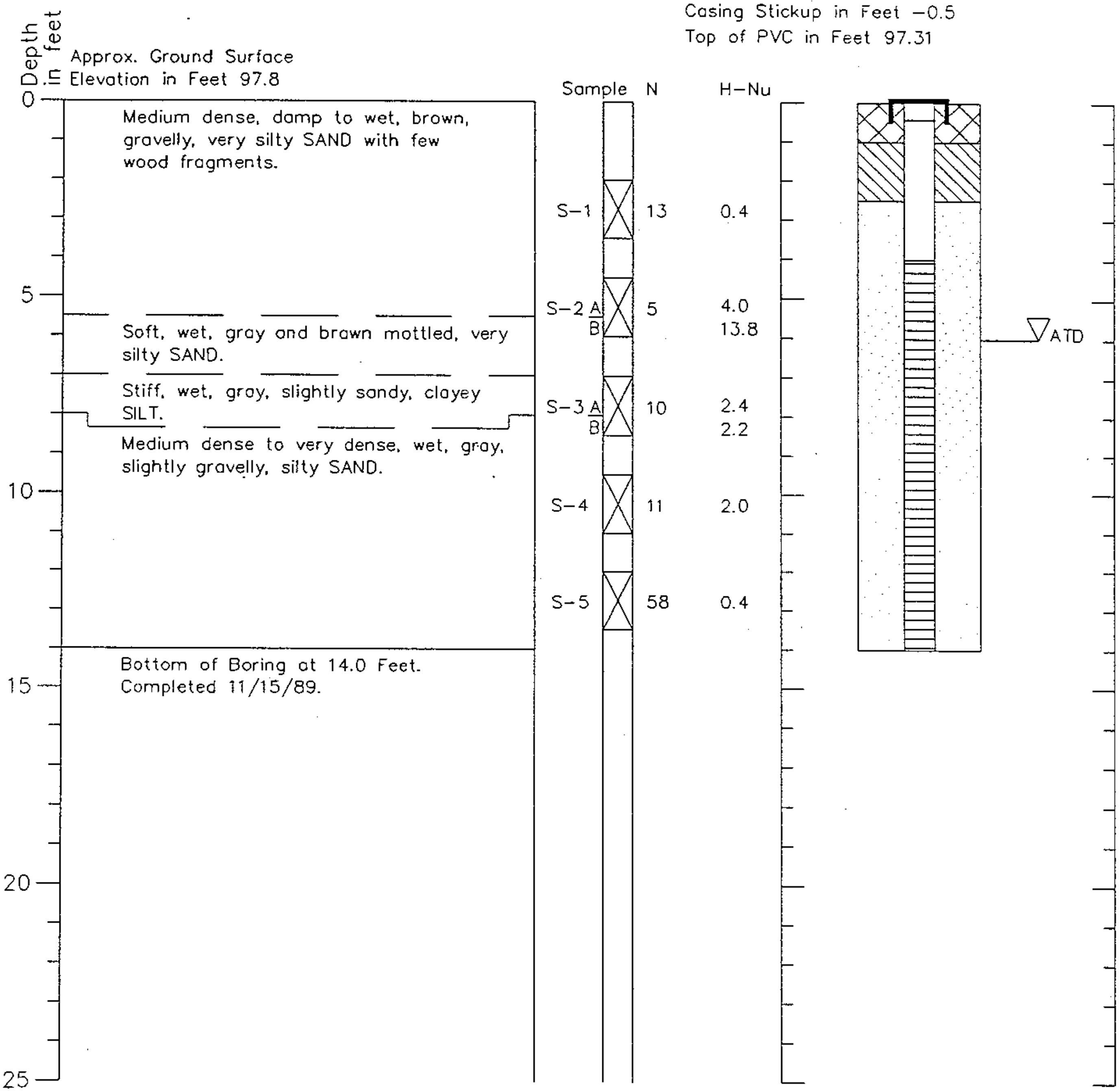
Boring Log and Construction Data for Monitoring Well HC-1

Geologic Log

Approx. Ground Surface Elevation in Feet 97.8

Monitoring Well Design

Casing Stickup in Feet −0.5
Top of PVC in Feet 97.31



Medium dense, damp to wet, brown, gravelly, very silty SAND with few wood fragments.

Soft, wet, gray and brown mottled, very silty SAND.

Stiff, wet, gray, slightly sandy, clayey SILT.

Medium dense to very dense, wet, gray, slightly gravelly, silty SAND.

Bottom of Boring at 14.0 Feet.
Completed 11/15/89.

1. Refer to Figure A−1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Ground water level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.
4. Elevations measured relative to an assumed reference datum of 100.0 feet at top of casing of MW−7.

HARTCROWSER
J-2692 11/89
Figure A-2

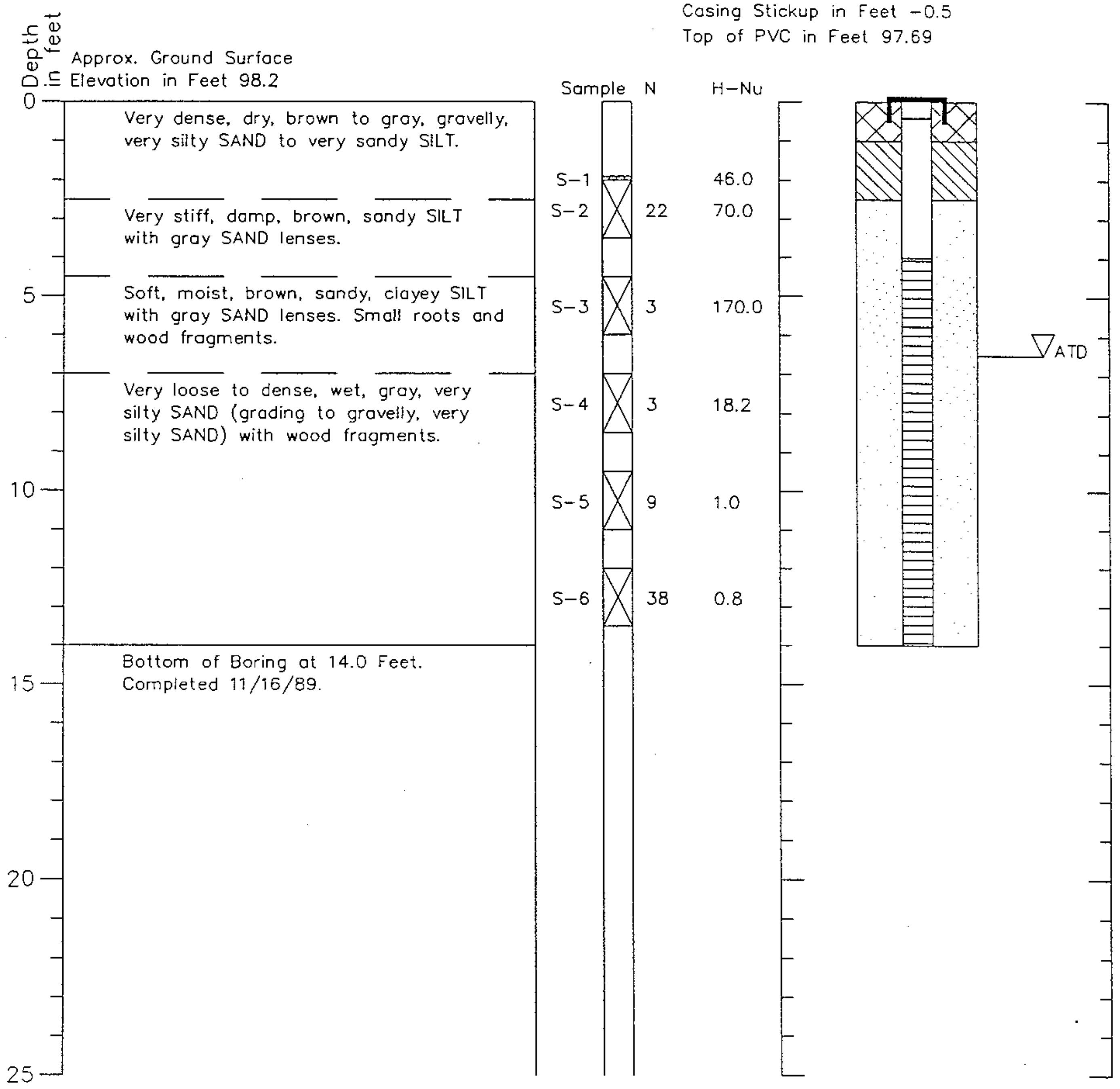
Boring Log and Construction Data for Monitoring Well HC-2

Geologic Log

Approx. Ground Surface
Elevation in Feet 98.2

Monitoring Well Design

Casing Stickup in Feet −0.5
Top of PVC in Feet 97.69



Very dense, dry, brown to gray, gravelly, very silty SAND to very sandy SILT.

Very stiff, damp, brown, sandy SILT with gray SAND lenses.

Soft, moist, brown, sandy, clayey SILT with gray SAND lenses. Small roots and wood fragments.

Very loose to dense, wet, gray, very silty SAND (grading to gravelly, very silty SAND) with wood fragments.

Bottom of Boring at 14.0 Feet.
Completed 11/16/89.

Sample	N	H−Nu
S−1		46.0
S−2	22	70.0
S−3	3	170.0
S−4	3	18.2
S−5	9	1.0
S−6	38	0.8

1. Refer to Figure A−1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Ground water level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.
4. Elevations measured relative to an assumed reference datum of 100.0 feet at top of casing of MW−7.

HARTCROWSER
J-2692 11/89

Figure A-3

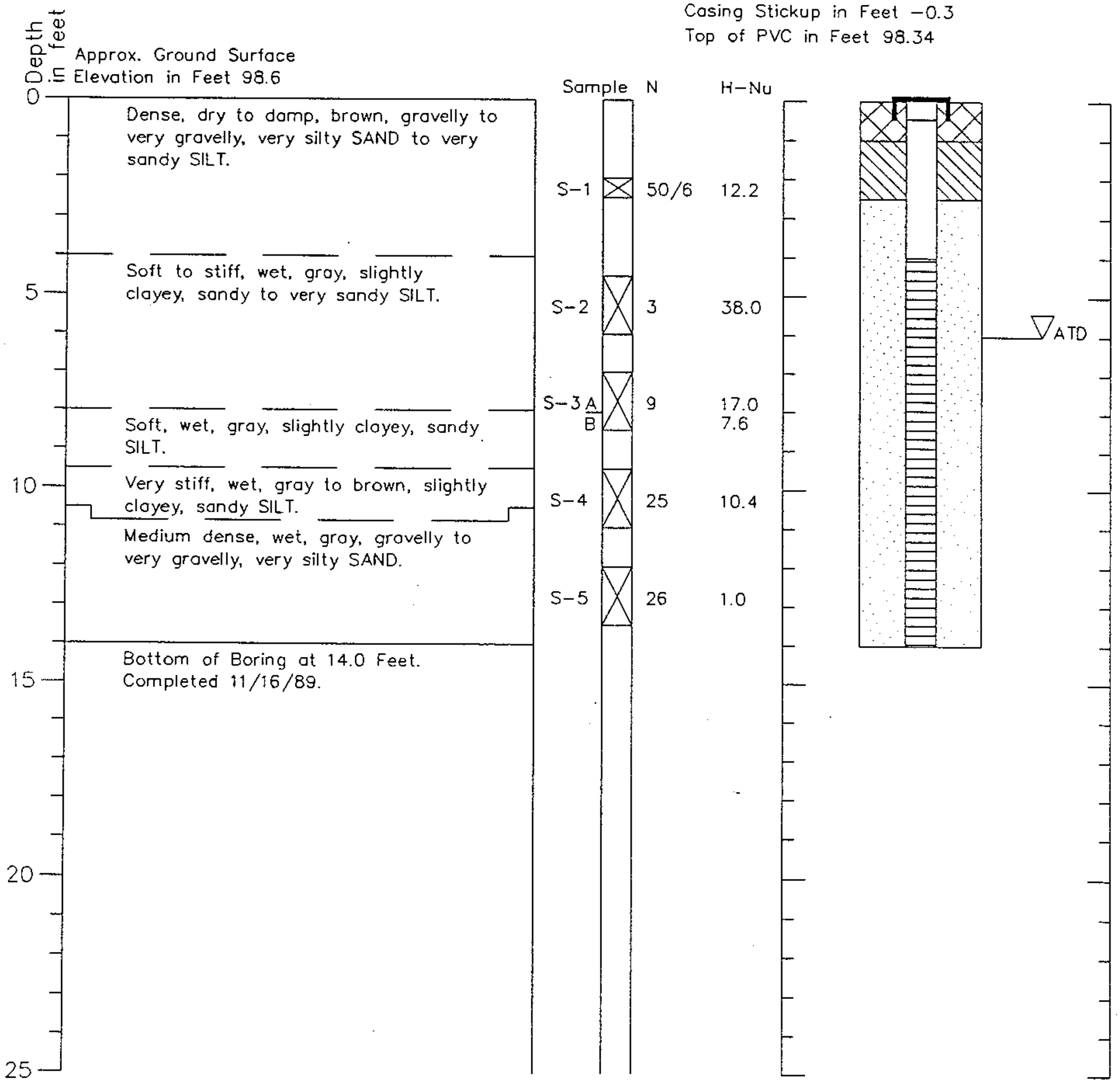
Boring Log and Construction Data for Monitoring Well HC-3

Geologic Log

Monitoring Well Design

Casing Stickup in Feet -0.3
Top of PVC in Feet 98.34

Approx. Ground Surface Elevation in Feet 98.6



Dense, dry to damp, brown, gravelly to very gravelly, very silty SAND to very sandy SILT.

Soft to stiff, wet, gray, slightly clayey, sandy to very sandy SILT.

Soft, wet, gray, slightly clayey, sandy SILT.

Very stiff, wet, gray to brown, slightly clayey, sandy SILT.

Medium dense, wet, gray, gravelly to very gravelly, very silty SAND.

Bottom of Boring at 14.0 Feet.
Completed 11/16/89.

1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Ground water level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.
4. Elevations measured relative to an assumed reference datum of 100.0 feet at top of casing of MW-7.

HARTCROWSER
J-2692 11/89

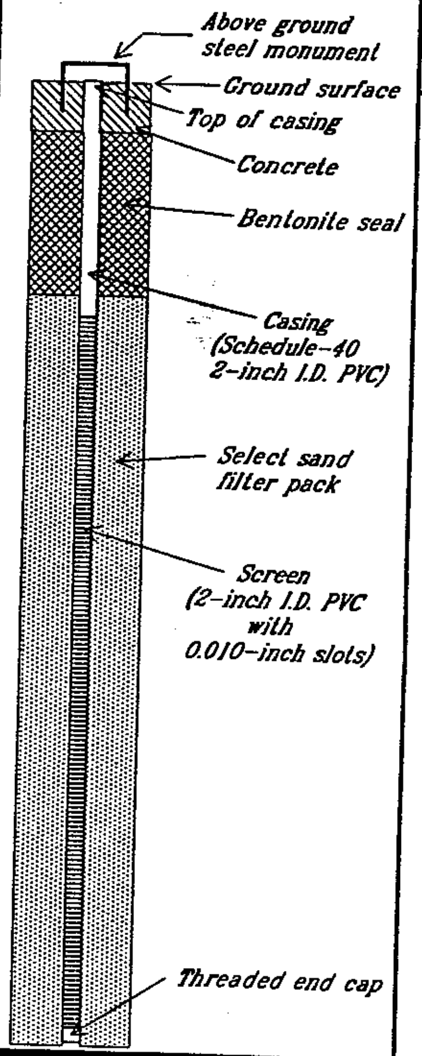
Figure A-4

PROJECT *Port of Port Angeles* **W.O.** *W-7007-1* **WELL NO.** *MW-1*

Elevation reference: *17.56'* **Ground surface elev:** *15.14'*
Well completed: *8-27-90* **Casing elevation:** *15.53'*

DEPTH (feet)	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	BLOW COUNTS	HEAD SPACE	GROUND WATER
0	*Loose, moist, light brown, silty, fine to medium SAND with some gravel*					
	Dense, moist, light brown to blue-gray, silty fine to medium SAND with some gravel. Interbedded lenses of clean, fine to medium SAND.	I	*S-1*	*35*	*10*	
5	*Medium dense, moist, blue-gray, fine to coarse SAND with some gravel and silt.*	I	*S-2*	*16*	*50*	
	Strong Petroleum hydrocarbon odor. Interbedded lenses of silt 1 – 2" thick.	I	*S-3*	*19*	*120*	
10	*Soils appeared slightly discolored. A sheen was observed on wet soil samples.* *Increasing moisture content to wet.*	I	*S-4*	*12*	*140*	▼ ATD
		I	*S-5*	*10*	*120*	
	Slight petroleum hydrocarbon odor.					
15	*Medium dense, wet to saturated, gray fine to coarse SAND with some silt and gravel, some shell fragments present.*	I	*S-6*	*11*	*90*	
	Interbedded lenses of silt, fine SAND.					
20		I	*S-7*	*13*	*5*	
	Boring terminated at 21.5 feet.					
25						
30						

AS-BUILT DESIGN



TESTING

Well completed: *27 August 1990*

LEGEND

I 2-inch O.D. split-spoon sample

▼ ATD Observed groundwater level (ATD = at time of drilling)

RZA
RITTENHOUSE-ZEMAN & ASSOCIATES, INC.
Geotechnical & Environmental Consultants
1400 140th Ave NE
Bellevue, Washington 98005

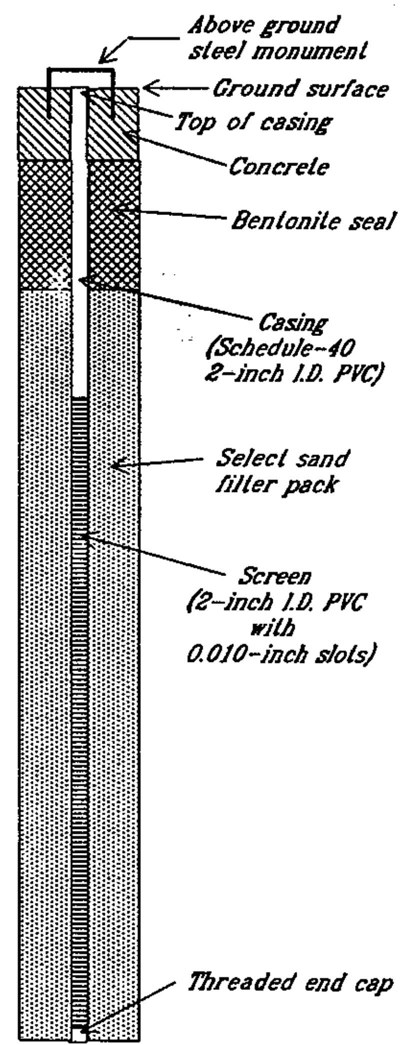
Drilling started: *27 August 1990* **Drilling completed:** *27 August 1990* **Logged by:** *JTC*

PROJECT *Port of Port Angeles* W.O. *W-7007-1* WELL NO. *MW-2*

Elevation reference: *17.56'* **Ground surface elev:** *17.78'*
Well completed: *8-27-90* **Casing elevation:** *18.82'*

DEPTH (feet)	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	BLOW COUNTS	HEAD SPACE	GROUND WATER
0	*Topsoil*					
	Medium dense to dense, moist, dork gray to black, silty SAND with some gravel.	I	*S-1*	*30/3"*	*30*	
	Increasing gravel content.					
5	*Medium dense, moist, blue-gray, silty fine SAND with interbedded lenses of silty, medium coarse SAND.*	I	*S-2*	*17*	*20*	
	Petroleum hydrocarbon odors detected.	I	*S-3*	*12*	*50*	
10	*Loose, moist to wet, blue-gray, fine to coarse SAND with interbedded lenses of fine, sandy SILT.* *Petroleum hydrocarbon odor detected and a sheen on wet soil samples was observed.*	I	*S-4*	*12*	*120*	▼ ATD
	Medium dense, wet to saturated, blue-gray, silty, fine to medioum SAND with some gravel. Some shell fragments present.	I	*S-5*	*12*	*70*	
15	*Slight petroleum hydrocarbon odor.*					
	Increasing moisture content to saturated.					
20	*Increasing coarse SAND and GRAVEL interbedded lenses of gravel 2'-3" thick.*	I	*S-6*	*11*	*90*	
	Boring terminated at 21.5 feet.					
25						
30						

AS-BUILT DESIGN



TESTING

Well completed: *27 August 1990*

LEGEND

I 2-inch O.D. split-spoon sample

▼ ATD Observed groundwater level (ATD = at time of drilling)

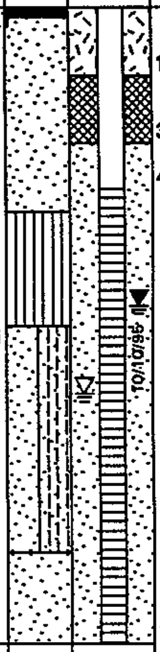
RZA
RITTENHOUSE-ZEMAN & ASSOCIATES, INC.
Geotechnical & Environmental Consultants
1400 140th Ave NE
Bellevue, Washington 98005

Drilling started: *27 August 1990* **Drilling completed:** *27 August 1990* **Logged by:** *JTC*

ENVIRONMENTAL BOREHOLE LOG

Date Started 10/2/95	Location Port Angeles, Washington	Depth Water First Encountered (Ft) 8.5
Date Completed 10/2/95	Drilling Company EDI	Drilling Method Hollow-Stem Auger
Total Depth (Ft) 14.0	Sampling Method Split-spoon	Hammer: Weight (lbs) 140 Drop (In) 30
Borehole Diam. (In) 8	Ground Elev. (ft) 15.36	Monument Elev. (ft) PVC Elev. (ft) 14.79

Depth (Ft)	Sample Number	Interval	Blow Counts/6 In	Recovery(%)	PID (ppm)	Time	Depth (Ft)	Lithologic Description	USCS* Symbol	Depth (Ft)
								Ground Surface		
							0.2	Asphalt.	ASPHAL	
								Medium dense, brown and black, gravelly, fine to medium SAND, trace silt; moist.	SP	1.5
	01		16/12/6	60		0935				3.0
										4.0
							4.5	Very loose, gray, fine sandy SILT; moist.	ML	
5	02		1/1/3	90	5.3	0940				
							7.0	Loose, black, slightly silty, gravelly SAND; wet.	SP-SM	
	03		2/5/7	50	6.0	0950				
10										
							12.0	Gray, gravelly, medium to coarse SAND; wet.	SP	
				75		1009				
							14.0	BOTTOM OF BORING 14 FEET		14.0
15										
20										



S&W 000377

Remarks: Refer to key for explanation of terminology and symbols.

* USC soil descriptions are based on visual classification, unless otherwise noted. Contacts between soil layers are approximate and may be gradual.

LEGEND

Ⅰ	2" O.D. Split-Spoon Sample	▼	Water Level and Date Measured
Ⅲ	3" O.D. Split-Spoon Sample	▽	Water Level at Time of Drilling

Port of Port Angeles
Marine Terminal Log Yard

LOG OF BORING MW-5

October 1995 T-1396-06

Logged By ACT

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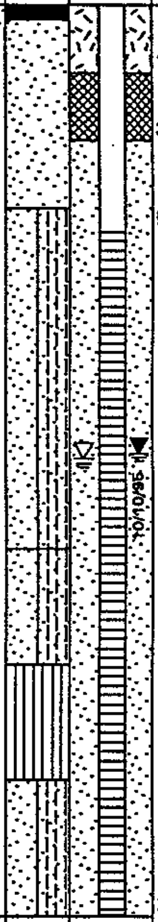
SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG.

ENVLOG2 3/20/96

ENVIRONMENTAL BOREHOLE LOG

Date Started 10/2/95	Location Port Angeles, Washington	Depth Water First Encountered (Ft) 10.0
Date Completed 10/3/95	Drilling Company EDI	Drilling Method Hollow-Stem Auger
Total Depth (Ft) 20.0	Sampling Method Split-spoon	Hammer: Weight (lbs) 140 Drop (In) 30
Borehole Diam. (In) 8	Ground Elev. (ft) 15.71	Monument Elev. (ft) PVC Elev. (ft) 15.53



Depth (Ft)	Sample Number	Interval	Blow Counts/6 In	Recovery(%)	PID (ppm)	Time	Depth (Ft)	Lithologic Description	USCS* Symbol	Soil Log	Well Log	Depth (Ft)
								Ground Surface				
							0.3	Asphalt.	ASPHAL			
								Dense, brown and gray, gravelly SAND, trace cobbles; dry; scattered to numerous shells.	SP			1.5 3.0
			9/17/18	80	0	1500						
							4.5	Loose to dense, brown and gray SAND and fine sandy SILT; moist to wet; scattered to numerous shells.	SP/ML			5.0
5			4/4/4	6	0	1503						
	07		9/12/20	85	0	1508						
10	08		3/6/9	85	0	1514						
							12.0	Medium dense, gray, slightly silty fine SAND; wet; numerous shells.	SP-SM			
	09		2/5/8	100	0	1519						
							14.5	Loose, gray, sandy SILT; wet; scattered shells.	ML			
15			2/3/5	80		1525						
							17.0	Medium dense, gray, slightly silty SAND and fine sandy SILT, trace gravel; wet.	SP-SM			
			4/4/7	80		1529						
20							20.0	BOTTOM OF BORING 20 FEET				20.0

Remarks: Refer to key for explanation of terminology and symbols.

* USC soil descriptions are based on visual classification, unless otherwise noted. Contacts between soil layers are approximate and may be gradual.

LEGEND

⌶ 2" O.D. Split-Spoon Sample
Ⅲ 3" O.D. Split-Spoon Sample
▼ Water Level and Date Measured
▽ Water Level at Time of Drilling

Port of Port Angeles
Marine Terminal Log Yard

LOG OF BORING MW-7

October 1995 T-1396-06

Logged By ACT

Reviewed By

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG.

ENVLOG2 3/20/96

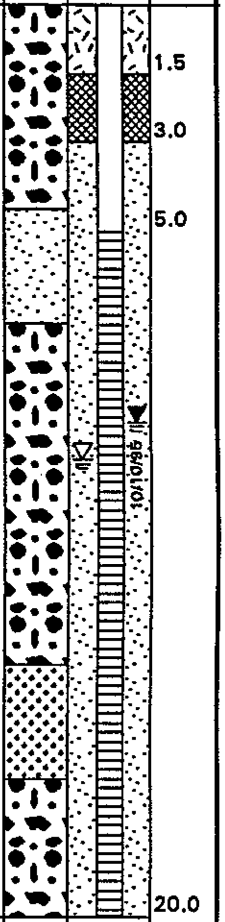
ENVIRONMENTAL BOREHOLE LOG

Date Started 10/3/95	Location Port Angeles, Washington	Depth Water First Encountered (Ft) 10.0
Date Completed 10/3/95	Drilling Company EDI	Drilling Method Hollow-Stem Auger
Total Depth (Ft) 20.0	Sampling Method Split-spoon	Hammer: Weight (lbs) 140 Drop (In) 30

Borehole Diam. (In) 8	Ground Elev. (ft) 14.88	Monument Elev. (ft)	PVC Elev. (ft) 15.15

Depth (Ft)	Sample Number	Interval	Blow Counts/6 In	Recovery(%)	PID (ppm)	Time
			11/16/ 11	20		1418
5	20		3/3/5	20	486	1422
	21		15/20/ 17	40	1678	1427
10	22		4/9/11	65	1233	1430
			11/8/5	50	431	1438
15			2/3/4	80	20.6	1442
			1/6/9	70		1445
20						

Depth (Ft)	Lithologic Description	USCS* Symbol
	Ground Surface	
	Medium dense, brownish black, fine to medium sandy GRAVEL; moist; scattered wood.	GP
4.5	Loose, brown, gravelly, medium SAND; moist; hydrocarbon odor.	SP
7.0	Medium dense to dense, sandy GRAVEL; moist to wet; hydrocarbon odor.	GP
14.5	Loose, gray, gravelly SAND; wet.	SW
17.0	Medium dense, gray, medium to coarse sandy GRAVEL; wet.	GP
20.0	BOTTOM OF BORING 20 FEET	



Remarks: Refer to key for explanation of terminology and symbols.

- USC soil descriptions are based on visual classification, unless otherwise noted. Contacts between soil layers are approximate and may be gradual.

LEGEND

⌶ 2" O.D. Split-Spoon Sample	▼ Water Level and Date Measured
Ⅲ 3" O.D. Split-Spoon Sample	▽ Water Level at Time of Drilling

Port of Port Angeles
Marine Terminal Log Yard

LOG OF BORING MW-11

October 1995 T-1396-06

Logged By ACT

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SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG.

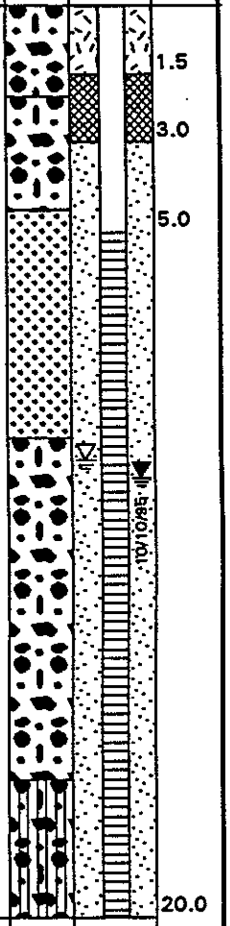
ENVLOG2 3/20/96

ENVIRONMENTAL BOREHOLE LOG

Date Started 10/4/95	Location Port Angeles, Washington	Depth Water First Encountered (Ft) 10.0
Date Completed 10/4/95	Drilling Company EDI	Drilling Method Hollow-Stem Auger
Total Depth (Ft) 20.0	Sampling Method Split-spoon	Hammer: Weight (lbs) 140 Drop (In) 30
Borehole Diam. (In) 8	Ground Elev. (ft) 15.92	Monument Elev. (ft) PVC Elev. (ft) 16.22

Sample Number	Blow Counts/6 In	Recovery(%)	PID (ppm)	Time	Depth (Ft)	Lithologic Description	USCS* Symbol
						Ground Surface	
						Brown, sandy GRAVEL; wet; numerous wood fragments.	GP
	11/24/32	60	10.5	1312	2.0	Very dense, brown and gray, sandy GRAVEL and gravelly SAND, trace silt; dry.	GP/SP
	3/11/11	80	248	1317	4.5	Medium dense to dense, gray, gravelly SAND, trace silt; dry to moist; hydrocarbon odor from 7.5 to 9 feet.	SW
32	11/15/18	60	1543	1321			
33	9/9/9	80	905	1326	9.5	Medium dense to dense, gray, medium to coarse sandy GRAVEL; wet; hydrocarbon odor from 10 to 11.5 feet.	GP
34	8/17/21	60	468	1330			
	4/11/15	60	386	1334			
	2/2/5	33	85.1	1338	17.0	Loose, gray, silty, medium to coarse sandy GRAVEL; wet.	GM
					20.0	BOTTOM OF BORING 20 FEET	

Soil Log · Well Log · Depth (Ft)



Remarks: Refer to key for explanation of terminology and symbols.

- USC soil descriptions are based on visual classification, unless otherwise noted. Contacts between soil layers are approximate and may be gradual.

LEGEND

⌶	2" O.D. Split-Spoon Sample	▼	Water Level and Date Measured
Ⅲ	3" O.D. Split-Spoon Sample	▽	Water Level at Time of Drilling

Port of Port Angeles
Marine Terminal Log Yard

LOG OF BORING MW-15

October 1995 T-1396-06

Logged By ACT

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Geotechnical and Environmental Consultants

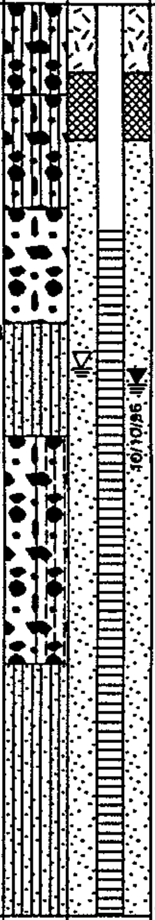
FIG.

ENVLOG2 3/20/96

ENVIRONMENTAL BOREHOLE LOG

Date Started 10/5/95	Location Port Angeles, Washington	Depth Water First Encountered (Ft) 8.0
Date Completed 10/5/95	Drilling Company EDI	Drilling Method Hollow-Stem Auger
Total Depth (Ft) 20.0	Sampling Method Split-spoon	Hammer: Weight (lbs) 140 Drop (In) 30
Borehole Diam. (In) 8	Ground Elev. (ft) 13.79 / Monument Elev. (ft)	PVC Elev. (ft) 14.35

Depth (Ft)	Sample Number	Interval	Blow Counts/6 In	Recovery(%)	PID (ppm)	Time	Depth (Ft)	Lithologic Description	USCS* Symbol	Soil Log	Well Log	Depth (Ft)
								Ground Surface				
								Brown, silty, sandy GRAVEL; wet; numerous wood fragments.	GM			1.5
			2/5/7	50	43.5	0836	2.0	Medium dense, gray, brown, silty, sandy GRAVEL and fine sandy SILT; moist.	GM/ML			3.0
5	38		6/16/24	0	1477	0845	4.5	Dense, gray, fine to medium sandy GRAVEL; moist; hydrocarbon odor.	GP			5.0
	39		3/5/10	50	1851	0848	7.0	Medium dense, brown, gray, silty, gravelly SAND and silty, sandy GRAVEL; wet; scattered wood fragments; hydrocarbon odor.	SM/GM			
10	40		4/17/25	75	2195	0852	9.5	Medium dense to dense, gray, slightly silty, sandy GRAVEL; wet; scattered wood fragments; hydrocarbon odor at 10 to 11.5 feet.	GP-GM			
			6/11/15	75	617	0857						
15			9/11/11	60	726	0903	14.5	Medium dense to dense, gray, silty, gravelly SAND; wet; scattered wood fragments.	SM			
			8/15/21	50		0908						20.0
20							20.0	BOTTOM OF BORING 20 FEET				



Remarks: Refer to key for explanation of terminology and symbols.

* USC soil descriptions are based on visual classification, unless otherwise noted. Contacts between soil layers are approximate and may be gradual.

LEGEND

⌶ 2" O.D. Split-Spoon Sample	▼ Water Level and Date Measured
Ⅲ 3" O.D. Split-Spoon Sample	▽ Water Level at Time of Drilling

Port of Port Angeles
Marine Terminal Log Yard

LOG OF BORING MW-16

October 1995 T-1396-06

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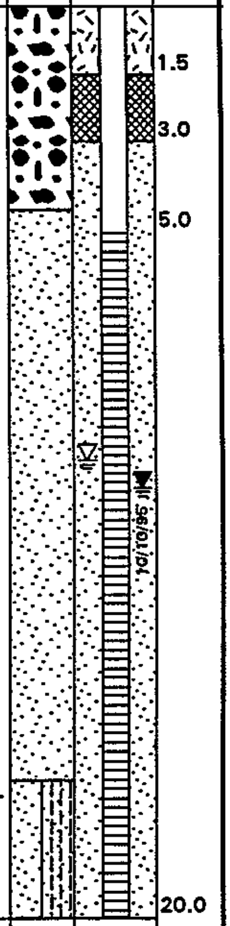
FIG.

ENVIRONMENTAL BOREHOLE LOG

Date Started 10/4/95	Location Port Angeles, Washington	Depth Water First Encountered (Ft) 10.0
Date Completed 10/4/95	Drilling Company EDI	Drilling Method Hollow-Stem Auger
Total Depth (Ft) 20.0	Sampling Method Split-spoon	Hammer: Weight (lbs) 140 Drop (In) 30
Borehole Diam. (In) 8	Ground Elev. (ft) 15.98	Monument Elev. (ft)
		PVC Elev. (ft) 16.20

Depth (Ft)	Sample Number	Interval	Blow Counts/6 In	Recovery(%)	PID (ppm)	Time	Depth (Ft)	Lithologic Description	USCS* Symbol
								Ground Surface	
			50(6") rock	3	15.4	1450		Brown and gray, fine to medium sandy GRAVEL; moist to wet; scattered wood fragments and shells.	GP
5	35		4/9/12	75	330	1454	4.5	Medium dense, gray, fine to medium SAND, trace silt and gravel; moist to wet; scattered shells.	SP
	36		4/7/10	80	680	1458			
10	37		4/12/14	75	709	1503			
			3/7/14	50	265	1507			
15			4/4/8	75	32.6	1511			
			3/4/5	100	117	1516	17.0	Loose, gray SAND and fine sandy SILT, trace gravel; wet; scattered shells.	SP/ML
20							20.0	BOTTOM OF BORING 20 FEET	



Remarks: Refer to key for explanation of terminology and symbols.

* USC soil descriptions are based on visual classification, unless otherwise noted. Contacts between soil layers are approximate and may be gradual.

LEGEND

Ⅰ 2" O.D. Split-Spoon Sample	▼ Water Level and Date Measured
Ⅲ 3" O.D. Split-Spoon Sample	∇ Water Level at Time of Drilling

Port of Port Angeles
Marine Terminal Log Yard

LOG OF BORING MW-17

October 1995 T-1396-06

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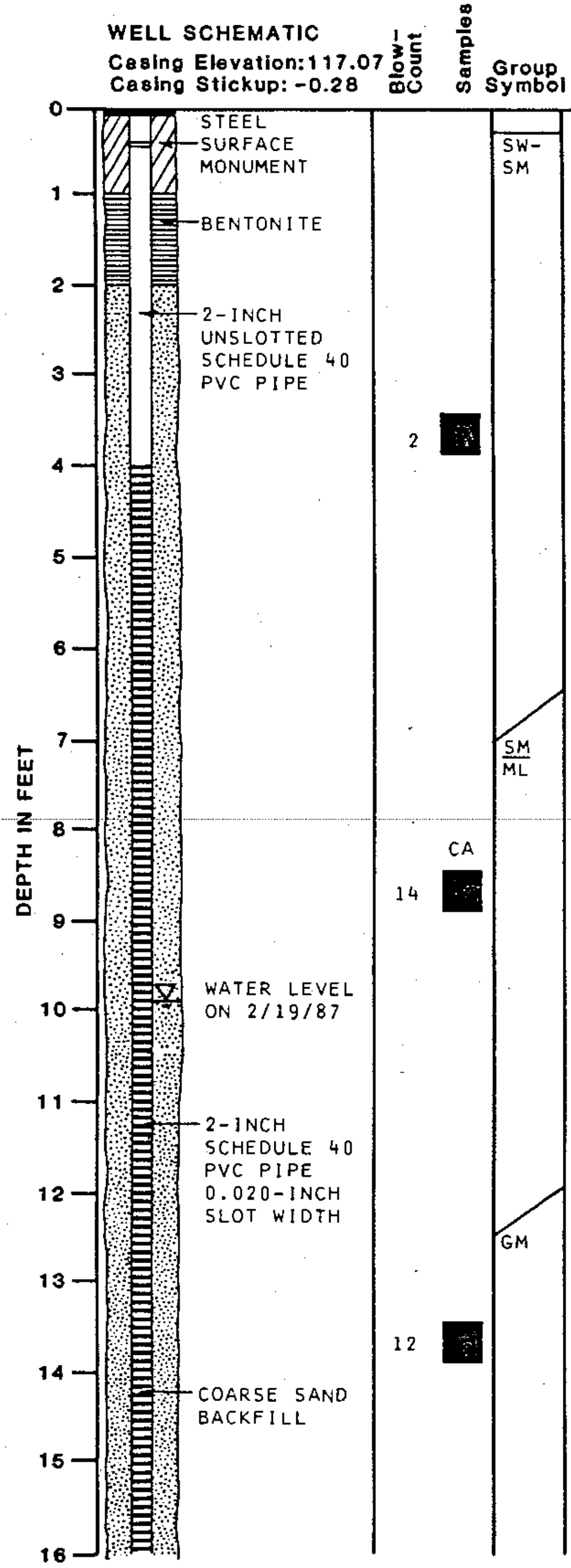
FIG.

MONITOR WELL NO. MW-7



DESCRIPTION

Surface Elevation: 117.35

1 INCH CRUSHED ROCK SURFACE LAYER

2 INCHES ASPHALTIC CONCRETE

GRAY FINE TO COARSE SAND WITH SILT AND GRAVEL (VERY LOOSE, MOIST)

GRAY SILTY FINE TO COARSE SAND WITH GRAVEL AND COBBLES AND LENSES OF SANDY SILT (STIFF, MOIST)

MODERATE HYDROCARBON ODOR AT 8.5 FEET

WOOD AT 9 FEET

GRAY SILTY FINE TO COARSE GRAVEL WITH SAND AND OCCASIONAL COBBLES (MEDIUM DENSE, WET)

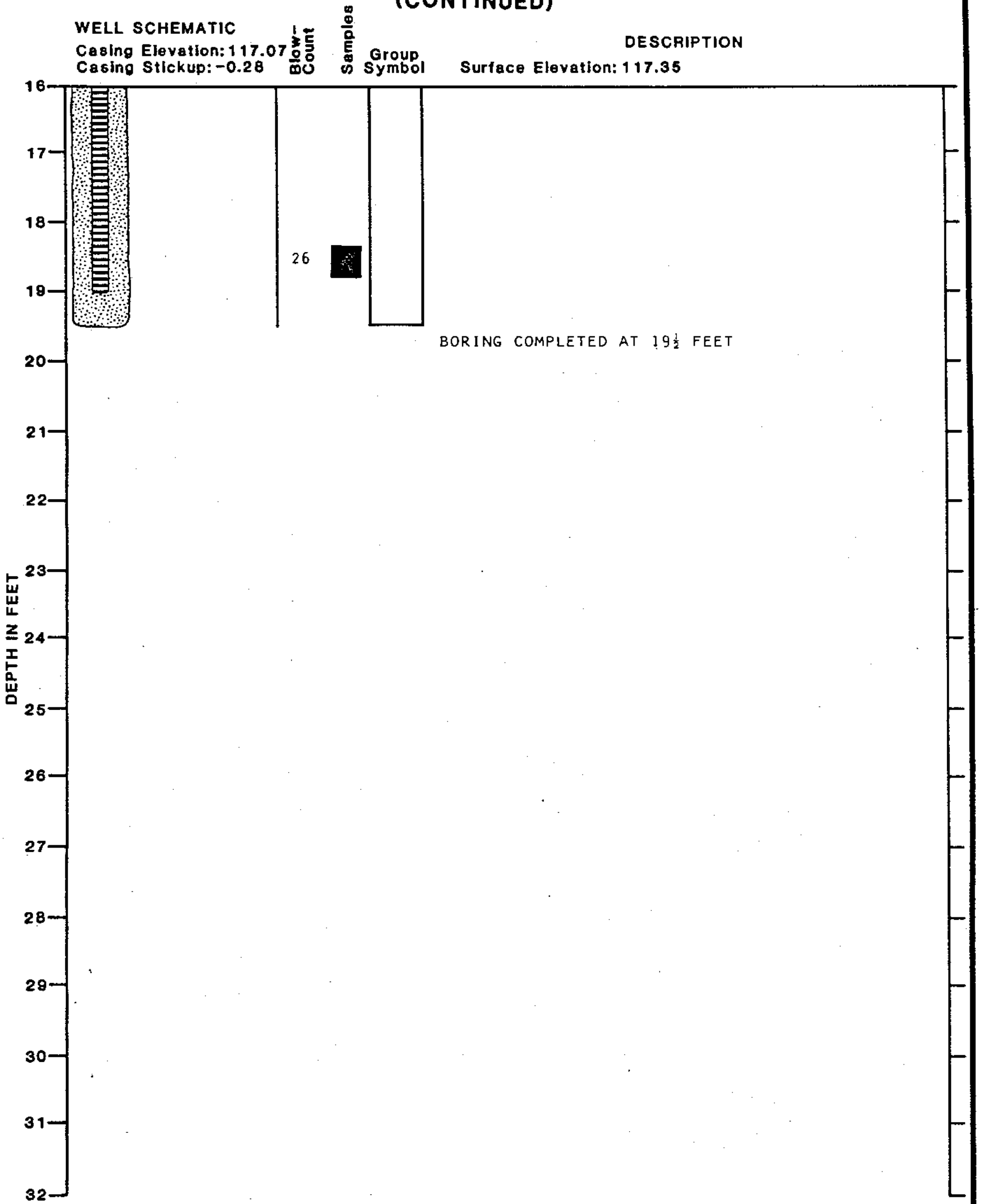
372-23 JF:DMP:EL 2/13/87

GeoEngineers Incorporated

LOG OF MONITOR WELL

FIGURE A-9A

MONITOR WELL NO. MW-7
(CONTINUED)



BORING COMPLETED AT 19½ FEET

372-23 JF:DMP:EL 2/13/87

GeoEngineers Incorporated

LOG OF MONITOR WELL

FIGURE A-9B

LAI-B1

SAMPLE DATA					SOIL PROFILE			GROUNDWATER
Depth (ft)	Sample Number & Interval	Sampler Type	Blows/Foot	Test Data	Graphic Symbol	USCS Symbol	Drilling Method: Hollow-stem Auger Ground Elevation (ft): 15 1/2 Drilled By: Environmental Drilling Inc.	Water Level
0						GP-GM	Brown, silty, sandy, fine to coarse GRAVEL (medium dense, moist) (fill)	
	1	b2	24	PID=0		SM	Dark brown, silty, gravelly, fine to medium SAND, with wood debris (medium dense, mioist)(fill)(slight solvent-like odor)	
5	2	b2	29	PID=1885			@ 5 ft - becomes gray-brown; strong gasoline-like odor	
	3	b2	30	PID=1399			@ 7.5 ft - with less gravel; strong gasoline-like odor; sheen on water	▽ ATD
10	4	b2	18	PID=150		GP-GM	Brown-gray, very sandy, fine to coarse GRAVEL, with silt (medium dense, wet) (fill) (strong gasoline-like odor; sheen on water)	
	5	b2	23	PID=109		SP-SM	Brown-gray, gravelly, fine to coarse SAND, with silt, to sandy fine to medium GRAVEL with silt (medium dense to dense, wet)(fill and possible native soil)	
15	6	b2	10	PID=92.5				
	7	b2	21	PID=94				
20	8	b2	34	PID=12				
	9	b2	18	PID=0		SM	Dark gray, very silty, fine SAND, with trace fine gravel and occassional shell fragments (medium dense, wet)(native)	
25	10	b2	14	PID=0				
	11	b2	11	PID=0		SP	Gray-black, medium to coarse SAND, with trace silt (medium dense, wet)(native)	
30								

Boring Completed 09/10/02
Total Depth of Boring = 29.0 ft.

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

718002.011 1/22/03 \\EDMNAS\GINT\GINTW\PROJECTS\718002.GPJ SOIL BORING LOG

LANDAU ASSOCIATES

Westport Shipyard
Port Angeles, Washington

Log of Boring LAI-B1

Figure
A-2

LAI-B2

Drilling Method: Hollow-stem Auger
Ground Elevation (ft): 15 1/2
Drilled By: Environmental Drilling Inc.

SAMPLE DATA

Depth (ft): 0, 5, 10, 15, 20, 25, 30

Sample Number & Interval	Sampler Type	Blows/Foot	Test Data
1	b2	25	PID=0
2	b2	30	PID=25
3	b2	55	PID=600
4	b2	18	PID=500
5	b2	17	PID=25
6	b2	6	PID=0
7	b2	14	PID=0
8	b2	14	PID=0
9	b2	25	PID=0
10	b2	45	PID=0
11	b2	36	PID=0

SOIL PROFILE

USCS Symbol	Description
SM	Dark brown, silty, gravelly, fine to medium SAND, with scattered fine wood debris (medium dense to dense, moist)(fill)(very slight petroleum-like odor) @ 7.5 ft - slight gasoline-like odor
ML	Brown, sandy, gravelly, SILT, with occassional wood fibers (very stiff, moist)(fill)(slight gasoline-like odor)
SP	Gray-brown, gravelly, medium to coarse SAND, trace silt (loose to medium dense, wet)(fill)(slight petroleum-like odor in 12.5 ft sample)
SP-SM	Gray-brown, fine to medium SAND, with gravel and silt (medium dense, wet)(possible native)
SP-SM	Dark gray, gravelly, fine to coarse SAND, with silt (medium dense to dense, wet)(native)

GROUNDWATER

Water Level

▽ ATD

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

718002.011 1/22/03 \EDMNAS\GINT\GINTW\PROJECTS\718002.GPJ SOIL BORING LOG

LANDAU ASSOCIATES

Westport Shipyard
Port Angeles, Washington

Log of Boring LAI-B2

Figure
A-3
(1 of 2)

LAI-B2

Drilling Method: Hollow-stem Auger

Ground Elevation (ft): 15 1/2

Drilled By: Environmental Drilling Inc.

SAMPLE DATA					SOIL PROFILE			GROUNDWATER
Depth (ft)	Sample Number & Interval	Sampler Type	Blows/Foot	Test Data	Graphic Symbol	USCS Symbol		Water Level
30	12 ▮	b2	38	PID=0	‖	SP-SM	Dark gray, gravelly, fine to coarse SAND, with silt (medium dense to dense, wet)(native) @ 30 ft - decreasing silt content to trace silt	
35								
40								
45								
50								
55								
60								

Boring Completed 09/10/02
Total Depth of Boring = 31.5 ft.

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

LANDAU ASSOCIATES

Westport Shipyard
Port Angeles, Washington

Log of Boring LAI-B2

Figure
A-3
(2 of 2)

LAI-B3

Drilling Method: Hollow-stem Auger

Ground Elevation (ft): 15 1/2

Drilled By: Environmental Drilling Inc.

SAMPLE DATA					SOIL PROFILE		GROUNDWATER
Depth (ft)	Sample Number & Interval	Sampler Type	Blows/Foot	Test Data	USCS Symbol		Water Level
0					SP-SM	Brown, fine to medium SAND, with silt, varying amounts of gravel, and occassional wood debris (medium dense, moist to wet)(fill)	
	1	b2	24	PID=0			
5	2	b2	39	PID=0		@ 5 ft - becomes gray with occassional gravel and shell fragments	
	3	b2	17	PID=22		@ 7.5 ft - very slight diesel-like odor	
							∇ ATD
10	4	b2	24	PID=0		@ 10 ft - very slight diesel-like odor, becomes wet	
	5	b2	14	PID=0	GP	Brown-gray, sandy fine GRAVEL, with trace silt (medium dense, wet)(fill)	
15	6	b2	10	PID=0	SM	Brown-gray, silty, gravelly, fine to coarse SAND (medium dense, wet)(fill)(slight diesel-like odor)	
	7	b2	11	PID=0	SM	Brown-gray, very silty, fine SAND, with trace gravel and shell fragments (medium dense, wet)(native)	
20	8	b2	25	PID=0			
	9	b2	31	PID=0			
25	10	b2	24	PID=0			
	11	b2	15	PID=0			
30							

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

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Westport Shipyard
Port Angeles, Washington

Log of Boring LAI-B3

Figure
A-4
(1 of 2)

LAI-B3

Drilling Method: Hollow-stem Auger

Ground Elevation (ft): 15 1/2

Drilled By: Environmental Drilling Inc.

SAMPLE DATA					SOIL PROFILE			GROUNDWATER
Depth (ft)	Sample Number & Interval	Sampler Type	Blows/Foot	Test Data	Graphic Symbol	USCS Symbol		Water Level
30	12	b2	13	PID=0		SM	Brown-gray, very silty, fine SAND, with trace gravel and shell fragments (medium dense, wet)(native)	
	13	b2	11	PID=0				
35	14	b2	13	PID=0				
40								
45								
50								
55								
60								

Boring Completed 09/09/02
Total Depth of Boring = 36.5 ft.

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

718002.011 1/21/03 \EDMNAS\GINT\GINTW\PROJECTS\718002.GPJ SOIL BORING LOG

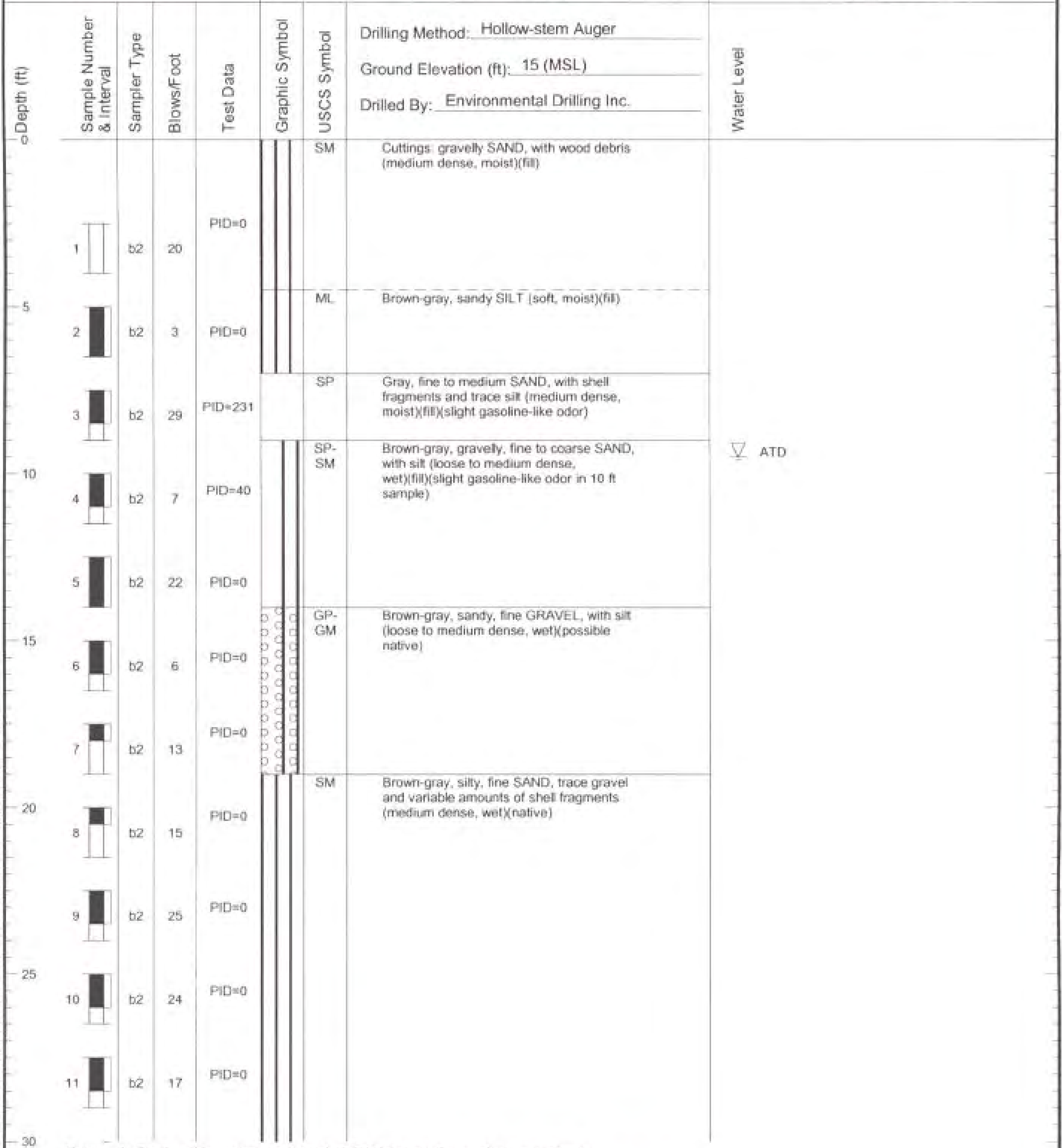
LANDAU ASSOCIATES

Westport Shipyard
Port Angeles, Washington

Log of Boring LAI-B3

Figure
A-4
(2 of 2)

LAI-B4



SAMPLE DATA | **SOIL PROFILE** | **GROUNDWATER**

Drilling Method: Hollow-stem Auger

Ground Elevation (ft): 15 (MSL)

Drilled By: Environmental Drilling Inc.

Sample Number & Interval	Sampler Type	Blows/Foot	Test Data
1	b2	20	PID=0
2	b2	3	PID=0
3	b2	29	PID=231
4	b2	7	PID=40
5	b2	22	PID=0
6	b2	6	PID=0
7	b2	13	PID=0
8	b2	15	PID=0
9	b2	25	PID=0
10	b2	24	PID=0
11	b2	17	PID=0

USCS Symbol	Description
SM	Cuttings: gravelly SAND, with wood debris (medium dense, moist)(fill)
ML	Brown-gray, sandy SILT (soft, moist)(fill)
SP	Gray, fine to medium SAND, with shell fragments and trace silt (medium dense, moist)(fill)(slight gasoline-like odor)
SP-SM	Brown-gray, gravelly, fine to coarse SAND, with silt (loose to medium dense, wet)(fill)(slight gasoline-like odor in 10 ft sample)
GP-GM	Brown-gray, sandy, fine GRAVEL, with silt (loose to medium dense, wet)(possible native)
SM	Brown-gray, silty, fine SAND, trace gravel and variable amounts of shell fragments (medium dense, wet)(native)

▽ ATD

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

718002.011 1/21/03 \EDMNAS\GINT\GINTW\PROJECTS\718002.GPJ SOIL BORING LOG

LANDAU ASSOCIATES

Westport Shipyard
Port Angeles, Washington

Log of Boring LAI-B4

Figure
A-5
(1 of 2)

LAI-B4

SAMPLE DATA					SOIL PROFILE			GROUNDWATER
Depth (ft)	Sample Number & Interval	Sampler Type	Blows/Foot	Test Data	Graphic Symbol	USCS Symbol	Drilling Method: Hollow-stem Auger Ground Elevation (ft): 15 (MSL) Drilled By: Environmental Drilling Inc.	Water Level
30	12	b2	14	PID=0		SM	Brown-gray, silty, fine SAND, trace gravel and variable amounts of shell fragments (medium dense, wet)(native)	

Boring Completed 09/09/02
Total Depth of Boring = 31.5 ft

35

40

45

50

55

60

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

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Port Angeles, Washington

Log of Boring LAI-B4

Figure
A-5
(2 of 2)

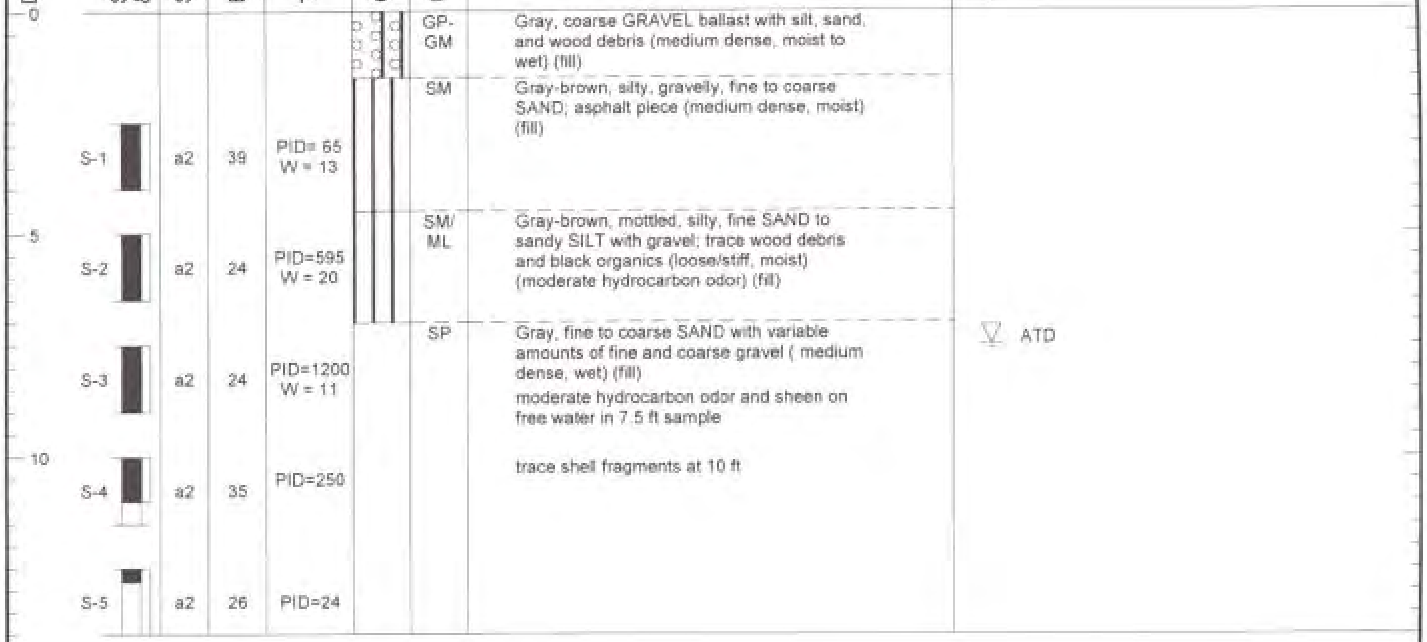
LAI-B5

SAMPLE DATA				SOIL PROFILE		GROUNDWATER

Drilling Method: Hollow-stem Auger

Ground Elevation (ft): 15 (MSL)

Drilled By: Environmental Drilling Inc.



Sample Number & Interval	Sampler Type	Blows/Foot	Test Data
S-1	a2	39	PID= 65 W = 13
S-2	a2	24	PID=595 W = 20
S-3	a2	24	PID=1200 W = 11
S-4	a2	35	PID=250
S-5	a2	26	PID=24

USCS Symbol		Water Level
GP-GM	Gray, coarse GRAVEL ballast with silt, sand, and wood debris (medium dense, moist to wet) (fill)	
SM	Gray-brown, silty, gravelly, fine to coarse SAND; asphalt piece (medium dense, moist) (fill)	
SM/ML	Gray-brown, mottled, silty, fine SAND to sandy SILT with gravel; trace wood debris and black organics (loose/stiff, moist) (moderate hydrocarbon odor) (fill)	
SP	Gray, fine to coarse SAND with variable amounts of fine and coarse gravel (medium dense, wet) (fill) moderate hydrocarbon odor and sheen on free water in 7.5 ft sample trace shell fragments at 10 ft	▽ ATD

Boring Completed 12/30/02
Total Depth of Boring = 14.0 ft

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.
4. PID readings taken from bagged samples during laboraotry

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Port Angeles, Washington

Log of Boring LAI-B5

Figure
A-6

LAI-B6

Drilling Method: Hollow-stem Auger
Ground Elevation (ft): 15 1/2
Drilled By: Environmental Drilling Inc.

SAMPLE DATA					SOIL PROFILE		GROUNDWATER
Depth (ft)	Sample Number & Interval	Sampler Type	Blows/Foot	Test Data	USCS Symbol		Water Level
0					GP-GM	Gray, coarse GRAVEL ballast with silt, sand, and wood debris (medium dense, moist to wet) (fill)	
					SP-SM	Dark gray, fine to coarse SAND with silt to silty, fine to coarse sand with variable amounts of fine to coarse gravel (medium dense to dense, moist) (faint hydrocarbon odor) (fill)	
	S-1	b2	25	PID=170 W = 11 GS			
5	S-2A S-2B S-2C	a2	77	PID=440 W = 9 PID=143 W = 4	SP-SM	Gray, fine to medium SAND with silt; trace gravel and shell fragments (dense, moist) (fill)	
					SP	Gray, fine to coarse SAND with gravel (loose to medium dense, wet) (fill)	
	S-3	b2	15	PID=1060 W = 13		moderate hydrocarbon odor and sheen on free water in 7.5 ft sample	▽ ATD
10	S-4	b2	17	PID=90		moderate hydrocarbon odor at 10.0 ft	
	S-5	b2	8	PID=38		gravelly at 12.5 ft	
15	S-6	b2	9	PID=98			
20							
25							
30							

Boring Completed 12/30/02
Total Depth of Boring = 16.5 ft.

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.
4. PID readings taken from bagged samples during laboraotry.

LAI-B7

Drilling Method: Hollow-stem Auger

Ground Elevation (ft): 15 1/2

Drilled By: Environmental Drilling Inc.

SAMPLE DATA					SOIL PROFILE		GROUNDWATER
Depth (ft)	Sample Number & Interval	Sampler Type	Blows/Foot	Test Data	USCS Symbol		Water Level
0					GP-GM	Gray, coarse GRAVEL ballast with silt, sand, and wood debris (medium dense to dense, moist to wet) (fill)	
	S-1	b2	44		GP/SP	Gray, sandy, fine to coarse GRAVEL to gravelly, fine to coarse SAND with silt; asphalt piece (dense, moist) (fill)	
5	S-2	b2	12	PID=63 W = 8	SM	Gray, silty, fine to medium SAND (medium dense, moist) (slight hydrocarbon odor) (fill)	
	S-3	b2	15	PID=23 W = 17	SP-SM	Gray, fine to medium SAND with silt; trace woody debris and shell fragments (medium dense, wet) (fill)	▽ ATD
10	S-4A	b2	21	PID=26	ML	Dark gray, sandy SILT with woody lense/piece 1 1/2" thick (very stiff, wet) (fill)	
	S-4B			PID=15	SP	Gray, fine to medium SAND with fine gravel (medium dense, wet) (possible fill)	
	S-5	b2	11	PID=19			
15	S-6	b2	7	PID=22	SM	Gray, silty to very silty, fine SAND with fine gravel (loose, wet) (possible native)	
	S-7	b2	9	PID=27	SP-SM	Gray, fine to medium SAND with silt to fine to coarse SAND with gravel; variable amounts of shell fragments (loose to dense, wet) (native)	
20	S-8	b2	13	PID=12		with lense (1/8" thick) of organics at 20 ft	
	S-9	b2	20	PID=35			
25	S-10	b2	18	PID=2.5		increasing silt content at 25 ft	
	S-11	b2	33	PID=5.0		2" zone of gravelly SAND at 27 5 ft	
30							

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.
4. PID readings taken from bagged samples during laboraotry

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Log of Boring LAI-B7

Figure
A-8
(1 of 2)

LAI-B7

Drilling Method: Hollow-stem Auger

Ground Elevation (ft): 15 1/2

Drilled By: Environmental Drilling Inc.

SAMPLE DATA					SOIL PROFILE			GROUNDWATER
Depth (ft)	Sample Number & Interval	Sampler Type	Blows/Foot	Test Data	Graphic Symbol	USCS Symbol		Water Level
30	S-12	b2	19	PID=12		SM	Gray, silty, fine SAND with numerous shell fragments (medium dense, wet) (native)	
	S-13	b2	16	PID=3.0				
35	S-14	b2	16	PID=1.7				
	S-15A	b2	34	PID=0.0				
	S-15B			PID=0.0		SP-SM	Gray with yellowish tint, fine to coarse SAND with silt to trace silt, trace fine gravel (medium dense, wet) (native)	
40	S-16	b2	25	PID=0.0				

Boring Completed 12/30/02
Total Depth of Boring = 41.5 ft.

45

50

55

60

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.
4. PID readings taken from bagged samples during laboraotry

718002.011 1/22/03 \\EDMNAS\GINT\GINTW\PROJECTS\718002.GPJ SOIL BORING LOG

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Log of Boring LAI-B7

Figure
A-8
(2 of 2)

LAI-B8

Drilling Method: Hollow-stem Auger

Ground Elevation (ft): 15 1/2

Drilled By: Environmental Drilling Inc.

SAMPLE DATA					SOIL PROFILE			GROUNDWATER
Depth (ft)	Sample Number & Interval	Sampler Type	Blows/Foot	Test Data	Graphic Symbol	USCS Symbol		Water Level
0						GP-GM	Gray, coarse GRAVEL ballast with silt, sand, and wood debris (medium dense, moist to wet) (fill)	
						SP-SM	Gray, fine to coarse SAND with silt and fine gravel (medium dense, damp to wet) (fill)	
	S-1	b2	27	PID=325 W = 3				
5	S-2	b2	19	PID=240 W = 3 GS			faint hydrocarbon odor at 5 ft	
	S-3	b2	28	PID=1250			with silt and shell fragments at 7.5 ft moderate hydrocarbon odor at 7.5 ft	∇ ATD
10	S-4	b2	28	PID=920			becomes fine to coarse SAND at 10 ft	
	S-5	b2	31	PID=110				
15						SP-SM	Gray, fine to medium SAND with silt and trace gravel (medium dense, wet) (possible native)	
	S-6	b2	13	PID=43				
20								
25								
30								

Boring Completed 12/30/02
Total Depth of Boring = 16.5 ft.

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.
4. PID readings taken from bagged samples during laboraotry

718002.011 1/22/03 \\EDMNAS\GINT\GINTW\PROJECTS\718002.GPJ SOIL BORING LOG

LAI-B9

Drilling Method: Hollow-stem Auger
Ground Elevation (ft): 15 (MSL)
Drilled By: Environmental Drilling Inc.

SAMPLE DATA					SOIL PROFILE			GROUNDWATER
Depth (ft)	Sample Number & Interval	Sampler Type	Blows/Foot	Test Data	Graphic Symbol	USCS Symbol		Water Level
0						GP-GM	Gray, coarse GRAVEL ballast with silt, and snad (medium dense, moist) (fill)	
						WD	Large piece of wood debris from about 1.5 to 2.5 ft	
						SP-SM	Gray, fine to medium SAND with silt to silty gravelly fine to coarse SAND (medium dense, moist to wet) (moderate hydrocarbon odor) (fill)	
	S-1	a2	57	PID=205 W = 8 GS				
5							2" thick lense of laminated, sandy SILT at 5 ft	
	S-2	a2	34	PID=230 W = 4				
	S-3	b2	17	PID=3500 W = 7				▽ ATD
10							becomes fine to coarse SAND with gravel at 10 ft	
	S-4	b2	12	PID=3040				
	S-5	b2	35	PID=595				
15								
20								
25								
30								

Boring Completed 12/30/02
Total Depth of Boring = 14.0 ft.

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.
4. PID readings taken from bagged samples during laboraotry

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Port Angeles, Washington

Log of Boring LAI-B9

Figure
A-10

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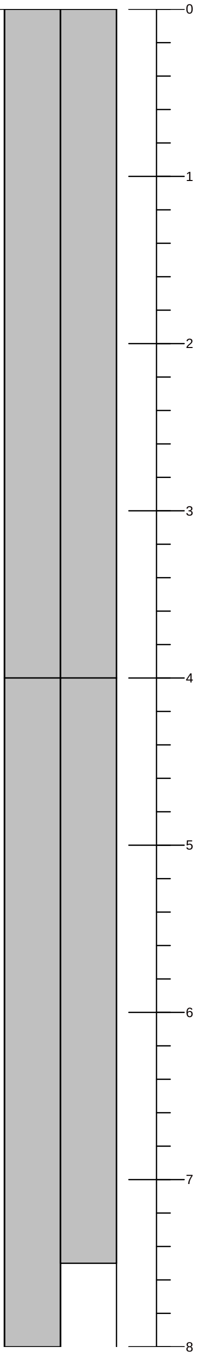
Boring ID: FS-1

Drill Date: February 6, 2008
Logged By: Brett Beaulieu
Drilled By: Frank Scott/Cascade Drilling, Inc.
Drill Type: direct-push probe
Sample Method: direct push 2"x4' core
Boring Diameter: 2 inches
Boring Depth (ft bgs): 16 feet
Groundwater ATD (ft bgs): 10 feet bgs

Client: MTA Group
Project: Marine Trades Area
Task: SJZ-MTA T.6
Address: 638 Marine Drive
Port Angeles, WA

Coordinate System: NAD 83(91) NAVD 88
Ground Surface Elevation: 14.59
Latitude/Northing: 420943.418
Longitude/Easting: 1002681.654
Boring Location: North of Westport

Remarks: Overcast, 40s. Piston sampler used below water table. Located adjacent to bulkhead. Ground surface asphalt.



PID (ppm)	OIL INDICAT.	SAMPLE ID	DRIVEN / RECOVERED	DEPTH FT BGS	USCS SYMBOL	SOIL DESCRIPTION AND OBSERVATIONS
4.5					SW-SM	Dark brown, olive green and grey, moist to dry, well-graded sand with silt and gravel (15%), fine to medium. No hydrocarbon odors. Dark brown, organic-rich lense at 2' bgs. Gravel-sized woody debris from 4' to 4.5'.
					SW	Grey, moist to dry, well-graded sand, fine to medium. No hydrocarbon odors.
0.0					ML	Dark grey, moist, silt, plastic, with fine laminations.
		FS-1 6-8' (soil)			SW	Brownish-grey, moist to dry, well-graded sand, fine to medium, with shell fragments. No petroleum odors. Woody debris and orange oxidation coating at 6'.
1151					ML	Grey, moist, silt, plastic. Possible hydrocarbon odor.
					SW	Grey, moist, well-graded sand with gravel, shell fragments(10%), fine to medium. Hydrocarbon odor. Becomes wet by 10'.

Notes:
FT BGS = feet below ground surface
ppm = parts per million
--- Dashed contact line in soil description indicates a gradational contact
USCS = Unified Soil Classification System
▼ = denotes groundwater table

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Boring ID: FS-1

Drill Date: February 6, 2008
Logged By: Brett Beaulieu
Drilled By: Frank Scott/Cascade Drilling, Inc.

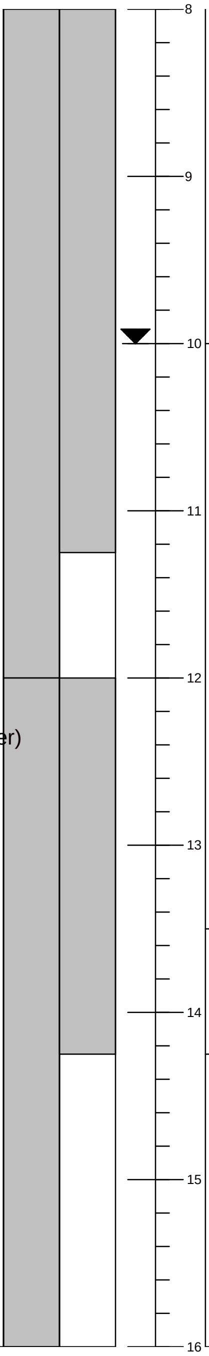
Coordinate System: NAD 83(91) NAVD 88
Ground Surface Elevation: 14.59
Latitude/Northing: 420943.418
Longitude/Easting: 1002681.654
Boring Location: North of Westport

Drill Type: direct-push probe
Sample Method: direct push 2"x4' core
Boring Diameter: 2 inches
Boring Depth (ft bgs): 16 feet
Groundwater ATD (ft bgs): 10 feet bgs

Client: MTA Group
Project: Marine Trades Area
Task: SJZ-MTA T.6
Address: 638 Marine Drive
Port Angeles, WA

Remarks: Overcast, 40s. Piston sampler used below water table. Located adjacent to bulkhead.
Ground surface asphalt.

PID (ppm)	OIL INDICAT.	SAMPLE ID	DRIVEN / RECOVERED	DEPTH FT BGS	USCS SYMBOL	SOIL DESCRIPTION AND OBSERVATIONS
1400	NAPL			8		
1100		FS-1 9-10' (soil)		9		
				10	SW-SM	Grey, wet, sand with silt and gravel, shell fragments, fine to medium, laminated. 1/2" grey, moist, silt lense, plastic, at 11' and 1" grey silt lense, plastic, at 12.5'. Increasing gravel and shell content near contact at 13 to 13.5'.
				11		
38		FS-1 12-16' (groundwater)		12		
				13		
				13.5	SM	Black, wet, silty sand with gravel, fine to medium, organic fines and woody debris. No hydrocarbon odors.
				14		
				15		
				16		



Notes:
FT BGS = feet below ground surface
ppm = parts per million
--- Dashed contact line in soil description indicates a gradational contact
USCS = Unified Soil Classification System
▼ = denotes groundwater table

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Boring ID: FS-2

Drill Date: February 6, 2008
Logged By: Brett Beaulieu
Drilled By: Frank Scott/Cascade Drilling, Inc.
Drill Type: direct-push probe
Sample Method: direct push 2"x4' core
Boring Diameter: 2 inches
Boring Depth (ft bgs): 16 feet
Groundwater ATD (ft bgs): 10 feet bgs

Coordinate System: NAD 83(91) NAVD 88
Ground Surface Elevation: 14.66
Latitude/Northing: 420975.555
Longitude/Easting: 1002772.105
Boring Location: North of Westport

Client: MTA Group
Project: Marine Trades Area
Task: SJZ-MTA T.6
Address: 638 Marine Drive
Port Angeles, WA

Remarks: Overcast, 40s. Piston sampler used below water table. Located adjacent to bulkhead. Ground surface asphalt.

PID (ppm)	OIL INDICAT.	SAMPLE ID	DRIVEN / RECOVERED	DEPTH FT BGS	USCS SYMBOL	SOIL DESCRIPTION AND OBSERVATIONS
0.0				0	SW-SM	Reddish-brown, moist, well-graded sand with silt and gravel, fine to medium. No hydrocarbon odors.
				1		
				2		
				3		
1.2				4	SW	Reddish-brown, moist, well-graded sand, fine to medium, with laminations. Trace shells. Orange oxidation discolorations. No hydrocarbon odors.
				5		
0.3				6		
				7	ML	Dark grey, moist, silt, plastic, with red oxidized layer beneath.
					SP	Light grey, moist, poorly-graded sand, fine. No petroleum odors.
	trace NAPL, rainbow sheen	FS-2 8-11' (soil)		8	SW-SM	Greyish-black, moist to wet, well graded sand with silt and gravel, fine to medium, shell fragments. Possible stained. Strong sulfur odor, possible diesel odor, decreasing with depth.

Notes:
FT BGS = feet below ground surface
ppm = parts per million
--- Dashed contact line in soil description indicates a gradational contact
USCS = Unified Soil Classification System
▼ = denotes groundwater table

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Boring ID: FS-2

Drill Date: February 6, 2008
Logged By: Brett Beaulieu
Drilled By: Frank Scott/Cascade Drilling, Inc.

Coordinate System: NAD 83(91) NAVD 88
Ground Surface Elevation: 14.66
Latitude/Northing: 420975.555
Longitude/Easting: 1002772.105
Boring Location: North of Westport

Drill Type: direct-push probe
Sample Method: direct push 2"x4' core
Boring Diameter: 2 inches
Boring Depth (ft bgs): 16 feet
Groundwater ATD (ft bgs): 10 feet bgs

Client: MTA Group
Project: Marine Trades Area
Task: SJZ-MTA T.6
Address: 638 Marine Drive
Port Angeles, WA

Remarks: Overcast, 40s. Piston sampler used below water table. Located adjacent to bulkhead. Ground surface asphalt.

PID (ppm)	OIL INDICAT.	SAMPLE ID	DRIVEN / RECOVERED	DEPTH FT BGS	USCS SYMBOL	SOIL DESCRIPTION AND OBSERVATIONS
324				9		
				10 ▼		
		FS-2 11-15' (groundwater)		11		
10.3				12		
				13		
10.1		FS-2 14-15' (soil)		14	ML	Grey, wet, silt, plastic.
					SW-SM	Greyish-black, moist to wet, well graded sand with silt and gravel, fine to medium, shell fragments. Possible stained. Strong sulfur odor, possible diesel odor, decreasing with depth.
				15	SW-SM	Black, wet, well-graded sand with silt, fine to medium, organic fines and woody debris. No hydrocarbon odors.
				16		
				17		

Notes:
FT BGS = feet below ground surface
ppm = parts per million
--- Dashed contact line in soil description indicates a gradational contact
USCS = Unified Soil Classification System
▼ = denotes groundwater table

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Boring ID: FS-3

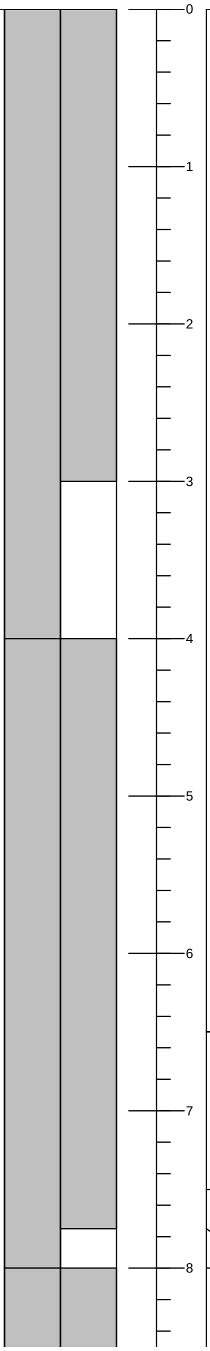
Drill Date: February 6, 2008
Logged By: Brett Beaulieu
Drilled By: Frank Scott/Cascade Drilling, Inc.

Coordinate System: NAD 83(91) NAVD 88
Ground Surface Elevation: 14.47
Latitude/Northing: 420998.475
Longitude/Easting: 1002918.654
Boring Location: North of Westport

Drill Type: direct-push probe
Sample Method: direct push 2"x4' core
Boring Diameter: 2 inches
Boring Depth (ft bgs): 16 feet
Groundwater ATD (ft bgs): 9.5 feet bgs

Client: MTA Group
Project: Marine Trades Area
Task: SJZ-MTA T.6
Address: 638 Marine Drive
Port Angeles, WA

Remarks: Overcast, 30s. Piston sampler used below water table. Located adjacent to bulkhead. Ground surface asphalt.



PID (ppm)	OIL INDICAT.	SAMPLE ID	DRIVEN / RECOVERED	DEPTH FT BGS	USCS SYMBOL	SOIL DESCRIPTION AND OBSERVATIONS
1.2					SW	Reddish-brown, moist to dry, well-graded sand with gravel (5%), fine to medium, trace shell fragments. Woody debris at 6". No hydrocarbon odors.
0.0						
0.0					SW	Brownish-grey, moist to dry, well-graded sand with gravel (5%), fine to medium, trace shell fragments. No hydrocarbon odors.
					SP	Brownish grey, moist, poorly graded sand, fine.
					SW	Greyish-brown (with red grains), moist, well-graded sand, fine to medium, trace gravel and shell fragments. No hydrocarbon odors.

Notes:
FT BGS = feet below ground surface
ppm = parts per million
--- Dashed contact line in soil description indicates a gradational contact
USCS = Unified Soil Classification System
▼ = denotes groundwater table

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Boring ID: FS-3

Drill Date: February 6, 2008
Logged By: Brett Beaulieu
Drilled By: Frank Scott/Cascade Drilling, Inc.

Coordinate System: NAD 83(91) NAVD 88
Ground Surface Elevation: 14.47
Latitude/Northing: 420998.475
Longitude/Easting: 1002918.654
Boring Location: North of Westport

Drill Type: direct-push probe
Sample Method: direct push 2"x4' core
Boring Diameter: 2 inches
Boring Depth (ft bgs): 16 feet
Groundwater ATD (ft bgs): 9.5 feet bgs

Client: MTA Group
Project: Marine Trades Area
Task: SJZ-MTA T.6
Address: 638 Marine Drive
Port Angeles, WA

Remarks: Overcast, 30s. Piston sampler used below water table. Located adjacent to bulkhead. Ground surface asphalt.

PID (ppm)	OIL INDICAT.	SAMPLE ID	DRIVEN / RECOVERED	DEPTH FT BGS	USCS SYMBOL	SOIL DESCRIPTION AND OBSERVATIONS
0.0	No sheen.			9		
				▼	SW-SM	Brown, wet, well-graded sand with gravel and silt, fine to coarse. No hydrocarbon odors.
		FS-3 10-11' (soil)		10		
0.7				11		
					SW-SM	Grey, wet, well-graded sand with gravel and silt, fine to coarse. No hydrocarbon odors.
		FS-3 10-14' (groundwater)		12		
12.4				13		
				14		
					SM	Grey, wet, silty sand.
3.1				15	ML	Olive-grey, wet, silt. Plastic.
					SM	Grey, wet, silty sand.
				16		
				17		

Notes:
FT BGS = feet below ground surface
ppm = parts per million
--- Dashed contact line in soil description indicates a gradational contact
USCS = Unified Soil Classification System
▼ = denotes groundwater table

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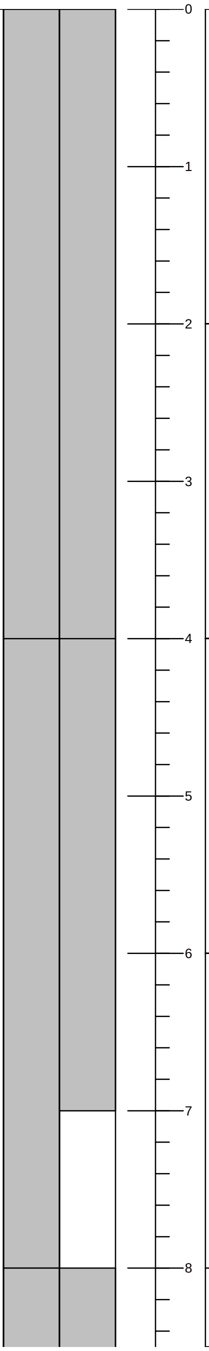
Boring ID: FS-4

Drill Date: February 7, 2008
Logged By: Brett Beaulieu
Drilled By: Frank Scott/Cascade Drilling, Inc.
Drill Type: direct-push probe
Sample Method: direct push 2"x4' core
Boring Diameter: 2 inches
Boring Depth (ft bgs): 16 feet
Groundwater ATD (ft bgs): 9.25 feet bgs

Client: MTA Group
Project: Marine Trades Area
Task: SJZ-MTA T.6
Address: 638 Marine Drive
Port Angeles, WA

Coordinate System: NAD 83(91) NAVD 88
Ground Surface Elevation: 14.13
Latitude/Northing: 420893.668
Longitude/Easting: 1002602.833
Boring Location: North of Westport

Remarks: Sunny, windy, 30s. Piston sampler used below water table. Loc. adjacent to Tumwater Creek bridge. Ground surface asphalt. Composite log of FS-4A (0-6' bgs) and FS-4B (4-16' bgs) due to refusal in FS-4A at 6'.



PID (ppm)	OIL INDICAT.	SAMPLE ID	DEPTH FT BGS	USCS SYMBOL	SOIL DESCRIPTION AND OBSERVATIONS
149	No sheen		0	SW-SM	Grey and brown, dry, well-graded, fine to medium sand with silt and gravel. Cobbles.
	No sheen	FS-4A 2-3' (soil)	2	SW	Grey, dry, well-graded sand with gravel, fine to medium. Hydrocarbon odors.
75	No sheen		4	SM	Grey, dry to moist, silty sand with gravel, fine. Hydrocarbon odors. *Refusal in FS-4A at 6' bgs.
			6	SW	Grey, moist, well-graded sand with gravel, fine to medium. Gravel (10-15%). Cobble at 7' bgs. Hydrocarbon odors.
			8	SW-SM	Black-stained, moist, well graded sand with silt and gravel. Shell fragments. Hydrocarbon odors.

Notes:
FT BGS = feet below ground surface
ppm = parts per million
--- Dashed contact line in soil description indicates a gradational contact
USCS = Unified Soil Classification System
▼ = denotes groundwater table

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Boring ID: FS-4

Drill Date: February 7, 2008
Logged By: Brett Beaulieu
Drilled By: Frank Scott/Cascade Drilling, Inc.

Coordinate System: NAD 83(91) NAVD 88
Ground Surface Elevation: 14.13
Latitude/Northing: 420893.668
Longitude/Easting: 1002602.833
Boring Location: North of Westport

Drill Type: direct-push probe
Sample Method: direct push 2"x4' core
Boring Diameter: 2 inches
Boring Depth (ft bgs): 16 feet
Groundwater ATD (ft bgs): 9.25 feet bgs

Client: MTA Group
Project: Marine Trades Area
Task: SJZ-MTA T.6
Address: 638 Marine Drive
Port Angeles, WA

Remarks: Sunny, windy, 30s. Piston sampler used below water table. Loc. adjacent to Tumwater Creek bridge. Ground surface asphalt. Composite log of FS-4A (0-6' bgs) and FS-4B (4-16' bgs) due to refusal in FS-4A at 6'.

PID (ppm)	OIL INDICAT.	SAMPLE ID	DRIVEN /	RECOVERED	DEPTH FT BGS	USCS SYMBOL	SOIL DESCRIPTION AND OBSERVATIONS
1427	NAPL	FS-4B 9-10' (soil)	▨	▨	9 ▼	ML SW-SM	Black-stained, moist, silt. Hydrocarbon odors. Black-stained, moist to wet, well graded sand with silt and gravel. Shell fragments. Wet at 9.25' bgs. Hydrocarbon odors.
1504			▨	▨	10		
			▨		11		
		FS-4B 10-14' (groundwater)	▨	▨	12 13		
			▨		14		Lost recovery due to shredded core catcher.
1.7	Rainbow sheen	FS-4B 15-16' (soil)	▨	▨	15	SW	Grey, well-graded sand with gravel, fine to medium. Light hydrocarbon odors.
					16 17		

Notes:
FT BGS = feet below ground surface
ppm = parts per million
--- Dashed contact line in soil description indicates a gradational contact
USCS = Unified Soil Classification System
▼ = denotes groundwater table

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Boring ID: FS-5

Drill Date: February 6, 2008
Logged By: Brett Beaulieu
Drilled By: Frank Scott/Cascade Drilling, Inc.

Coordinate System: NAD 83(91) NAVD 88
Ground Surface Elevation: 14.71
Latitude/Northing: 420909.188
Longitude/Easting: 1002668.785
Boring Location: North of Westport

Drill Type: direct-push probe
Sample Method: direct push 2"x4' core
Boring Diameter: 2 inches
Boring Depth (ft bgs): 16 feet
Groundwater ATD (ft bgs): 9 feet bgs

Client: MTA Group
Project: Marine Trades Area
Task: SJZ-MTA T.6
Address: 638 Marine Drive
Port Angeles, WA

Remarks: Overcast, 40s. Piston sampler used below water table. Ground surface asphalt.

PID (ppm)	OIL INDICAT.	SAMPLE ID	DRIVEN / RECOVERED	DEPTH FT BGS	USCS SYMBOL	SOIL DESCRIPTION AND OBSERVATIONS
39.9		FS-5 2-3a (soil) FS-5 2-3b (soil)		0 1 2	SW-SM	Grey, moist to dry, well-graded sand with gravel (20%) and silt, fine to medium, cobbles. Dark brown woody debris at 2'. No hydrocarbon odors.
				3	SW	Grey, moist to dry, well-graded sand with gravel (5-10%), fine to medium. Hydrocarbon odors at 3'.
5.9				4 5		
26.9				6	ML	Dark grey silt with sand, fine, moist, laminated, plastic. Woody debris at base. Light hydrocarbon odor.
				7	SW	Grey, moist, well-graded sand with gravel (5-10%), fine to medium, shell fragments.
					ML	Dark grey silt with sand, fine, moist, laminated, plastic.
				8		

Notes:
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ppm = parts per million
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Boring ID: FS-5

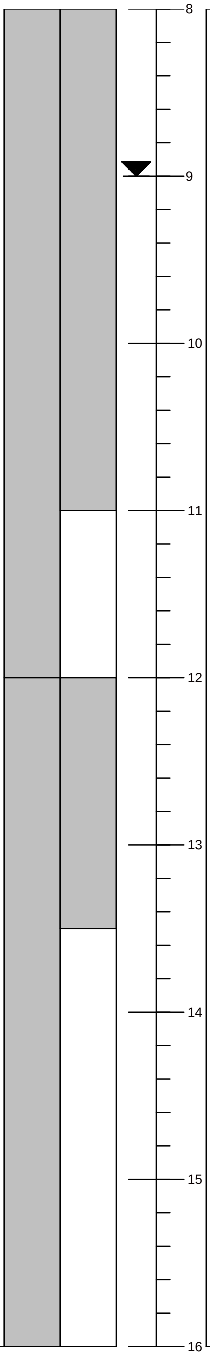
Drill Date: February 6, 2008
Logged By: Brett Beaulieu
Drilled By: Frank Scott/Cascade Drilling, Inc.

Coordinate System: NAD 83(91) NAVD 88
Ground Surface Elevation: 14.71
Latitude/Northing: 420909.188
Longitude/Easting: 1002668.785
Boring Location: North of Westport

Drill Type: direct-push probe
Sample Method: direct push 2"x4' core
Boring Diameter: 2 inches
Boring Depth (ft bgs): 16 feet
Groundwater ATD (ft bgs): 9 feet bgs

Client: MTA Group
Project: Marine Trades Area
Task: SJZ-MTA T.6
Address: 638 Marine Drive
Port Angeles, WA

Remarks: Overcast, 40s. Piston sampler used below water table. Ground surface asphalt.



PID (ppm)	OIL INDICAT.	SAMPLE ID	DRIVEN / RECOVERED	DEPTH FT BGS	USCS SYMBOL	SOIL DESCRIPTION AND OBSERVATIONS
540				8	SW-SM	Grey, moist to wet, well-graded sand with gravel (25%) and silt, fine to medium. No hydrocarbon odors. Wet at 9' bgs. Hydrocarbon odor and visible rainbow sheen at 9' bgs. Lighter hydrocarbon odor at 12-13' bgs.
1200	Trace NAPL with heavy sheen	FS-5 9-10' (soil)		9		
				10		
				11		
21.8				12		Same as above.
				13		
				14		
				15		
				16		

Notes:
FT BGS = feet below ground surface
ppm = parts per million
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▼ = denotes groundwater table

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Boring ID: FS-6

Drill Date: February 6, 2008
Logged By: Brett Beaulieu
Drilled By: Frank Scott/Cascade Drilling, Inc.

Coordinate System: NAD 83(91) NAVD 88
Ground Surface Elevation: 14.95
Latitude/Northing: 420924.642
Longitude/Easting: 1002736.333
Boring Location: North of Westport

Drill Type: direct-push probe
Sample Method: direct push 2"x4' core
Boring Diameter: 2 inches
Boring Depth (ft bgs): 16 feet
Groundwater ATD (ft bgs): 11 ft bgs

Client: MTA Group
Project: Marine Trades Area
Task: SJZ-MTA T.6
Address: 638 Marine Drive
Port Angeles, WA

Remarks: Overcast, 40s. Piston sampler used below water table. Located along south side of roadway north of Westport Marine. Ground surface asphalt.

PID (ppm)	OIL INDICAT.	SAMPLE ID	DRIVEN / RECOVERED	DEPTH FT BGS	USCS SYMBOL	SOIL DESCRIPTION AND OBSERVATIONS
39.8				0 1 2 3	SW-SM	Grey, olive, and dark brown, moist, well-graded sand with silt and gravel, fine to medium. Dark brown woody debris at 2' bgs. Possible dark brown staining at 3' bgs. No hydrocarbon odors.
1.3				4 5 6	SW	Grey, moist to dry, well-graded sand with gravel (20% decreasing with depth), fine to medium, shell fragments. Light hydrocarbon odors.
3.0				7 8	SM	Grey, moist, silty sand, fine, laminated.

Notes:
FT BGS = feet below ground surface
ppm = parts per million

--- Dashed contact line in soil description indicates a gradational contact
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▼ = denotes groundwater table

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Boring ID: FS-6

Drill Date: February 6, 2008
Logged By: Brett Beaulieu
Drilled By: Frank Scott/Cascade Drilling, Inc.

Coordinate System: NAD 83(91) NAVD 88
Ground Surface Elevation: 14.95
Latitude/Northing: 420924.642
Longitude/Easting: 1002736.333
Boring Location: North of Westport

Drill Type: direct-push probe
Sample Method: direct push 2"x4' core
Boring Diameter: 2 inches
Boring Depth (ft bgs): 16 feet
Groundwater ATD (ft bgs): 11 ft bgs

Client: MTA Group
Project: Marine Trades Area
Task: SJZ-MTA T.6
Address: 638 Marine Drive
Port Angeles, WA

Remarks: Overcast, 40s. Piston sampler used below water table. Located along south side of roadway north of Westport Marine. Ground surface asphalt.

PID (ppm)	OIL INDICAT.	SAMPLE ID	DRIVEN / RECOVERED	DEPTH FT BGS	USCS SYMBOL	SOIL DESCRIPTION AND OBSERVATIONS
				8	SW	Grey, moist to wet, well-graded sand with gravel, fine to medium, shell fragments. Hydrocarbon odors.
1085	Trace NAPL with heavy sheen					
				9		
					SM	Grey, wet silty sand, fine.
385		FS-6 10-11' (soil)		10	SW	Grey, moist to wet, well-graded sand with gravel, fine to medium, shell fragments.
				▼ 11	SM	Grey, wet silty sand, fine.
35.2		FS-6 11-15' (groundwater)		12	SW-SM	Grey, wet, well-graded sand with silt and gravel, fine to medium.
				13		
45.0				14	ML	Dark grey, wet, silt with sand, fine, with organics and woody debris. Become increasingly plastic and organic-rich with depth.
					SM	Black, wet, silty sand with gravel (25%), shell fragments.
				15		
				16		

Notes:
FT BGS = feet below ground surface
ppm = parts per million
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▼ = denotes groundwater table

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Boring ID: FS-7

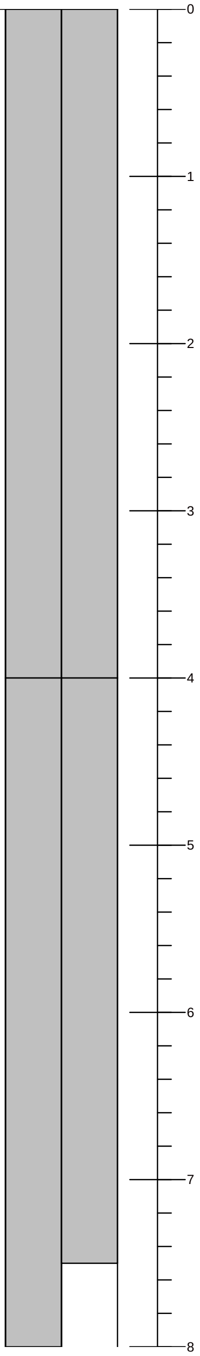
Drill Date: February 5, 2008
Logged By: Brett Beaulieu
Drilled By: Frank Scott/Cascade Drilling, Inc.

Coordinate System: NAD 83(91) NAVD 88
Ground Surface Elevation: 15.01
Latitude/Northing: 420936.412
Longitude/Easting: 1002802.494
Boring Location: North of Westport

Drill Type: direct-push probe
Sample Method: direct push 2"x4' core
Boring Diameter: 2 inches
Boring Depth (ft bgs): 16 feet
Groundwater ATD (ft bgs): 10 ft bgs

Client: MTA Group
Project: Marine Trades Area
Task: SJZ-MTA T.6
Address: 638 Marine Drive
Port Angeles, WA

Remarks: Rain, windy, 40s. Piston sampler used below water table. Ground surface asphalt.



PID (ppm)	OIL INDICAT.	SAMPLE ID	DRIVEN / RECOVERED	DEPTH FT BGS	USCS SYMBOL	SOIL DESCRIPTION AND OBSERVATIONS
22.1					SW-SM	Grey, brown, and dark brown, moist to dry, well-graded sand with silt and gravel, fine to medium. Dark brown woody debris at 3' bgs. Possible dark brown staining at 3' bgs. Possible light hydrocarbon odors.
					SW	Grey, moist, well-graded sand with gravel, fine to medium. Gravel content variable (20% 3-4' bgs; 10% 4-7' bgs; 30% 8-10' bgs). Shell fragments. Fine laminations. Cobbles 8-10' bgs. Light hydrocarbon odors 3-4' bgs; no hydrocarbon odors 4-7' bgs.
7.8						

Notes:
FT BGS = feet below ground surface
ppm = parts per million
--- Dashed contact line in soil description indicates a gradational contact
USCS = Unified Soil Classification System
▼ = denotes groundwater table

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Boring ID: FS-7

Drill Date: February 5, 2008
Logged By: Brett Beaulieu
Drilled By: Frank Scott/Cascade Drilling, Inc.

Coordinate System: NAD 83(91) NAVD 88
Ground Surface Elevation: 15.01
Latitude/Northing: 420936.412
Longitude/Easting: 1002802.494
Boring Location: North of Westport

Drill Type: direct-push probe
Sample Method: direct push 2"x4' core
Boring Diameter: 2 inches
Boring Depth (ft bgs): 16 feet
Groundwater ATD (ft bgs): 10 ft bgs

Client: MTA Group
Project: Marine Trades Area
Task: SJZ-MTA T.6
Address: 638 Marine Drive
Port Angeles, WA

Remarks: Rain, windy, 40s. Piston sampler used below water table. Ground surface asphalt.

PID (ppm)	OIL INDICAT.	SAMPLE ID	DRIVEN / RECOVERED	DEPTH FT BGS	USCS SYMBOL	SOIL DESCRIPTION AND OBSERVATIONS
				8		
1324				9		
	Rainbow sheen	FS-7 10-11' (soil)		▼ 10	SW-SM	Grey and dark-stained, wet, well-graded sand with silt and gravel. Shell fragments. Visible residual NAPL. Hydrocarbon odors.
				11		
		FS-7 12-16' (groundwater)		12	SM	Brown, wet, silty sand. Organic-rich. Visible sheen. Hydrocarbon odors.
					SW-SM	Grey, wet, well-graded sand with silt and gravel. Shell fragments. Visible sheen. Hydrocarbon odors.
5.0		FS-7 13-14' (soil)		13		
					SM	Brown, wet, silty sand. Organic-rich. Visible sheen. Hydrocarbon odors.
				14	SW-SM	Grey, wet, well-graded sand with silt and gravel. Shell fragments. Visible sheen. Hydrocarbon odors.
					SW-SM	Black, wet, well-graded sand with silt and gravel.
				15		
				16		

Notes:
FT BGS = feet below ground surface
ppm = parts per million

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USCS = Unified Soil Classification System
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Boring ID: FS-8

Drill Date: February 6, 2008
Logged By: Brett Beaulieu
Drilled By: Frank Scott/Cascade Drilling, Inc.

Coordinate System: NAD 83(91) NAVD 88
Ground Surface Elevation: 14.77
Latitude/Northing: 420956.387
Longitude/Easting: 1002880.684
Boring Location: North of Platypus shop

Drill Type: direct-push probe
Sample Method: direct push 2"x4' core
Boring Diameter: 2 inches
Boring Depth (ft bgs): 16 feet
Groundwater ATD (ft bgs): 9.5 ft bgs

Client: MTA Group
Project: Marine Trades Area
Task: SJZ-MTA T.6
Address: 638 Marine Drive
Port Angeles, WA

Remarks: Overcast, 40s. Piston sampler used below water table. Ground surface asphalt.

PID (ppm)	OIL INDICAT.	SAMPLE ID	DRIVEN / RECOVERED	DEPTH FT BGS	USCS SYMBOL	SOIL DESCRIPTION AND OBSERVATIONS
				0	SW-SM	SW-SM: Grey-brown, dry, well-graded sand with silt and gravel, fine to medium.
				1		
134				2		
					SW	SW: Grey, dry, well-graded sand with gravel (varies from 5 to 30% with depth), fine to medium, shell fragments. Brown at 8.5' bgs, dark grey at 12' bgs. Possible light hydrocarbon odors 4-9' bgs. Dry cobbles at 9-9.5' bgs. Wet at 9.5'. Strong hydrocarbon odors 9.5'-10.5' bgs, lighter hydrocarbon odors 12-13.5' bgs.
				3		
				4		
				5		
15.4						
				6		
				7		
152						
				8		

Notes:
FT BGS = feet below ground surface
ppm = parts per million

--- Dashed contact line in soil description indicates a gradational contact
USCS = Unified Soil Classification System
▼ = denotes groundwater table

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Boring ID: FS-8

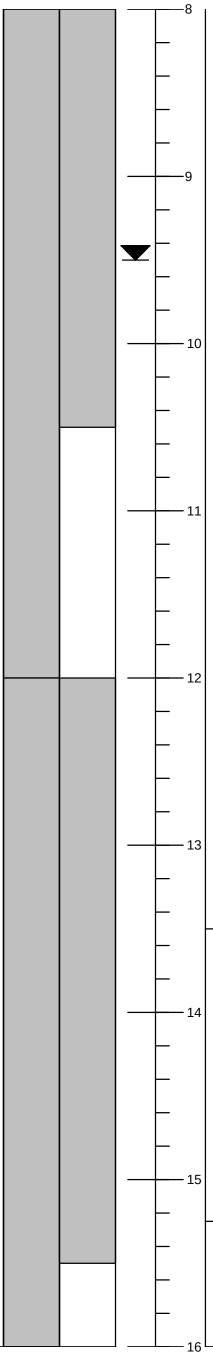
Drill Date: February 6, 2008
Logged By: Brett Beaulieu
Drilled By: Frank Scott/Cascade Drilling, Inc.

Coordinate System: NAD 83(91) NAVD 88
Ground Surface Elevation: 14.77
Latitude/Northing: 420956.387
Longitude/Easting: 1002880.684
Boring Location: North of Platypus shop

Drill Type: direct-push probe
Sample Method: direct push 2"x4' core
Boring Diameter: 2 inches
Boring Depth (ft bgs): 16 feet
Groundwater ATD (ft bgs): 9.5 ft bgs

Client: MTA Group
Project: Marine Trades Area
Task: SJZ-MTA T.6
Address: 638 Marine Drive
Port Angeles, WA

Remarks: Overcast, 40s. Piston sampler used below water table. Ground surface asphalt.



PID (ppm)	OIL INDICAT.	SAMPLE ID	DRIVEN / RECOVERED	DEPTH FT BGS	USCS SYMBOL	SOIL DESCRIPTION AND OBSERVATIONS
759	NAPL and sheen					Same as above.
1800		FS-8 9.5-10.5' (soil)				
12.9					ML	ML: Dark olive-grey, moist to wet silt with sand. Plastic, with lenses of varying sand content. Trace woody debris.
4.5					SM	SM: Black, wet, silty sand with gravel, fine. Shell fragments. Organic rich.

Notes:
FT BGS = feet below ground surface
ppm = parts per million
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Boring ID: FS-9

Drill Date: February 7, 2008
Logged By: Brett Beaulieu
Drilled By: Frank Scott/Cascade Drilling, Inc.
Drill Type: direct-push probe
Sample Method: direct push 2"x4' core
Boring Diameter: 2 inches
Boring Depth (ft bgs): 16 feet
Groundwater ATD (ft bgs): 10 ft bgs

Coordinate System: NAD 83(91) NAVD 88
Ground Surface Elevation: 15.15
Latitude/Northing: 420846.666
Longitude/Easting: 1002573.612
Boring Location: North of Westport

Client: MTA Group
Project: Marine Trades Area
Task: SJZ-MTA T.6
Address: 638 Marine Drive
Port Angeles, WA

Remarks: Partly cloudy, windy, 30s. Piston sampler used below water table. Ground surface gravel, located west of road adjacent to Westport, near Tumwater Creek bridge.

PID (ppm)	OIL INDICAT.	SAMPLE ID	DRIVEN / RECOVERED	DEPTH FT BGS	USCS SYMBOL	SOIL DESCRIPTION AND OBSERVATIONS
				0	SW-SM	Brown, reddish-brown, and dark brown, dry to moist, well-graded sand with silt and gravel, fine to medium. Cobbles. Organic rich lense at contact at 3' bgs.
				1		
20.8				2		
				3	ML	Mottled green-grey with orange, moist, silt. Plastic.
				4	SW	Grey, moist to dry, well-graded sand with gravel, fine to coarse. Cobble at 5' bgs. Light hydrcarbon odors.
585				5		
				6		
				7		
				8		

Notes:
FT BGS = feet below ground surface
ppm = parts per million

--- Dashed contact line in soil description indicates a gradational contact
USCS = Unified Soil Classification System
▼ = denotes groundwater table

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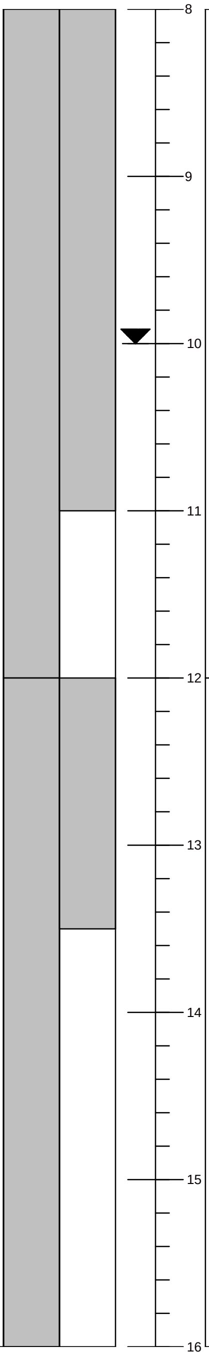
Boring ID: FS-9

Drill Date: February 7, 2008
Logged By: Brett Beaulieu
Drilled By: Frank Scott/Cascade Drilling, Inc.
Drill Type: direct-push probe
Sample Method: direct push 2"x4' core
Boring Diameter: 2 inches
Boring Depth (ft bgs): 16 feet
Groundwater ATD (ft bgs): 10 ft bgs

Client: MTA Group
Project: Marine Trades Area
Task: SJZ-MTA T.6
Address: 638 Marine Drive
Port Angeles, WA

Coordinate System: NAD 83(91) NAVD 88
Ground Surface Elevation: 15.15
Latitude/Northing: 420846.666
Longitude/Easting: 1002573.612
Boring Location: North of Westport

Remarks: Partly cloudy, windy, 30s. Piston sampler used below water table. Ground surface gravel, located west of road adjacent to Westport, near Tumwater Creek bridge.



PID (ppm)	OIL INDICAT.	SAMPLE ID	DRIVEN / RECOVERED	DEPTH FT BGS	USCS SYMBOL	SOIL DESCRIPTION AND OBSERVATIONS
1495				8	SW	Black-stained, moist to wet, well graded sand with gravel, fine to medium. Shell fragments. Organic-rich silt lense (<1") at 10' bgs with woody debris. Increase in gravel to 25-30% by 11' bgs. Wet at 10' bgs. Visible sheen and strong hydrocarbon odors.
	Rainbow sheen	FS-9 9-10' (soil)		9		
1575				10 ▼		
				11		
160	No sheen			12	SW-SM	Grey, wet, well-graded sand with silt and gravel (30-40%). Light hydrocarbon odors.
				13		
				14		
				15		
				16		

Notes:
FT BGS = feet below ground surface
ppm = parts per million
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Boring ID: FS-10

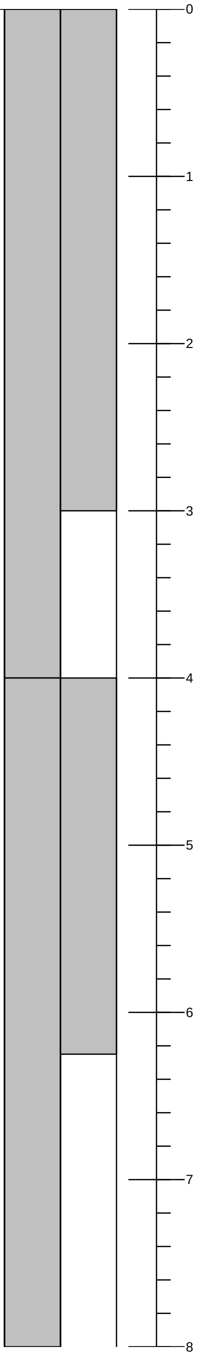
Drill Date: February 4, 2008
Logged By: Brett Beaulieu
Drilled By: Frank Scott/Cascade Drilling, Inc.

Coordinate System: NAD 83(91) NAVD 88
Ground Surface Elevation: 14.92
Latitude/Northing: 420867.070
Longitude/Easting: 1002647.007
Boring Location: North of Westport

Drill Type: direct-push probe
Sample Method: direct push 2"x4' core
Boring Diameter: 2 inches
Boring Depth (ft bgs): 16 feet
Groundwater ATD (ft bgs): 9 ft bgs

Client: MTA Group
Project: Marine Trades Area
Task: SJZ-MTA T.6
Address: 638 Marine Drive
Port Angeles, WA

Remarks: Light rain, 40s. Piston sampler used below water table. Ground surface gravel.



PID (ppm)	OIL INDICAT.	SAMPLE ID	DRIVEN / RECOVERED	DEPTH FT BGS	USCS SYMBOL	SOIL DESCRIPTION AND OBSERVATIONS
53					SW-SM	Brown , dry to moist, well-graded sand with silt and gravel (25%), fine to medium. Cobbles. Becomes dark brown, organic-rich with woody debris at 3' bgs.
67						Dark brown apparent staining, hydrocarbon odors 4' - 5.9'. Shell fragments, woody debris, and plastic fibers 4' -5.9'.
261	Heavy sheen	FS-10 5-6' (soil)				
					SW	Grey, moist, well-graded sand with gravel, fine to medium.

Notes:
FT BGS = feet below ground surface
ppm = parts per million

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▼ = denotes groundwater table

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Boring ID: FS-10

Drill Date: February 4, 2008
Logged By: Brett Beaulieu
Drilled By: Frank Scott/Cascade Drilling, Inc.

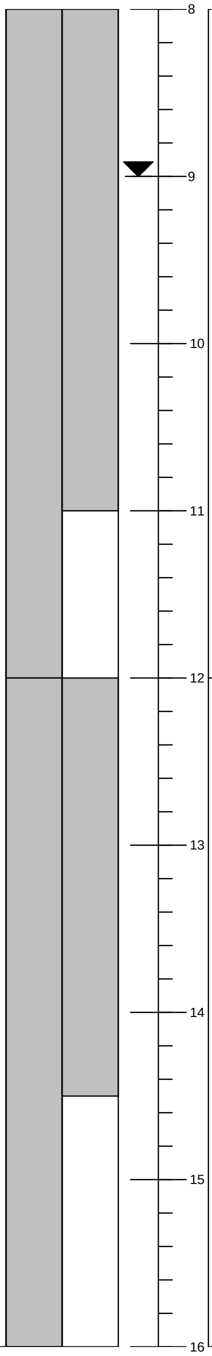
Coordinate System: NAD 83(91) NAVD 88
Ground Surface Elevation: 14.92
Latitude/Northing: 420867.070
Longitude/Easting: 1002647.007
Boring Location: North of Westport

Drill Type: direct-push probe
Sample Method: direct push 2"x4' core
Boring Diameter: 2 inches
Boring Depth (ft bgs): 16 feet
Groundwater ATD (ft bgs): 9 ft bgs

Client: MTA Group
Project: Marine Trades Area
Task: SJZ-MTA T.6
Address: 638 Marine Drive
Port Angeles, WA

Remarks: Light rain, 40s. Piston sampler used below water table. Ground surface gravel.

PID (ppm)	OIL INDICAT.	SAMPLE ID	DRIVEN / RECOVERED	DEPTH FT BGS	USCS SYMBOL	SOIL DESCRIPTION AND OBSERVATIONS
1429				8	SM	Dark grey to black, moist to wet, silty sand with gravel, fine. Shell fragments. Wet at 9' bgs. Strong hydrocarbon odors.
		FS-10 9-10' (soil)		9		
1654				10		
				11		
156				12	SW	Dark grey, wet, well-graded sand with gravel, fine to medium. Shell fragments. Silty lense at 14' bgs.
				13		
45				14		
				15		
				16		



Notes:
FT BGS = feet below ground surface
ppm = parts per million

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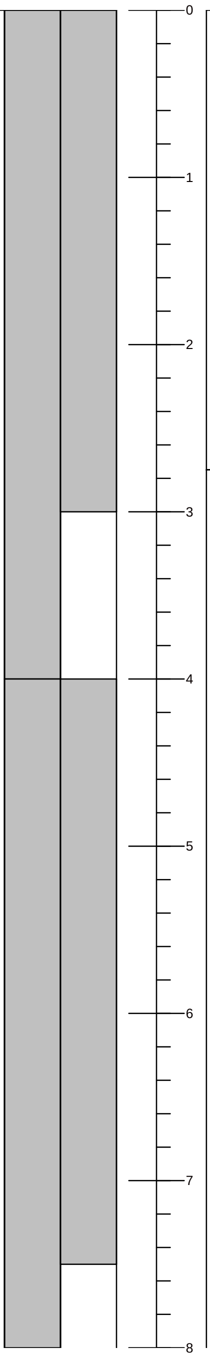
Boring ID: FS-11

Drill Date: February 5, 2008
Logged By: Brett Beaulieu
Drilled By: Frank Scott/Cascade Drilling, Inc.
Drill Type: direct-push probe
Sample Method: direct push 2"x4' core
Boring Diameter: 2 inches
Boring Depth (ft bgs): 16 feet
Groundwater ATD (ft bgs): 9.5 ft bgs

Coordinate System: NAD 83(91) NAVD 88
Ground Surface Elevation: 15.28
Latitude/Northing: 420879.443
Longitude/Easting: 1002715.932
Boring Location: North of Westport

Client: MTA Group
Project: Marine Trades Area
Task: SJZ-MTA T.6
Address: 638 Marine Drive
Port Angeles, WA

Remarks: High winds, 30s. Piston sampler used below water table. Ground surface gravel.



PID (ppm)	OIL INDICAT.	SAMPLE ID	DRIVEN / RECOVERED	DEPTH FT BGS	USCS SYMBOL	SOIL DESCRIPTION AND OBSERVATIONS
25.7					SW-SM	Olive brown to dark brown to grey, dry to moist, well-graded sand with silt and gravel (25%), fine to coarse. Cobbles. No odors.
					SW	Grey, moist, well-graded sand with gravel (15%), fine to medium. Shell fragments (<5%) increasing with depth. Light odor at 3'. Strong odor below 6'. Dark brown color and woody debris at 4.5' bgs.
34.7						
747						

Notes:
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ppm = parts per million
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Boring ID: FS-11

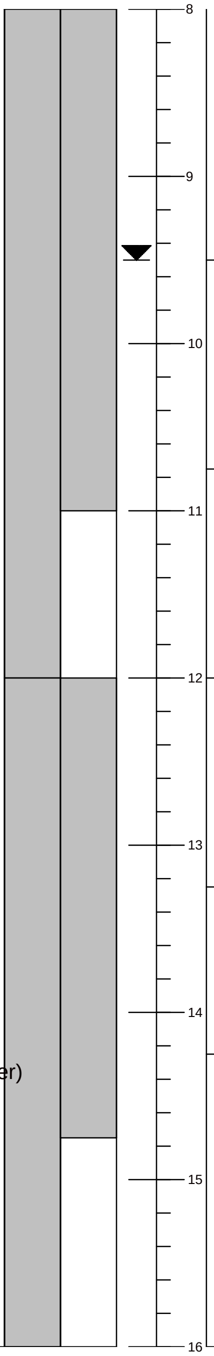
Drill Date: February 5, 2008
Logged By: Brett Beaulieu
Drilled By: Frank Scott/Cascade Drilling, Inc.

Coordinate System: NAD 83(91) NAVD 88
Ground Surface Elevation: 15.28
Latitude/Northing: 420879.443
Longitude/Easting: 1002715.932
Boring Location: North of Westport

Drill Type: direct-push probe
Sample Method: direct push 2"x4' core
Boring Diameter: 2 inches
Boring Depth (ft bgs): 16 feet
Groundwater ATD (ft bgs): 9.5 ft bgs

Client: MTA Group
Project: Marine Trades Area
Task: SJZ-MTA T.6
Address: 638 Marine Drive
Port Angeles, WA

Remarks: High winds, 30s. Piston sampler used below water table. Ground surface gravel.



PID (ppm)	OIL INDICAT.	SAMPLE ID	USCS SYMBOL	SOIL DESCRIPTION AND OBSERVATIONS
	Light broken sheen	FS-11 10-11' (soil)	SM/ML	Grey, wet, silty sand, fine, laminated, grading to dark brown, wet, silt, plastic, laminated, organic-rich, Hydrocarbon odors.
447			SW	Grey, wet, well-graded sand, fine to medium. Shell fragments.
			SM	Dark brown to black, wet, silty sand, fine.
20.1			SW	Dark brown to black, wet, well-graded sand with gravel, fine to medium. Shell fragments.
		FS-11 12-16' (groundwater)	SM	Dark brown to black, wet, silty sand, fine. Organic-rich lamination at 14.5' bgs.

Notes:
FT BGS = feet below ground surface
ppm = parts per million
--- Dashed contact line in soil description indicates a gradational contact
USCS = Unified Soil Classification System
▼ = denotes groundwater table

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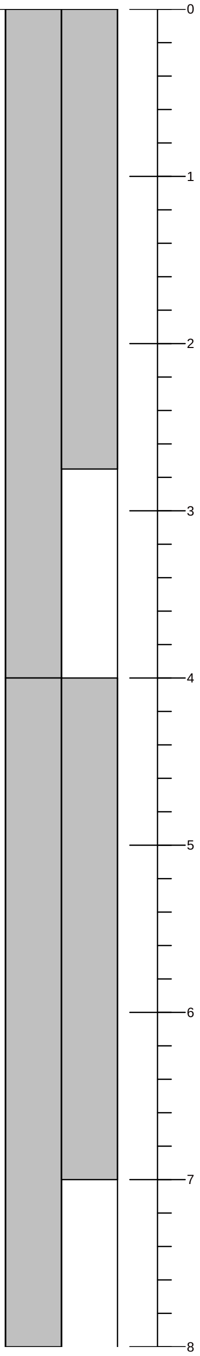
Boring ID: FS-12

Drill Date: February 5, 2008
Logged By: Brett Beaulieu
Drilled By: Frank Scott/Cascade Drilling, Inc.
Drill Type: direct-push probe
Sample Method: direct push 2"x4' core
Boring Diameter: 2 inches
Boring Depth (ft bgs): 16 feet
Groundwater ATD (ft bgs): 9 ft bgs

Client: MTA Group
Project: Marine Trades Area
Task: SJZ-MTA T.6
Address: 638 Marine Drive
Port Angeles, WA

Coordinate System: NAD 83(91) NAVD 88
Ground Surface Elevation: 15.20
Latitude/Northing: 420899.740
Longitude/Easting: 1002777.970
Boring Location: North of Westport

Remarks: Light rain, 40s. Piston sampler used below water table. Ground surface gravel.



PID (ppm)	OIL INDICAT.	SAMPLE ID	DRIVEN / RECOVERED	DEPTH FT BGS	USCS SYMBOL	SOIL DESCRIPTION AND OBSERVATIONS
6.2	Light broken sheen				SW-SM	SW-SM: Brown, grey, and dark grey, dry to moist, well-graded sand with silt and gravel, fine, Cobbles. Hydrocarbon odors.
22					SW	SW: Grey, moist, well-graded sand, fine to medium. Shell fragments (5-10%), gravel (<5%). Light hydrocarbon odors. At 9' bgs (contact), 25% shell fragments, 10-20% gravel. Increased hydrocarbon odor 8-9' bgs.
9.7						

Notes:
FT BGS = feet below ground surface
ppm = parts per million
--- Dashed contact line in soil description indicates a gradational contact
USCS = Unified Soil Classification System
▼ = denotes groundwater table

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Boring ID: FS-12

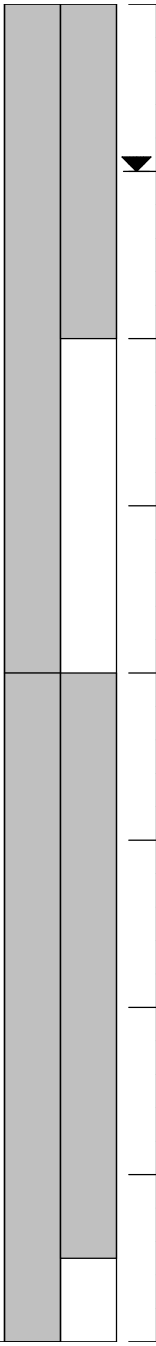
Drill Date: February 5, 2008
Logged By: Brett Beaulieu
Drilled By: Frank Scott/Cascade Drilling, Inc.

Coordinate System: NAD 83(91) NAVD 88
Ground Surface Elevation: 15.20
Latitude/Northing: 420899.740
Longitude/Easting: 1002777.970
Boring Location: North of Westport

Drill Type: direct-push probe
Sample Method: direct push 2"x4' core
Boring Diameter: 2 inches
Boring Depth (ft bgs): 16 feet
Groundwater ATD (ft bgs): 9 ft bgs

Client: MTA Group
Project: Marine Trades Area
Task: SJZ-MTA T.6
Address: 638 Marine Drive
Port Angeles, WA

Remarks: Light rain, 40s. Piston sampler used below water table. Ground surface gravel.



PID (ppm)	OIL INDICAT.	SAMPLE ID	DRIVEN / RECOVERED	DEPTH FT BGS	USCS SYMBOL	SOIL DESCRIPTION AND OBSERVATIONS
1437	NAPL, rainbow sheen	FS-12 8-10' (soil)		8		
				9 ▼	SW-SM	SW-SM: Grey, wet, well-graded sand with silt and gravel. Silty sand laminations. Organic-rich laminations. Hydrocarbon odors.
				10		
				11		
				12		
31.2				13		
				14		
					ML	ML: Greenish brown, wet, silt. Woody debris piece >1" in diameter.
6.3	No sheen			15	SW-SM	SW-SM: Black, well-graded sand with silt and gravel, organic rich.
				16		

Notes:
FT BGS = feet below ground surface
ppm = parts per million
--- Dashed contact line in soil description indicates a gradational contact
USCS = Unified Soil Classification System
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Boring ID: FS-13

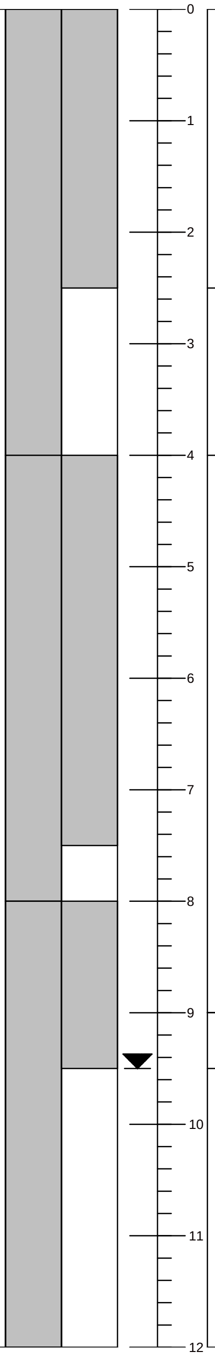
Drill Date: February 5, 2008
Logged By: Brett Beaulieu
Drilled By: Frank Scott/Cascade Drilling, Inc.

Coordinate System: NAD 83(91) NAVD 88
Ground Surface Elevation: 15.11
Latitude/Northing: 420919.501
Longitude/Easting: 1002857.595
Boring Location: North of Westport

Drill Type: direct-push probe
Sample Method: direct push 2"x4' core
Boring Diameter: 2 inches
Boring Depth (ft bgs): 12 feet
Groundwater ATD (ft bgs): 9.5 ft bgs

Client: MTA Group
Project: Marine Trades Area
Task: SJZ-MTA T.6
Address: 638 Marine Drive
Port Angeles, WA

Remarks: Light rain, 40s. Piston sampler used below water table. Ground surface gravel. Cave-in causes camming, driller unable to probe below 12'. Analytical samples planned for FS-13 switched to FS-18.



PID (ppm)	OIL INDICAT.	SAMPLE ID	DRIVEN / RECOVERED	DEPTH FT BGS	USCS SYMBOL	SOIL DESCRIPTION AND OBSERVATIONS
0.0					SW-SM	Dark brown, olive-brown, and blue-grey, moist, well-graded sand with silt and gravel (20%), fine to medium. Cobbles. Organic-rich from 0-1' bgs.
0.0					SW	Brown, moist, well-graded sand, fine to medium. Shell fragments (5%), gravel (5%). No odor 4-6' bgs, light odor 6-9' bgs. Becomes grey at 6' bgs.
5.4						
987						
	NAPL, rainbow sheen	FS-13 9' (soil)			SW-SM	Grey, wet, sand with silt and gravel. Hydrocarbon odors.

Notes:
FT BGS = feet below ground surface
ppm = parts per million
--- Dashed contact line in soil description indicates a gradational contact
USCS = Unified Soil Classification System
▼ = denotes groundwater table

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Boring ID: FS-14

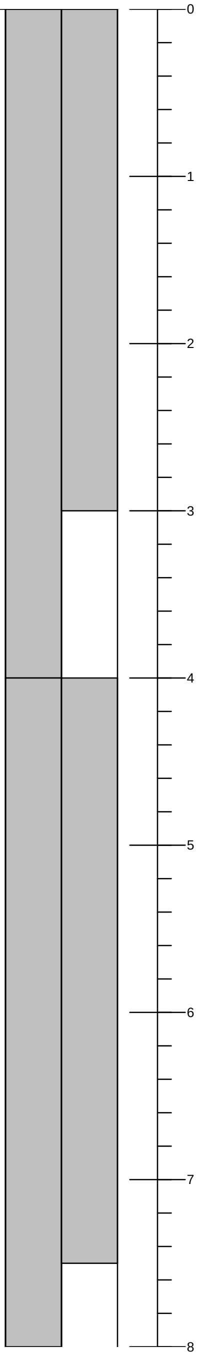
Drill Date: February 6, 2008
Logged By: Brett Beaulieu
Drilled By: Frank Scott/Cascade Drilling, Inc.

Coordinate System: NAD 83(91) NAVD 88
Ground Surface Elevation: 15.09
Latitude/Northing: 420934.052
Longitude/Easting: 1002935.580
Boring Location: North of Platypus shop

Drill Type: direct-push probe
Sample Method: direct push 2"x4' core
Boring Diameter: 2 inches
Boring Depth (ft bgs): 16 feet
Groundwater ATD (ft bgs): 10 ft bgs

Client: MTA Group
Project: Marine Trades Area
Task: SJZ-MTA T.6
Address: 638 Marine Drive
Port Angeles, WA

Remarks: Overcast, 40s. Piston sampler used below water table. Ground surface gravel.
Additional core collected from 9-13' in adjacent boring for in-situ chemical oxidation bench testing.



PID (ppm)	OIL INDICAT.	SAMPLE ID	DRIVEN / RECOVERED	DEPTH FT BGS	USCS SYMBOL	SOIL DESCRIPTION AND OBSERVATIONS
				0	SW-SM	Brown, moist, well-graded sand with silt and gravel, fine to medium.
0.0				1	GM	Blue-grey, moist, silty gravel, fine to coarse, with cobbles.
				2	SW	Grey and brown, moist to wet, well-graded sand with gravel, fine to medium. Cobbles 2-3' bgs., gravel (<5%), shell fragments (<5%). Some red sand grains. Gravelly deposit at 9' bgs. Shell-fragment-rich deposit at 10.75' bgs. Wet at 10'. No odors.
				3		
				4		
0.0				5		
				6		
				7		
				8		

Notes:
FT BGS = feet below ground surface
ppm = parts per million
--- Dashed contact line in soil description indicates a gradational contact
USCS = Unified Soil Classification System
▼ = denotes groundwater table

Boring ID: FS-14

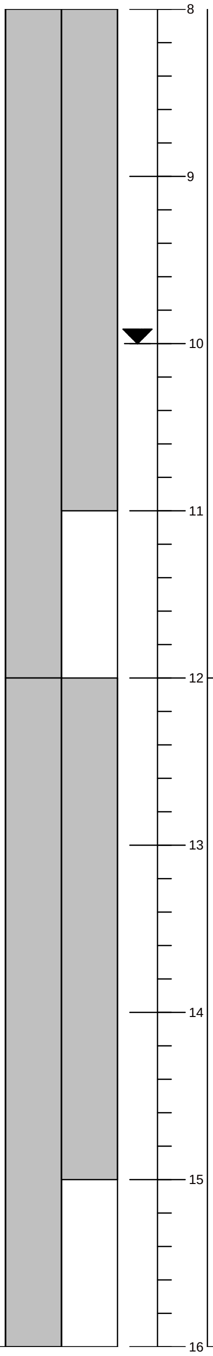
Drill Date: February 6, 2008
Logged By: Brett Beaulieu
Drilled By: Frank Scott/Cascade Drilling, Inc.

Coordinate System: NAD 83(91) NAVD 88
Ground Surface Elevation: 15.09
Latitude/Northing: 420934.052
Longitude/Easting: 1002935.580
Boring Location: North of Platypus shop

Drill Type: direct-push probe
Sample Method: direct push 2"x4' core
Boring Diameter: 2 inches
Boring Depth (ft bgs): 16 feet
Groundwater ATD (ft bgs): 10 ft bgs

Client: MTA Group
Project: Marine Trades Area
Task: SJZ-MTA T.6
Address: 638 Marine Drive
Port Angeles, WA

Remarks: Overcast, 40s. Piston sampler used below water table. Ground surface gravel.
Additional core collected from 9-13' in adjacent boring for in-situ chemical oxidation bench testing.



PID (ppm)	OIL INDICAT.	SAMPLE ID	DRIVEN / RECOVERED	DEPTH FT BGS	USCS SYMBOL	SOIL DESCRIPTION AND OBSERVATIONS
				8		
0.0		FS-14 9-10' (soil)		9		
	No sheen	FS-14 10-11' (soil)		10		
				11		
		FS-14 12-13' (soil)		12	SW-SM	Grey, wet, well-graded sand with silt (10%), fine to medium. Shell fragments (<5%). No odors.
		FS-14 13-15' (soil)		13		
				14		
				15		
				16		

Notes:
FT BGS = feet below ground surface
ppm = parts per million

--- Dashed contact line in soil description indicates a gradational contact
USCS = Unified Soil Classification System
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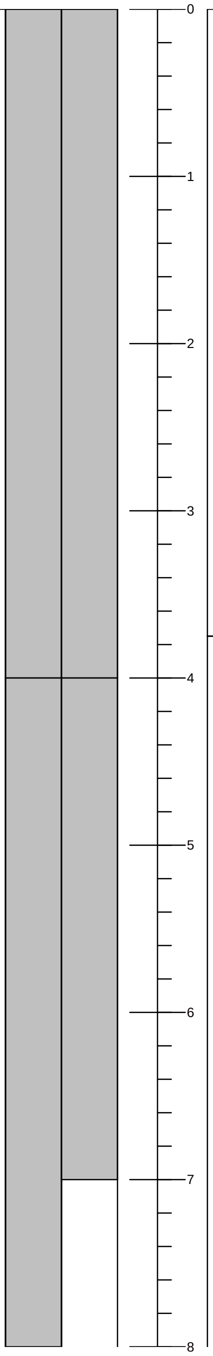
Boring ID: FS-15

Drill Date: February 7, 2008
Logged By: Brett Beaulieu
Drilled By: Frank Scott/Cascade Drilling, Inc.
Drill Type: direct-push probe
Sample Method: direct push 2"x4' core
Boring Diameter: 2 inches
Boring Depth (ft bgs): 16 feet
Groundwater ATD (ft bgs): 9 ft bgs

Client: MTA Group
Project: Marine Trades Area
Task: SJZ-MTA T.6
Address: 638 Marine Drive
Port Angeles, WA

Coordinate System: NAD 83(91) NAVD 88
Ground Surface Elevation: 15.13
Latitude/Northing: 420807.020
Longitude/Easting: 1002548.274
Boring Location: North of Westport

Remarks: Partly cloudy, 30s. Piston sampler used below water table. Ground surface gravel.



PID (ppm)	OIL INDICAT.	SAMPLE ID	DRIVEN / RECOVERED	DEPTH FT BGS	USCS SYMBOL	SOIL DESCRIPTION AND OBSERVATIONS
0.1					SW-SM	Brown, wet to moist, well-graded sand with silt and gravel, fine to medium. Organic-rich deposit at 1' bgs. Wood piece at 3.5' bgs.
0.6					SW	Grey and brown, moist, well-graded sand with gravel, fine to coarse. Gravel (15%). Cobble at 6'. Brown at 8' bgs. No hydrocarbon odors.

Notes:
FT BGS = feet below ground surface
ppm = parts per million
--- Dashed contact line in soil description indicates a gradational contact
USCS = Unified Soil Classification System
▼ = denotes groundwater table

Boring ID: FS-15

Drill Date: February 7, 2008
Logged By: Brett Beaulieu
Drilled By: Frank Scott/Cascade Drilling, Inc.

Coordinate System: NAD 83(91) NAVD 88
Ground Surface Elevation: 15.13
Latitude/Northing: 420807.020
Longitude/Easting: 1002548.274
Boring Location: North of Westport

Drill Type: direct-push probe
Sample Method: direct push 2"x4' core
Boring Diameter: 2 inches
Boring Depth (ft bgs): 16 feet
Groundwater ATD (ft bgs): 9 ft bgs

Client: MTA Group
Project: Marine Trades Area
Task: SJZ-MTA T.6
Address: 638 Marine Drive
Port Angeles, WA

Remarks: Partly cloudy, 30s. Piston sampler used below water table. Ground surface gravel.

PID (ppm)	OIL INDICAT.	SAMPLE ID	DRIVEN	RECOVERED	DEPTH FT BGS	USCS SYMBOL	SOIL DESCRIPTION AND OBSERVATIONS
1.6			▨	▨	8		
1900	Heavy rainbow sheen	FS-15 9-10' (soil)	▨	▨	9 ▼	SW-SM	Grey and black-stained, wet, well-graded sand with silt and gravel, fine to coarse. Wood piece at 11' bgs. Increasingly coarse with depth. Gravel 20-30% 12-13.5' bgs. Hydrocarbon odors.
			▨	▨	10		
			▨		11		
1.9			▨	▨	12		
0.9			▨	▨	13	SM	Black, wet, silty sand with gravel, fine to medium. Light hydrocarbon odors.
			▨	▨	14		
			▨		15		
					16		

Notes:
FT BGS = feet below ground surface
ppm = parts per million
--- Dashed contact line in soil description indicates a gradational contact
USCS = Unified Soil Classification System
▼ = denotes groundwater table

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Boring ID: FS-16

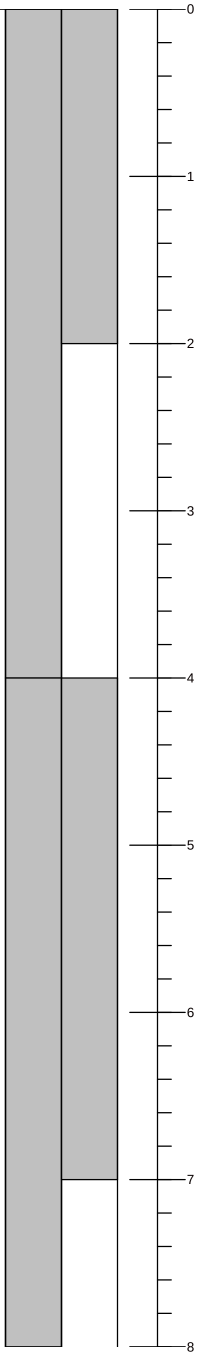
Drill Date: February 4, 2008
Logged By: Brett Beaulieu
Drilled By: Frank Scott/Cascade Drilling, Inc.

Coordinate System: NAD 83(91) NAVD 88
Ground Surface Elevation: 14.94
Latitude/Northing: 420826.309
Longitude/Easting: 1002614.291
Boring Location: North of Westport

Drill Type: direct-push probe
Sample Method: direct push 2"x4' core
Boring Diameter: 2 inches
Boring Depth (ft bgs): 16 feet
Groundwater ATD (ft bgs): 9.5 ft bgs

Client: MTA Group
Project: Marine Trades Area
Task: SJZ-MTA T.6
Address: 638 Marine Drive
Port Angeles, WA

Remarks: Overcast, light rain, 40s. Piston sampler used below water table. Ground surface gravel.



PID (ppm)	OIL INDICAT.	SAMPLE ID	DRIVEN / RECOVERED	DEPTH FT BGS	USCS SYMBOL	SOIL DESCRIPTION AND OBSERVATIONS
40.3	No sheen				SW-SM	Greenish-grey, grey, brown, and dark grey, moist to dry, well-graded sand with silt and gravel, fine to medium. Cobble at 1' bgs. Possible light hydrocarbon odor at 1.5' bgs with reddish-brown discoloration.
40.2					ML	Dark grey, moist, silt, plastic.
7.7	No sheen				SW	Grey, moist, well-graded sand, fine to medium. Gravel (10%). Shell fragments (<5%). Cobble at 6'. Light hydrocarbon odors.

Notes:
FT BGS = feet below ground surface
ppm = parts per million
--- Dashed contact line in soil description indicates a gradational contact
USCS = Unified Soil Classification System
▼ = denotes groundwater table

Boring ID: FS-16

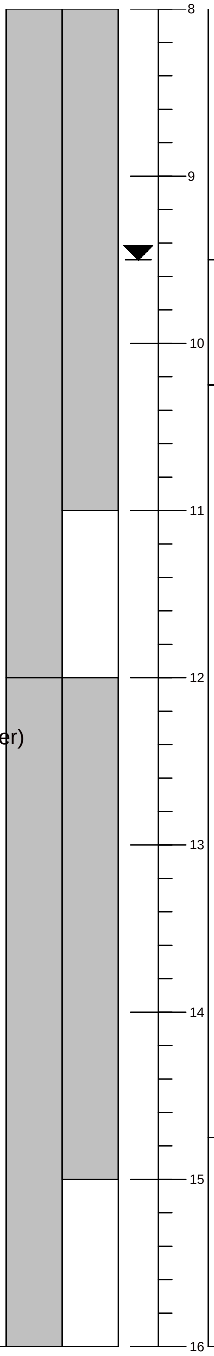
Drill Date: February 4, 2008
Logged By: Brett Beaulieu
Drilled By: Frank Scott/Cascade Drilling, Inc.

Coordinate System: NAD 83(91) NAVD 88
Ground Surface Elevation: 14.94
Latitude/Northing: 420826.309
Longitude/Easting: 1002614.291
Boring Location: North of Westport

Drill Type: direct-push probe
Sample Method: direct push 2"x4' core
Boring Diameter: 2 inches
Boring Depth (ft bgs): 16 feet
Groundwater ATD (ft bgs): 9.5 ft bgs

Client: MTA Group
Project: Marine Trades Area
Task: SJZ-MTA T.6
Address: 638 Marine Drive
Port Angeles, WA

Remarks: Overcast, light rain, 40s. Piston sampler used below water table. Ground surface gravel.



PID (ppm)	OIL INDICAT.	SAMPLE ID	DEPTH FT BGS	USCS SYMBOL	SOIL DESCRIPTION AND OBSERVATIONS
1025	Broken rainbow sheen	FS-16 9.5-10.5' (soil)	8–10	SM	Dark grey, wet, silty sand with gravel, fine to medium. Shell fragments (<5%). Sheen visible. Strong hydrocarbon odors.
1500	Moderate rainbow sheen		10–11	SW	Black to grey, wet, well-graded sand with gravel, fine to medium. Possible staining at 10.25' to 11' bgs. Cobbles at 14' bgs.
			11–12		
632		FS-16 12-16' (groundwater)	12–13		
			13–14		
16.1			14–15	SM	Black, wet, silty sand, fine. Rounded gravels (<15%). No hydrocarbon odors.
			15–16		

Notes:
FT BGS = feet below ground surface
ppm = parts per million
--- Dashed contact line in soil description indicates a gradational contact
USCS = Unified Soil Classification System
▼ = denotes groundwater table

Boring ID: FS-17

Drill Date: February 5, 2008
Logged By: Brett Beaulieu
Drilled By: Frank Scott/Cascade Drilling, Inc.
Drill Type: direct-push probe
Sample Method: direct push 2"x4' core
Boring Diameter: 2 inches
Boring Depth (ft bgs): 20 feet
Groundwater ATD (ft bgs): 9.5 ft bgs

Coordinate System: NAD 83(91) NAVD 88
Ground Surface Elevation: 15.57
Latitude/Northing: 420855.931
Longitude/Easting: 1002756.023
Boring Location: North of Westport

Client: MTA Group
Project: Marine Trades Area
Task: SJZ-MTA T.6
Address: 638 Marine Drive
Port Angeles, WA

Remarks: Overcast, 40s. Piston sampler used below water table. Ground surface gravel.

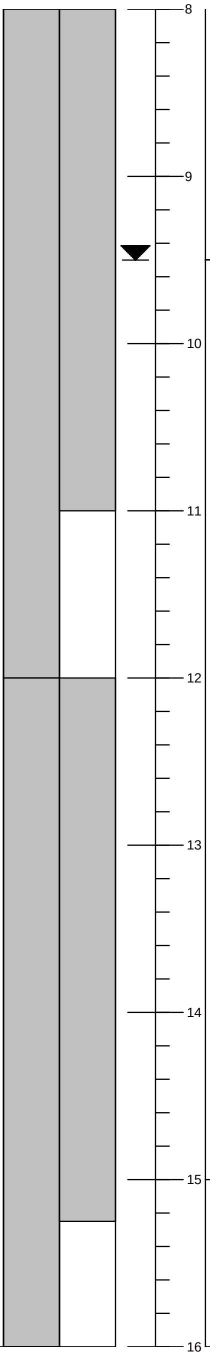
PID (ppm)	OIL INDICAT.	SAMPLE ID	DRIVEN / RECOVERED	DEPTH FT BGS	USCS SYMBOL	SOIL DESCRIPTION AND OBSERVATIONS
32.8				0	SW-SM	Dark brown and grey, moist to dry, well-graded sand with silt and gravel, fine to medium. Cobbles throughout.
>1000	NAPL	FS-17 4-6' (soil)		4	SW	Brownish-grey, moist, well-graded sand, fine to medium. Gravel (10%). Shell fragments (5%). Becomes grey, with less gravel (5%). Shell fragments (20%) layer at 8'.
					SM	Grey, moist, silty sand, fine.
1492				6	SM	Grey, moist, well-graded sand, fine to medium. Gravel (5%). Shell fragments up to 20% in layer at 8' bgs.
				8		

Notes:
FT BGS = feet below ground surface
ppm = parts per million
--- Dashed contact line in soil description indicates a gradational contact
USCS = Unified Soil Classification System
▼ = denotes groundwater table

Boring ID: FS-17

Drill Date: February 5, 2008
Logged By: Brett Beaulieu
Drilled By: Frank Scott/Cascade Drilling, Inc.
Coordinate System: NAD 83(91) NAVD 88
Ground Surface Elevation: 15.57
Latitude/Northing: 420855.931
Longitude/Easting: 1002756.023
Boring Location: North of Westport
Drill Type: direct-push probe
Sample Method: direct push 2"x4' core
Boring Diameter: 2 inches
Boring Depth (ft bgs): 20 feet
Groundwater ATD (ft bgs): 9.5 ft bgs
Client: MTA Group
Project: Marine Trades Area
Task: SJZ-MTA T.6
Address: 638 Marine Drive
Port Angeles, WA

Remarks: Overcast, 40s. Piston sampler used below water table. Ground surface gravel.



PID (ppm)	OIL INDICAT.	SAMPLE ID	DRIVEN / RECOVERED	DEPTH FT BGS	USCS SYMBOL	SOIL DESCRIPTION AND OBSERVATIONS
	NAPL			8		
1350	Moderate rainbow sheen	FS-17 10-11' (soil)		9.5	SW-SM	Grey, wet, sand with silt and gravel, fine to medium. Lenses of varying silt content. Gravel (5%). Shell fragments (5%). Visible sheen, hydrocarbon odors. Hydrocarbon odors light by 13'-15' bgs.
2.5				12		
22				14		
				15	SM	Black, wet, silty sand, fine. Soft. Trace coarse sand and shell fragments. Organic-rich. Sulfurous odor.

Notes:
FT BGS = feet below ground surface
ppm = parts per million
--- Dashed contact line in soil description indicates a gradational contact
USCS = Unified Soil Classification System
▼ = denotes groundwater table

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Boring ID: FS-18

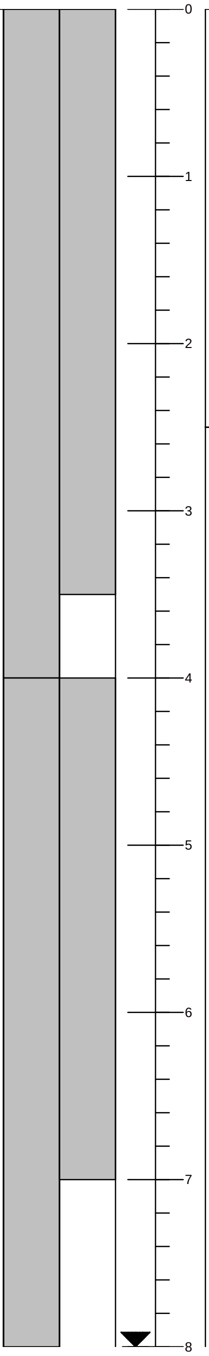
Drill Date: February 7, 2008
Logged By: Brett Beaulieu
Drilled By: Frank Scott/Cascade Drilling, Inc.

Coordinate System: NAD 83(91) NAVD 88
Ground Surface Elevation: 15.43
Latitude/Northing: 420872.174
Longitude/Easting: 1002839.544
Boring Location: North of Westport

Drill Type: direct-push probe
Sample Method: direct push 2"x4' core
Boring Diameter: 2 inches
Boring Depth (ft bgs): 16 feet
Groundwater ATD (ft bgs): 8 ft bgs

Client: MTA Group
Project: Marine Trades Area
Task: SJZ-MTA T.6
Address: 638 Marine Drive
Port Angeles, WA

Remarks: Overcast, light rain, windy, 30s-40s. Piston sampler used below water table. Ground surface gravel.



PID (ppm)	OIL INDICAT.	SAMPLE ID	DRIVEN / RECOVERED	DEPTH FT BGS	USCS SYMBOL	SOIL DESCRIPTION AND OBSERVATIONS
				0	SW-SM	Dark brown and grey, moist, well-graded sand with silt and gravel, fine to medium. Cobbles throughout.
45				1		
				2		
					SW	Grey, moist to wet, well-graded sand, fine to medium. Gravel (10%). Shell fragments (5%). Wetter than other nearby boring locations by 7-8' bgs. Hydrocarbon odors.
				3		
	No sheen	FS-18 4-6' (soil)		4		
58				5		
203	Light broken sheen			6		
				7		
				8		

Notes:
FT BGS = feet below ground surface
ppm = parts per million
--- Dashed contact line in soil description indicates a gradational contact
USCS = Unified Soil Classification System
▼ = denotes groundwater table

Boring ID: FS-18

Drill Date: February 7, 2008
Logged By: Brett Beaulieu
Drilled By: Frank Scott/Cascade Drilling, Inc.

Coordinate System: NAD 83(91) NAVD 88
Ground Surface Elevation: 15.43
Latitude/Northing: 420872.174
Longitude/Easting: 1002839.544
Boring Location: North of Westport

Drill Type: direct-push probe
Sample Method: direct push 2"x4' core
Boring Diameter: 2 inches
Boring Depth (ft bgs): 16 feet
Groundwater ATD (ft bgs): 8 ft bgs

Client: MTA Group
Project: Marine Trades Area
Task: SJZ-MTA T.6
Address: 638 Marine Drive
Port Angeles, WA

Remarks: Overcast, light rain, windy, 30s-40s. Piston sampler used below water table. Ground surface gravel.

PID (ppm)	OIL INDICAT.	SAMPLE ID	DRIVEN / RECOVERED	DEPTH FT BGS	USCS SYMBOL	SOIL DESCRIPTION AND OBSERVATIONS
1742				8		
				9	SW-SM	Grey, wet, well-graded sand with silt and gravel, fine to medium. Shell fragments. Hydrocarbon odors.
1387	Heavy rainbow sheen	FS-18 10-11' (soil)		10	SM	Grey, wet, silty sand, fine. Visible rainbow sheen. Hydrocarbon odors.
					SW-SM	Grey, wet, well-graded sand with silt and gravel, fine to medium. Shell fragments. Hydrocarbon odors.
				11		
52.6				12		
				13		
11.6				14	ML	Grey, wet, silt with sand, fine. Plastic.
				15	SW-SM	Grey, wet, well-graded sand with silt and gravel, fine to medium. Shell fragments. Hydrocarbon odors.
					SM	Black, wet, silty sand, fine. Trace shell fragments. Organic-rich.
				16		

Notes:
FT BGS = feet below ground surface
ppm = parts per million
--- Dashed contact line in soil description indicates a gradational contact
USCS = Unified Soil Classification System
▼ = denotes groundwater table

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Boring ID: FS-19

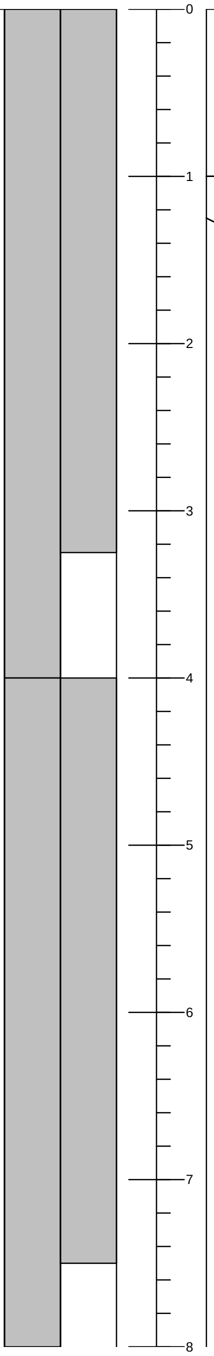
Drill Date: February 6, 2008
Logged By: Brett Beaulieu
Drilled By: Frank Scott/Cascade Drilling, Inc.
Drill Type: direct-push probe
Sample Method: direct push 2"x4' core
Boring Diameter: 2 inches
Boring Depth (ft bgs): 16 feet
Groundwater ATD (ft bgs): 9.5 ft bgs

Coordinate System: NAD 83(91) NAVD 88
Ground Surface Elevation: 15.10
Latitude/Northing: 420896.517
Longitude/Easting: 1002894.686
Boring Location: North of Platypus shop

Client: MTA Group
Project: Marine Trades Area
Task: SJZ-MTA T.6
Address: 638 Marine Drive
Port Angeles, WA

Remarks: Overcast, 40s. Piston sampler used below water table. Ground surface gravel.

PID (ppm)	OIL INDICAT.	SAMPLE ID	DRIVEN / RECOVERED	DEPTH FT BGS	USCS SYMBOL	SOIL DESCRIPTION AND OBSERVATIONS
					GW	Grey, dry, well-graded gravel with sand, fine to coarse. Cobbles.
					SW-SM	Dark brown, moist, sand with silt, fine to coarse.
0.0					SW	Brown, moist, well-graded sand with gravel (10-15%), fine to medium. Shell fragments (5%). No hydrocarbon odors.
0.0						
0.0						



Notes:
FT BGS = feet below ground surface
ppm = parts per million
--- Dashed contact line in soil description indicates a gradational contact
USCS = Unified Soil Classification System
▼ = denotes groundwater table

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Boring ID: FS-19

Drill Date: February 6, 2008
Logged By: Brett Beaulieu
Drilled By: Frank Scott/Cascade Drilling, Inc.

Coordinate System: NAD 83(91) NAVD 88
Ground Surface Elevation: 15.10
Latitude/Northing: 420896.517
Longitude/Easting: 1002894.686
Boring Location: North of Platypus shop

Drill Type: direct-push probe
Sample Method: direct push 2"x4' core
Boring Diameter: 2 inches
Boring Depth (ft bgs): 16 feet
Groundwater ATD (ft bgs): 9.5 ft bgs

Client: MTA Group
Project: Marine Trades Area
Task: SJZ-MTA T.6
Address: 638 Marine Drive
Port Angeles, WA

Remarks: Overcast, 40s. Piston sampler used below water table. Ground surface gravel.

PID (ppm)	OIL INDICAT.	SAMPLE ID	DRIVEN / RECOVERED	DEPTH FT BGS	USCS SYMBOL	SOIL DESCRIPTION AND OBSERVATIONS
0.4	No sheen			8 9		
0.4		FS-19 9-10' (soil)		10 11	SW-SM/SM	Interbedded grey, wet, well-graded sand with silt and gravel, fine to medium, gravel (<10%), shell fragments (5%) and grey, wet, silty sand, fine. No hydrocarbon odors.
2.7				12	SW	Grey, wet, well-graded sand with gravel, fine to medium. Shell fragments. No hydrocarbon odors.
				13 14	SW-SM/SM	Interbedded grey, wet, well-graded sand with silt and gravel, fine to medium, shell fragments and grey, wet, silty sand, fine. No hydrocarbon odors.
					ML	Dark grey, wet, silt. Laminated, plastic.
				15 16	SW-SM	Black, wet, sand with silt and gravel, fine to medium. Organic-rich.

Notes:
FT BGS = feet below ground surface
ppm = parts per million

--- Dashed contact line in soil description indicates a gradational contact
USCS = Unified Soil Classification System
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Boring ID: FS-20

Drill Date: February 4, 2008
Logged By: Brett Beaulieu
Drilled By: Frank Scott/Cascade Drilling, Inc.

Coordinate System: NAD 83(91) NAVD 88
Ground Surface Elevation: 15.61
Latitude/Northing: 420795.243
Longitude/Easting: 1002658.066
Boring Location: North of Westport

Drill Type: direct-push probe
Sample Method: direct push 2"x4' core
Boring Diameter: 2 inches
Boring Depth (ft bgs): 16 feet
Groundwater ATD (ft bgs): 10 ft bgs

Client: MTA Group
Project: Marine Trades Area
Task: SJZ-MTA T.6
Address: 638 Marine Drive
Port Angeles, WA

Remarks: Overcast, 40s. Piston sampler used below water table. Ground surface gravel.

PID (ppm)	OIL INDICAT.	SAMPLE ID	DRIVEN /	RECOVERED	DEPTH FT BGS	USCS SYMBOL	SOIL DESCRIPTION AND OBSERVATIONS
1.1			▨	▨	0 1 2 3	SW-SM	Grey-green, grey, and brown, dry to moist, well-graded sand with silt and gravel, fine to coarse. Cobbles at 2' bgs. Organic-rich deposit at 3' bgs.
0.0			▨	▨	4 5 6	SW	Grey, dry to moist, well-graded sand, fine to medium. Shell fragments. Gravel (<5%). Dark grey silt lamination at 6' bgs.
			▨		7 8		

Notes:
FT BGS = feet below ground surface
ppm = parts per million

--- Dashed contact line in soil description indicates a gradational contact
USCS = Unified Soil Classification System
▼ = denotes groundwater table

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Boring ID: FS-20

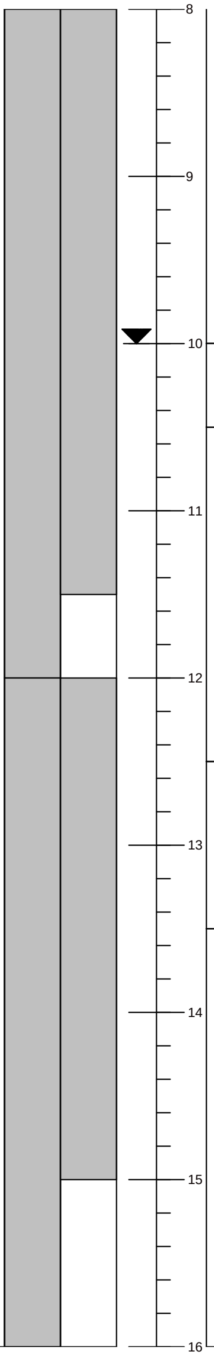
Drill Date: February 4, 2008
Logged By: Brett Beaulieu
Drilled By: Frank Scott/Cascade Drilling, Inc.

Coordinate System: NAD 83(91) NAVD 88
Ground Surface Elevation: 15.61
Latitude/Northing: 420795.243
Longitude/Easting: 1002658.066
Boring Location: North of Westport

Drill Type: direct-push probe
Sample Method: direct push 2"x4' core
Boring Diameter: 2 inches
Boring Depth (ft bgs): 16 feet
Groundwater ATD (ft bgs): 10 ft bgs

Client: MTA Group
Project: Marine Trades Area
Task: SJZ-MTA T.6
Address: 638 Marine Drive
Port Angeles, WA

Remarks: Overcast, 40s. Piston sampler used below water table. Ground surface gravel.



PID (ppm)	OIL INDICAT.	SAMPLE ID	DRIVEN / RECOVERED	DEPTH FT BGS	USCS SYMBOL	SOIL DESCRIPTION AND OBSERVATIONS
				8		
0.0				9		
	No sheen	FS-20 10-12' (soil)		10	GW	Grey, wet, well-graded gravel, fine to medium, with sand. Shell fragments.
3.4					SW	Grey, wet, well-graded sand, fine to medium. Gravel (<5%). Light hydrocarbon odors.
				11		
		FS-20 12-13' (soil)		12		
					SM	Dark grey, wet, silty sand, fine. Light hydrocarbon odors.
				13		
15.2					SW	Dark grey, well-graded sand, fine to coarse. Shell fragments. Light hydrocarbon odors.
				14		
				15		
				16		

Notes:
FT BGS = feet below ground surface
ppm = parts per million

--- Dashed contact line in soil description indicates a gradational contact
USCS = Unified Soil Classification System
▼ = denotes groundwater table

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Boring ID: FS-21

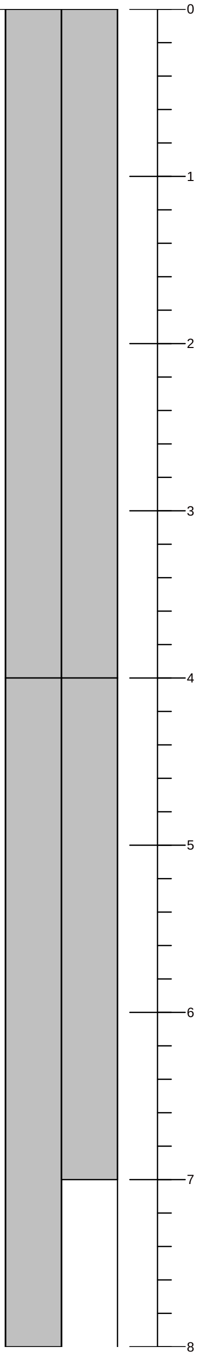
Drill Date: February 5, 2008
Logged By: Brett Beaulieu
Drilled By: Frank Scott/Cascade Drilling, Inc.
Drill Type: direct-push probe
Sample Method: direct push 2"x4' core
Boring Diameter: 2 inches
Boring Depth (ft bgs): 16 feet
Groundwater ATD (ft bgs): 10 ft bgs

Coordinate System: NAD 83(91) NAVD 88
Ground Surface Elevation: 15.74
Latitude/Northing: 420812.923
Longitude/Easting: 1002728.711
Boring Location: North of Westport

Client: MTA Group
Project: Marine Trades Area
Task: SJZ-MTA T.6
Address: 638 Marine Drive
Port Angeles, WA

Remarks: Light rain, 40s. Piston sampler used below water table. Ground surface gravel.

PID (ppm)	OIL INDICAT.	SAMPLE ID	DRIVEN / RECOVERED	DEPTH FT BGS	USCS SYMBOL	SOIL DESCRIPTION AND OBSERVATIONS
2.2					SW-SM	Grey and dark brown, moist to dry, well-graded sand with silt and gravel, fine to medium. Cobbles throughout. Woody debris at 1' bgs. Brick piece, woody debris, and woven apparent geotextile cloth piece at 3' bgs.
26					SW	Olive-grey and grey, moist, well-graded sand, fine to medium. Gravel increasing with depth up to 10%. Shell fragments. Cobble at 6'. No hydrocarbon odors to 7' bgs; hydrocarbon odors at 8' bgs increasing with depth.



Notes:
FT BGS = feet below ground surface
ppm = parts per million
--- Dashed contact line in soil description indicates a gradational contact
USCS = Unified Soil Classification System
▼ = denotes groundwater table

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Boring ID: FS-21

Drill Date: February 5, 2008
Logged By: Brett Beaulieu
Drilled By: Frank Scott/Cascade Drilling, Inc.

Coordinate System: NAD 83(91) NAVD 88
Ground Surface Elevation: 15.74
Latitude/Northing: 420812.923
Longitude/Easting: 1002728.711
Boring Location: North of Westport

Drill Type: direct-push probe
Sample Method: direct push 2"x4' core
Boring Diameter: 2 inches
Boring Depth (ft bgs): 16 feet
Groundwater ATD (ft bgs): 10 ft bgs

Client: MTA Group
Project: Marine Trades Area
Task: SJZ-MTA T.6
Address: 638 Marine Drive
Port Angeles, WA

Remarks: Light rain, 40s. Piston sampler used below water table. Ground surface gravel.

PID (ppm)	OIL INDICAT.	SAMPLE ID	DRIVEN / RECOVERED	DEPTH FT BGS	USCS SYMBOL	SOIL DESCRIPTION AND OBSERVATIONS
785				8		
				9		
	Moderate broken sheen	FS-21 9-10' (soil)		▼ 10	SW-SM	Dark grey, wet, well-graded sand with silt and gravel. Hydrocarbon odors.
				11		
				12		
		FS-21 13-14' (soil)		13	ML	Dark grey, wet, silt. Plastic. Laminated.
					SW-SM	Dark grey, wet, well-graded sand with silt and gravel. Hydrocarbon odors.
					ML	Dark grey, wet, silt. Plastic. Laminated. Contains roots and fine woody debris.
				14	SW-SM	Black, wet, well-graded sand with silt and gravel. Shell fragments. Organic-rich.
				15		
				16		

Notes:
FT BGS = feet below ground surface
ppm = parts per million
--- Dashed contact line in soil description indicates a gradational contact
USCS = Unified Soil Classification System
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Boring ID: FS-22

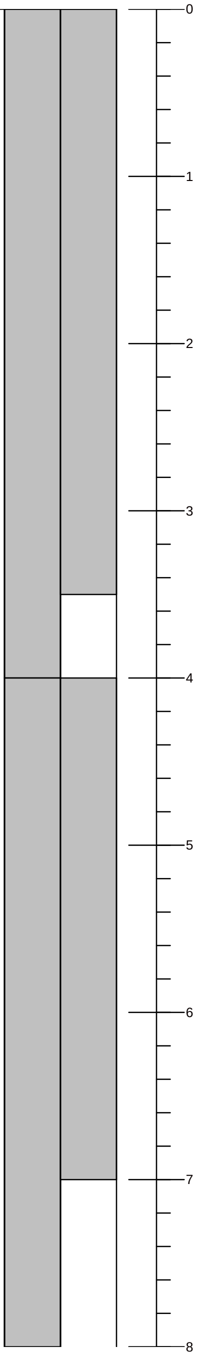
Drill Date: February 7, 2008
Logged By: Brett Beaulieu
Drilled By: Frank Scott/Cascade Drilling, Inc.

Coordinate System: NAD 83(91) NAVD 88
Ground Surface Elevation: 15.64
Latitude/Northing: 420833.630
Longitude/Easting: 1002818.598
Boring Location: North of Westport

Drill Type: direct-push probe
Sample Method: direct push 2"x4' core
Boring Diameter: 2 inches
Boring Depth (ft bgs): 16 feet
Groundwater ATD (ft bgs): 11 ft bgs

Client: MTA Group
Project: Marine Trades Area
Task: SJZ-MTA T.6
Address: 638 Marine Drive
Port Angeles, WA

Remarks: Windy, partly cloudy, 40s. Piston sampler used below water table. Ground surface gravel.



PID (ppm)	OIL INDICAT.	SAMPLE ID	DRIVEN / RECOVERED	DEPTH FT BGS	USCS SYMBOL	SOIL DESCRIPTION AND OBSERVATIONS
1.6					SW-SM	Grey and dark brown, moist to dry, well-graded sand with silt and gravel, fine to medium. Cobbles throughout. Organic-rich at 2' bgs with brick piece.
					SW	Brown, moist, well-graded sand, fine to coarse. Gravel (20%). Shell fragments (5-10%). No hydrocarbon odors to 4.9' bgs. 4.9' bgs to 5' bgs have grey color, sludgy texture, light hydrocarbon odors.
51					ML	Dark olive-grey, moist, silt with sand, fine. Plastic.
					SW	Grey, moist to wet, well-graded sand, fine to medium. Shell fragments (5-10%). Wet 8-9' bgs, with possible staining, light hydrocarbon odors.

Notes:
FT BGS = feet below ground surface
ppm = parts per million
--- Dashed contact line in soil description indicates a gradational contact
USCS = Unified Soil Classification System
▼ = denotes groundwater table

Boring ID: FS-22

Drill Date: February 7, 2008
Logged By: Brett Beaulieu
Drilled By: Frank Scott/Cascade Drilling, Inc.
Drill Type: direct-push probe
Sample Method: direct push 2"x4' core
Boring Diameter: 2 inches
Boring Depth (ft bgs): 16 feet
Groundwater ATD (ft bgs): 11 ft bgs

Client: MTA Group
Project: Marine Trades Area
Task: SJZ-MTA T.6
Address: 638 Marine Drive
Port Angeles, WA

Coordinate System: NAD 83(91) NAVD 88
Ground Surface Elevation: 15.64
Latitude/Northing: 420833.630
Longitude/Easting: 1002818.598
Boring Location: North of Westport

Remarks: Windy, partly cloudy, 40s. Piston sampler used below water table. Ground surface gravel.

PID (ppm)	OIL INDICAT.	SAMPLE ID	DRIVEN / RECOVERED	DEPTH FT BGS	USCS SYMBOL	SOIL DESCRIPTION AND OBSERVATIONS
129	Light sheen	FS-22 8-9' (soil)		8		
				9	SW	Grey, moist to wet, well-graded sand with gravel, fine to medium. Shell fragments (5-10%). Dense; water above appears to be perched on this gravelly deposit.
					SW	Grey, moist to wet, well-graded sand with gravel, fine to medium. Gravel (5-10%), shell fragments (5-10%). Cobble at 10.5' bgs. Light hydrocarbon odors.
1658	Moderate rainbow sheen	FS-22 10-11' (soil)		10		
				11 ▼		
1.7		FS-22 10-14' (groundwater)		12	SW-SM	Grey, moist to wet, well-graded sand with silt and gravel, fine to medium. Gravel (10-20%), shell fragments (10-20%). Light hydrocarbon odors.
				13	ML	Dark grey, wet, silt. Plastic. Laminated. Contains roots and fine woody debris.
5.1				14	SW-SM	Grey, moist to wet, well-graded sand with silt and gravel, fine to medium. Gravel (10-20%), shell fragments (10-20%). Light hydrocarbon odors.
	No sheen			15	ML	Dark grey, wet, silt. Plastic. Laminated. Contains roots and fine woody debris.
					SM	Black, wet, silty sand. Organic-rich.
				16		

Notes:
FT BGS = feet below ground surface
ppm = parts per million
--- Dashed contact line in soil description indicates a gradational contact
USCS = Unified Soil Classification System
▼ = denotes groundwater table

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Boring ID: FS-23

Drill Date: February 7, 2008
Logged By: Brett Beaulieu
Drilled By: Frank Scott/Cascade Drilling, Inc.
Drill Type: direct-push probe
Sample Method: direct push 2"x4' core
Boring Diameter: 2 inches
Boring Depth (ft bgs): 2 ft bgs
Groundwater ATD (ft bgs):

Coordinate System: NAD 83(91) NAVD 88
Ground Surface Elevation:
Latitude/Northing:
Longitude/Easting:
Boring Location: West of Platypus shop

Client: MTA Group
Project: Marine Trades Area
Task: SJZ-MTA T.6
Address: 638 Marine Drive
Port Angeles, WA

Remarks: Overcast, 40s. round surface gravel. Boring abandoned after three refusals at 2'. Apparent concrete structure.

PID (ppm)	OIL INDICAT.	SAMPLE ID	DRIVEN / RECOVERED	DEPTH FT BGS	USCS SYMBOL	SOIL DESCRIPTION AND OBSERVATIONS
			▨ (0–2)	0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16		No soil described. Boring abandoned after three refusals at 2' bgs.

Notes:
FT BGS = feet below ground surface
ppm = parts per million

--- Dashed contact line in soil description indicates a gradational contact
USCS = Unified Soil Classification System
▼ = denotes groundwater table

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Boring ID: FS-24

Drill Date: February 4, 2008
Logged By: Brett Beaulieu
Drilled By: Frank Scott/Cascade Drilling, Inc.

Coordinate System: NAD 83(91) NAVD 88
Ground Surface Elevation: 15.76
Latitude/Northing: 420756.656
Longitude/Easting: 1002629.417
Boring Location: North of Westport

Drill Type: direct-push probe
Sample Method: direct push 2"x4' core
Boring Diameter: 2 inches
Boring Depth (ft bgs): 16 feet
Groundwater ATD (ft bgs): 10 ft bgs

Client: MTA Group
Project: Marine Trades Area
Task: SJZ-MTA T.6
Address: 638 Marine Drive
Port Angeles, WA

Remarks: Overcast, 40s. Piston sampler used below water table. Ground surface gravel.

PID (ppm)	OIL INDICAT.	SAMPLE ID	DRIVEN / RECOVERED	DEPTH FT BGS	USCS SYMBOL	SOIL DESCRIPTION AND OBSERVATIONS
				0		
				1	SW-SM	Light brown, grey, and green, dry to moist, well-graded sand with silt and gravel, fine to coarse. Gravel (10-25%). Cobbles. Concretion, semi-plastic, at 1.25' bgs, slight odor?
10.4				2		
				3		
				4		
0.2		FS-24 5-7' (soil)		5		
					SM	Brown to grey, moist, silty sand, fine. Shell fragments in sandier portions. Woody debris at 6.5'. Possible light hydrocarbon odor.
				6		
0.4				7	ML	Grey, moist, silt. Plastic. Fine woody debris.
					SW	Grey, moist to wet, well-graded sand with gravel, fine to medium. Shell fragments. Wet at 10' bgs. Light hydrocarbon odor below 10' bgs.
				8		

Notes:
FT BGS = feet below ground surface
ppm = parts per million

--- Dashed contact line in soil description indicates a gradational contact
USCS = Unified Soil Classification System
▼ = denotes groundwater table

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Boring ID: FS-24

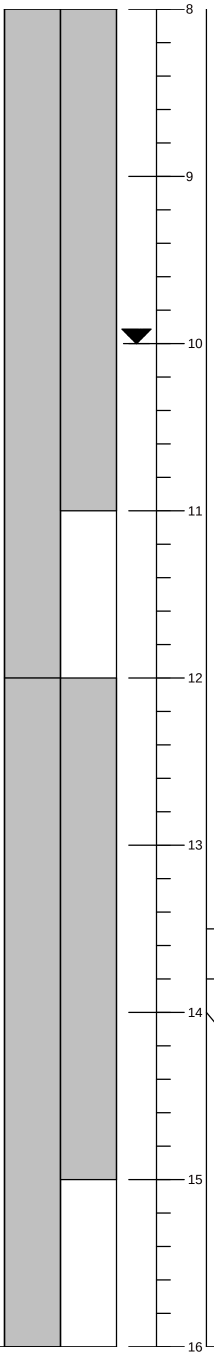
Drill Date: February 4, 2008
Logged By: Brett Beaulieu
Drilled By: Frank Scott/Cascade Drilling, Inc.
Drill Type: direct-push probe
Sample Method: direct push 2"x4' core
Boring Diameter: 2 inches
Boring Depth (ft bgs): 16 feet
Groundwater ATD (ft bgs): 10 ft bgs

Coordinate System: NAD 83(91) NAVD 88
Ground Surface Elevation: 15.76
Latitude/Northing: 420756.656
Longitude/Easting: 1002629.417
Boring Location: North of Westport

Client: MTA Group
Project: Marine Trades Area
Task: SJZ-MTA T.6
Address: 638 Marine Drive
Port Angeles, WA

Remarks: Overcast, 40s. Piston sampler used below water table. Ground surface gravel.

PID (ppm)	OIL INDICAT.	SAMPLE ID	DRIVEN / RECOVERED	DEPTH FT BGS	USCS SYMBOL	SOIL DESCRIPTION AND OBSERVATIONS
15.0	No sheen	FS-24 8-11' (soil)				
14.6		FS-24 12-15' (soil)			ML	Grey, wet, silt. Plastic. Light hydrocarbon odors.
					GW	Grey, wet, well-graded gravel, medium. Rounded grains.
					SW	Grey, wet, well-graded sand with gravel, fine to medium. Shell fragments.



Notes:
FT BGS = feet below ground surface
ppm = parts per million
--- Dashed contact line in soil description indicates a gradational contact
USCS = Unified Soil Classification System
▼ = denotes groundwater table

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Boring ID: FS-25

Drill Date: February 4, 2008
Logged By: Brett Beaulieu
Drilled By: Frank Scott/Cascade Drilling, Inc.

Coordinate System: NAD 83(91) NAVD 88
Ground Surface Elevation: 15.80
Latitude/Northing: 420765.228
Longitude/Easting: 1002703.484
Boring Location: North of Westport

Drill Type: direct-push probe
Sample Method: direct push 2"x4' core
Boring Diameter: 2 inches
Boring Depth (ft bgs): 16 feet
Groundwater ATD (ft bgs): 9 ft bgs

Client: MTA Group
Project: Marine Trades Area
Task: SJZ-MTA T.6
Address: 638 Marine Drive
Port Angeles, WA

Remarks: Overcast, 40s. Piston sampler used below water table. Ground surface gravel.

PID (ppm)	OIL INDICAT.	SAMPLE ID	DRIVEN / RECOVERED	DEPTH FT BGS	USCS SYMBOL	SOIL DESCRIPTION AND OBSERVATIONS
			▨ ▨	0		
				1	SW-SM	Brownish-green, brown, and dark brown, moist to dry, well-graded sand with silt and gravel, fine to medium. Organic-rich deposit with woody debris at 1' bgs. Cobbles at 1.5' bgs.
0.3				2		
				3		
			▨ ▨	4		
				5	SW	Brown and grey, moist, well-graded sand, fine to medium. Shell fragments (<5%). Color changes to grey at 9' bgs. Light hydrocarbon odors 8-10.5' bgs.
0.0				6		
				7		
				8		

Notes:
FT BGS = feet below ground surface
ppm = parts per million
--- Dashed contact line in soil description indicates a gradational contact
USCS = Unified Soil Classification System
▼ = denotes groundwater table

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Boring ID: FS-25

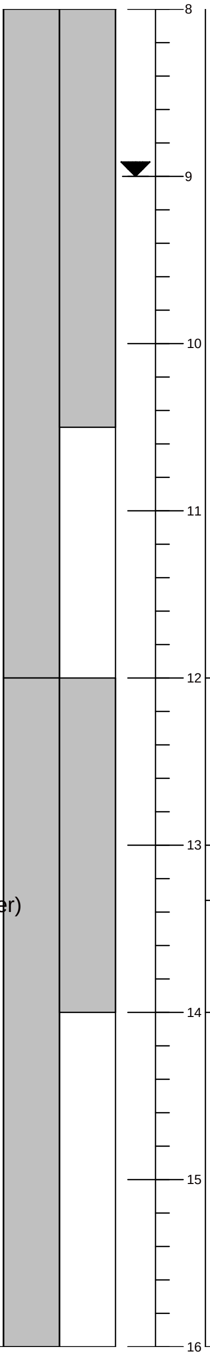
Drill Date: February 4, 2008
Logged By: Brett Beaulieu
Drilled By: Frank Scott/Cascade Drilling, Inc.

Coordinate System: NAD 83(91) NAVD 88
Ground Surface Elevation: 15.80
Latitude/Northing: 420765.228
Longitude/Easting: 1002703.484
Boring Location: North of Westport

Drill Type: direct-push probe
Sample Method: direct push 2"x4' core
Boring Diameter: 2 inches
Boring Depth (ft bgs): 16 feet
Groundwater ATD (ft bgs): 9 ft bgs

Client: MTA Group
Project: Marine Trades Area
Task: SJZ-MTA T.6
Address: 638 Marine Drive
Port Angeles, WA

Remarks: Overcast, 40s. Piston sampler used below water table. Ground surface gravel.



PID (ppm)	OIL INDICAT.	SAMPLE ID	DRIVEN / RECOVERED	DEPTH FT BGS	USCS SYMBOL	SOIL DESCRIPTION AND OBSERVATIONS
0.0	No sheen					Same as above.
111						
36		FS-25 12-14' (soil)			SW-SM	Grey, wet, well-graded sand with silt and gravel, fine to medium. Cobbles. Visible rainbow sheen. Light hydrocarbon odors.
		FS-25 12-16' (groundwater)			ML	Grey, wet, silt. Plastic. Visible rainbow sheen. Light hydrocarbon odors.
					SW-SM	Grey, wet, well-graded sand with silt and gravel, fine to medium. Cobbles. Visible rainbow sheen. Light hydrocarbon odors.

Notes:
FT BGS = feet below ground surface
ppm = parts per million

--- Dashed contact line in soil description indicates a gradational contact
USCS = Unified Soil Classification System
▼ = denotes groundwater table

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Boring ID: FS-26

Drill Date: February 7, 2008
Logged By: Brett Beaulieu
Drilled By: Frank Scott/Cascade Drilling, Inc.
Drill Type: direct-push probe
Sample Method: direct push 2"x4' core
Boring Diameter: 2 inches
Boring Depth (ft bgs): 16 feet
Groundwater ATD (ft bgs): 10 ft bgs

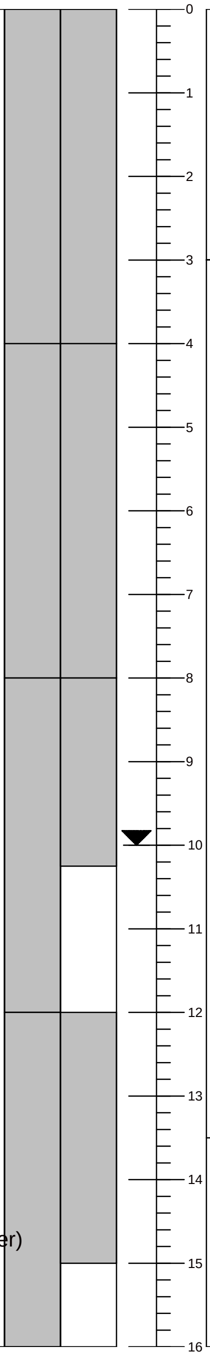
Coordinate System: NAD 83(91) NAVD 88
Ground Surface Elevation: 15.96
Latitude/Northing: 420791.015
Longitude/Easting: 1002773.330
Boring Location: North of Westport

Client: MTA Group
Project: Marine Trades Area
Task: SJZ-MTA T.6
Address: 638 Marine Drive
Port Angeles, WA

Remarks: Sunny, high winds, 30s. Piston sampler used below water table. Ground surface gravel.

PID (ppm)	OIL INDICAT.	SAMPLE ID
7.2		
1.5		
2.1		
9.1		
4.9	No sheen	FS-26 9-10' (soil)
21.4		
34.5		FS-26 12-16' (groundwater)

DRIVEN / RECOVERED | DEPTH FT BGS



USCS SYMBOL	SOIL DESCRIPTION AND OBSERVATIONS
SW-SM	Olive-grey, grey, dark brown, and brown, moist, well-graded sand with silt and gravel, fine to coarse. Organic-rich deposit at 1.5' bgs. Cobble at 1.5' bgs.
SW	Grey, moist to wet, well-graded sand with gravel, fine to medium. Gravel decreases from 10-15% at 3-4' bgs to <5% gravel below 4' bgs.. Shell fragments increase from <5% at 3-4' bgs to 5-10% below 4 ft bgs. Cobbles 3-4' bgs. Wet below 10' bgs. No hydrocarbon odors.
ML/SW	Olive-green, wet, silt lenses (1-2" each) interbedded with grey, wet, well-graded sand, fine to medium (4-6" each). No hydrocarbon odors.

Notes:
FT BGS = feet below ground surface
ppm = parts per million
--- Dashed contact line in soil description indicates a gradational contact
USCS = Unified Soil Classification System
▼ = denotes groundwater table

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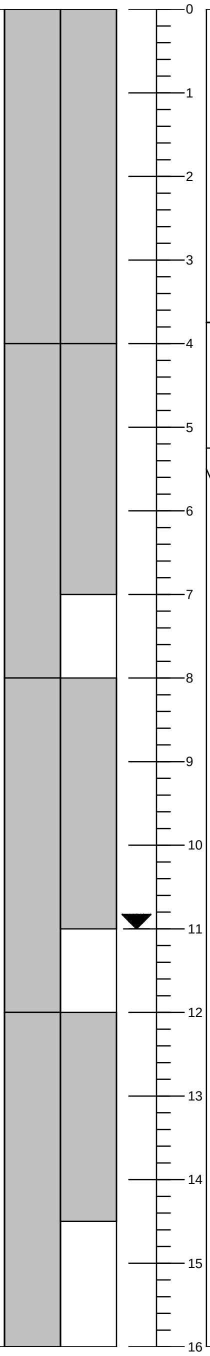
Boring ID: FS-27

Drill Date: February 7, 2008
Logged By: Brett Beaulieu
Drilled By: Frank Scott/Cascade Drilling, Inc.
Drill Type: direct-push probe
Sample Method: direct push 2"x4' core
Boring Diameter: 2 inches
Boring Depth (ft bgs): 16 feet
Groundwater ATD (ft bgs): 11 ft bgs

Coordinate System: NAD 83(91) NAVD 88
Ground Surface Elevation: 15.89
Latitude/Northing: 420775.600
Longitude/Easting: 1002816.818
Boring Location: North of Westport

Client: MTA Group
Project: Marine Trades Area
Task: SJZ-MTA T.6
Address: 638 Marine Drive
Port Angeles, WA

Remarks: Light rain, high winds, 30s. Piston sampler used below water table. Ground surface gravel.



PID (ppm)	OIL INDICAT.	SAMPLE ID	USCS SYMBOL	SOIL DESCRIPTION AND OBSERVATIONS
23.8			SW-SM	Brown and grey, moist to dry, well-graded sand with silt and gravel, fine to coarse. Gravel (25%). Cobbles at 1.5' bgs. Organic-rich deposit at 2' bgs and 3.5' bgs.
0.0			SW	Brown and grey, moist, well-graded sand with gravel, fine to medium. Gravel (10-15%). No hydrocarbon odors.
			ML	Dark grey, moist, silt. Plastic.
2.1			SW	Grey, moist to wet, well-graded sand, fine to medium. Gravel (5%). Shell fragments (5%). Sulfur odor noted 6-7' bgs. Wet at 11' bgs. Increased silt and gravel content 12-14.5' bgs.
0.9				
1.1	No sheen.			
0.1				
		FS-27 13-14' (soil)		
0.0				

Notes:
FT BGS = feet below ground surface
ppm = parts per million
--- Dashed contact line in soil description indicates a gradational contact
USCS = Unified Soil Classification System
▼ = denotes groundwater table

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Boring ID: FS-28

Drill Date: February 7, 2008
Logged By: Brett Beaulieu
Drilled By: Frank Scott/Cascade Drilling, Inc.

Coordinate System: NAD 83(91) NAVD 88
Ground Surface Elevation: 14.83
Latitude/Northing: 420853.600
Longitude/Easting: 1002603.069
Boring Location: North of Westport

Drill Type: direct-push probe
Sample Method: direct push 2"x4' core
Boring Diameter: 2 inches
Boring Depth (ft bgs): 16 feet
Groundwater ATD (ft bgs): 10 ft bgs

Client: MTA Group
Project: Marine Trades Area
Task: SJZ-MTA T.6
Address: 638 Marine Drive
Port Angeles, WA

Remarks: Light rain, windy, 30s. Piston sampler used below water table. Ground surface asphalt, located west in road near Tumwater Creek bridge.

PID (ppm)	OIL INDICAT.	SAMPLE ID	DRIVEN / RECOVERED	DEPTH FT BGS	USCS SYMBOL	SOIL DESCRIPTION AND OBSERVATIONS
71.1	No sheen		▨ / ▨	0	SW-SM	Brown and grey, dry to moist, well-graded sand with silt and gravel, fine to medium. Gravel (25%).
			▨ / ▨	1		
			▨ / ▨	2		
			▨ / ▨	3		
			▨ / ▨		SW	Grey, moist, well-graded sand with gravel, fine. Wet at 5' bgs. Light hydrocarbon odors.
27.2			▨ / ▨	4		
230			▨ / ▨	5		
			▨ / ▨		ML	Dark olive-grey, moist, silt. Plastic.
			▨ / ▨	6	SW	Grey, moist, well-graded sand with gravel, fine to medium. Gravel (10-15%). Shell fragments (5%). Light hydrcarbon odors.
			▨ /	7		
				8		

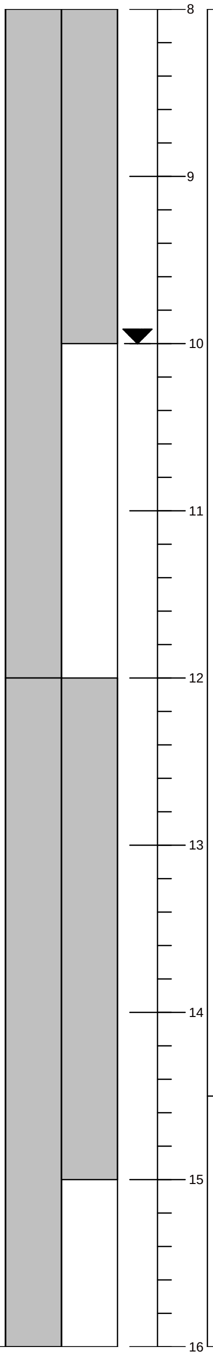
Notes:
FT BGS = feet below ground surface
ppm = parts per million

--- Dashed contact line in soil description indicates a gradational contact
USCS = Unified Soil Classification System
▼ = denotes groundwater table

Boring ID: FS-28

Drill Date: February 7, 2008
Logged By: Brett Beaulieu
Drilled By: Frank Scott/Cascade Drilling, Inc.
Coordinate System: NAD 83(91) NAVD 88
Ground Surface Elevation: 14.83
Latitude/Northing: 420853.600
Longitude/Easting: 1002603.069
Boring Location: North of Westport
Drill Type: direct-push probe
Sample Method: direct push 2"x4' core
Boring Diameter: 2 inches
Boring Depth (ft bgs): 16 feet
Groundwater ATD (ft bgs): 10 ft bgs
Client: MTA Group
Project: Marine Trades Area
Task: SJZ-MTA T.6
Address: 638 Marine Drive
Port Angeles, WA

Remarks: Light rain, windy, 30s. Piston sampler used below water table. Ground surface asphalt, located west in road near Tumwater Creek bridge.



PID (ppm)	OIL INDICAT.	SAMPLE ID	DRIVEN / RECOVERED	DEPTH FT BGS	USCS SYMBOL	SOIL DESCRIPTION AND OBSERVATIONS
					SW	Black-stained, moist to wet, well graded sand, fine to medium. Gravel (5-10%). Visible staining. Hydrocarbon odors. Wet at 10' bgs. Sand becomes fine to coarse 12-14.5' bgs. Gravel content greater (25%) 12-13' bgs.
2070	Heavy sheen	FS-28 9-10' (soil)				
27.6						
		FS-28 12.5-13' (soil)				
		FS-28 13-14.5' (soil)				
2.7						
					SM	Black, wet, silty sand. Shell fragments. Possible light hydrocarbon odor.

Notes:
FT BGS = feet below ground surface
ppm = parts per million
--- Dashed contact line in soil description indicates a gradational contact
USCS = Unified Soil Classification System
▼ = denotes groundwater table

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Boring ID: FS-29

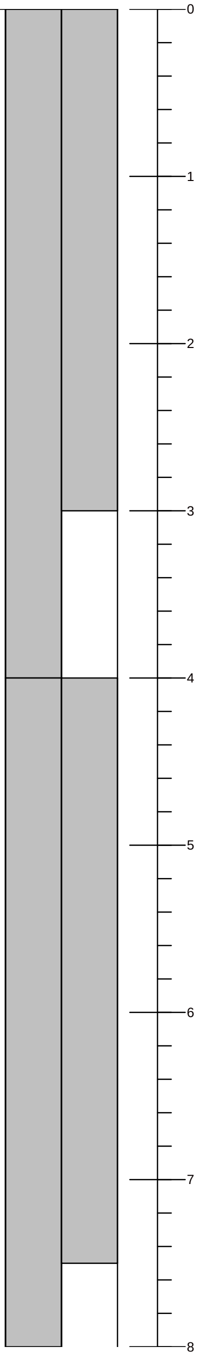
Drill Date: February 5, 2008
Logged By: Brett Beaulieu
Drilled By: Frank Scott/Cascade Drilling, Inc.
Drill Type: direct-push probe
Sample Method: direct push 2"x4' core
Boring Diameter: 2 inches
Boring Depth (ft bgs): 16 feet
Groundwater ATD (ft bgs): 9.5 ft bgs

Coordinate System: NAD 83(91) NAVD 88
Ground Surface Elevation: 15.37
Latitude/Northing: 420911.219
Longitude/Easting: 1002819.373
Boring Location: North of Westport

Client: MTA Group
Project: Marine Trades Area
Task: SJZ-MTA T.6
Address: 638 Marine Drive
Port Angeles, WA

Remarks: Light rain, windy, 30s. Piston sampler used below water table. Ground surface gravel. Additional soil collected from additional 9-13' bgs drive for porosity and physical parameters.

PID (ppm)	OIL INDICAT.	SAMPLE ID	DRIVEN / RECOVERED	DEPTH FT BGS	USCS SYMBOL	SOIL DESCRIPTION AND OBSERVATIONS
0.0					SW-SM	Brown, dark brown, and grey, moist, well-graded sand with silt and gravel, fine to medium. Organic rich deposit at 1' bgs. Cobbles at 1.5-2.5' bgs. No odors.
13		FS-29 2-3' (soil)			SW	Brown and grey, moist, well-graded sand with gravel, fine to medium. Gravel (5-10%) increasing with depth. Shell fragments (5-10%) increasing with depth, with shell-rich deposit at 9.5' bgs. Visible staining, with hydrocarbon odors, beginning at 2.5' bgs. Increasing silt content 8-9.5' bgs.
126						
30						



Notes:
FT BGS = feet below ground surface
ppm = parts per million

--- Dashed contact line in soil description indicates a gradational contact
USCS = Unified Soil Classification System
▼ = denotes groundwater table

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Boring ID: FS-29

Drill Date: February 5, 2008
Logged By: Brett Beaulieu
Drilled By: Frank Scott/Cascade Drilling, Inc.

Coordinate System: NAD 83(91) NAVD 88
Ground Surface Elevation: 15.37
Latitude/Northing: 420911.219
Longitude/Easting: 1002819.373
Boring Location: North of Westport

Drill Type: direct-push probe
Sample Method: direct push 2"x4' core
Boring Diameter: 2 inches
Boring Depth (ft bgs): 16 feet
Groundwater ATD (ft bgs): 9.5 ft bgs

Client: MTA Group
Project: Marine Trades Area
Task: SJZ-MTA T.6
Address: 638 Marine Drive
Port Angeles, WA

Remarks: Light rain, windy, 30s. Piston sampler used below water table. Ground surface gravel. Additional soil collected from additional 9-13' bgs drive for porosity and physical parameters.

PID (ppm)	OIL INDICAT.	SAMPLE ID	DRIVEN / RECOVERED	DEPTH FT BGS	USCS SYMBOL	SOIL DESCRIPTION AND OBSERVATIONS
>900				8 9		
				▼	SW-SM	Grey, wet, well-graded sand with silt and gravel, fine to medium, with cobbles, shell fragments. Hydrocarbon odors.
1634	Heavy sheen	FS-29 10-11' (soil)		10		
					SM	Dark grey, wet, silty sand, fine. Visible residual petroleum impacts 10-11' bgs. Hydrocarbon odors.
				11		
		FS-29 12-16' (groundwater)		12		
				13	SW	Dark grey, wet, well-graded sand, medium to coarse. Shell fragments.
4.0	No sheen			14	ML	Dark grey, wet, silt. Plastic. Organic-rich, with fine woody debris.
				15	SW-SM	Black, wet, well-graded sand with silt and gravel, fine to medium. Organic-rich fines.
				16		

Notes:
FT BGS = feet below ground surface
ppm = parts per million
--- Dashed contact line in soil description indicates a gradational contact
USCS = Unified Soil Classification System
▼ = denotes groundwater table

Boring ID: FS-30

Drill Date: February 8, 2008
Logged By: Brett Beaulieu
Drilled By: Frank Scott/Cascade Drilling, Inc.

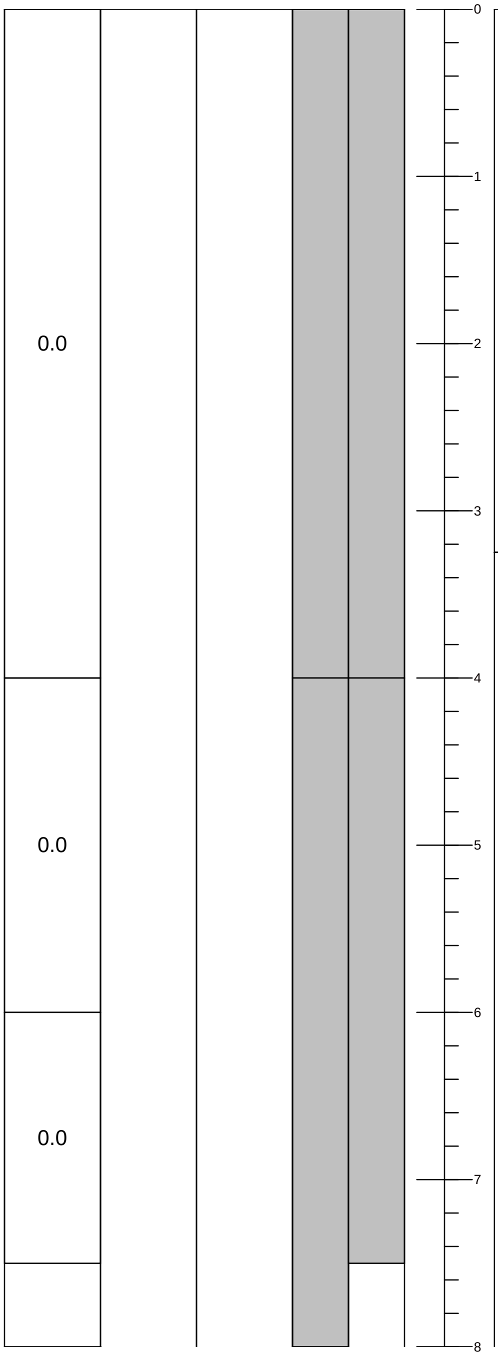
Coordinate System: NAD 83(91) NAVD 88
Ground Surface Elevation: 15.32
Latitude/Northing: 420767.175
Longitude/Easting: 1002521.337
Boring Location: West of Westport

Drill Type: direct-push probe
Sample Method: direct push 2"x4' core
Boring Diameter: 2 inches
Boring Depth (ft bgs): 16 feet
Groundwater ATD (ft bgs): 9.5 ft bgs

Client: MTA Group
Project: Marine Trades Area
Task: SJZ-MTA T.6
Address: 638 Marine Drive
Port Angeles, WA

Remarks: Overcast, windy, 30s. Piston sampler used below water table. Ground surface gravel, located west of road adjacent Westport.

PID (ppm)	OIL INDICAT.	SAMPLE ID	DRIVEN / RECOVERED	DEPTH FT BGS	USCS SYMBOL	SOIL DESCRIPTION AND OBSERVATIONS



SW-SM	Brown and dark brown, wet to moist, well-graded sand with silt and gravel, fine to medium. Gravel (15%). Cobbles. Organic rich deposit with woody debris at 1' bgs. No hydrocarbon odors.
SW	Grey and brown-grey, moist, well-graded sand with gravel, fine to coarse. Gravel (20-25%). Shell fragments (5-10%). No hydrocarbon odors.

Notes:
FT BGS = feet below ground surface
ppm = parts per million

--- Dashed contact line in soil description indicates a gradational contact
USCS = Unified Soil Classification System
▼ = denotes groundwater table

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Boring ID: FS-30

Drill Date: February 8, 2008
Logged By: Brett Beaulieu
Drilled By: Frank Scott/Cascade Drilling, Inc.
Drill Type: direct-push probe
Sample Method: direct push 2"x4' core
Boring Diameter: 2 inches
Boring Depth (ft bgs): 16 feet
Groundwater ATD (ft bgs): 9.5 ft bgs

Coordinate System: NAD 83(91) NAVD 88
Ground Surface Elevation: 15.32
Latitude/Northing: 420767.175
Longitude/Easting: 1002521.337
Boring Location: West of Westport

Client: MTA Group
Project: Marine Trades Area
Task: SJZ-MTA T.6
Address: 638 Marine Drive
Port Angeles, WA

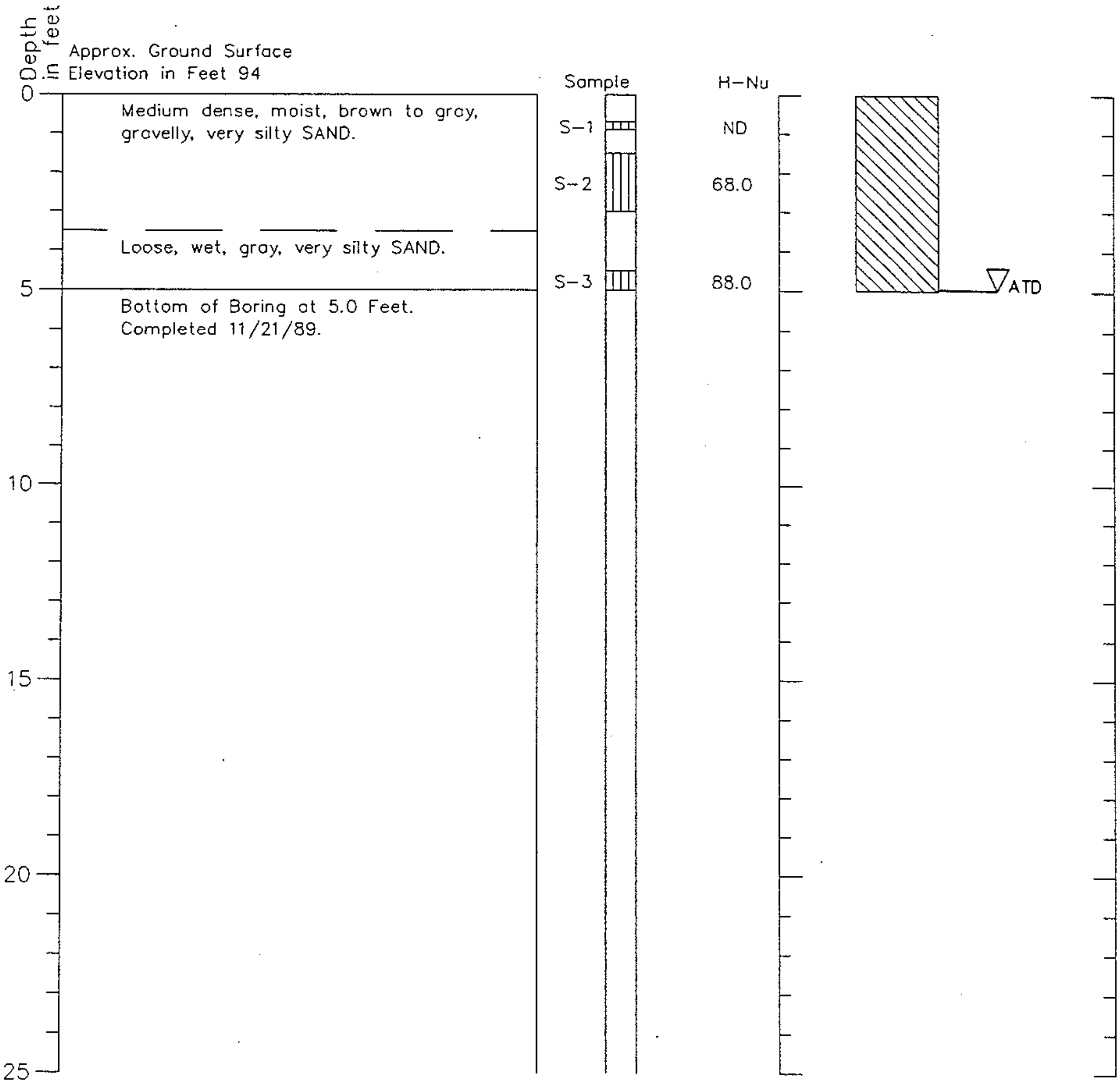
Remarks: Overcast, windy, 30s. Piston sampler used below water table. Ground surface gravel, located west of road adjacent Westport.

PID (ppm)	OIL INDICAT.	SAMPLE ID	DRIVEN / RECOVERED	DEPTH FT BGS	USCS SYMBOL	SOIL DESCRIPTION AND OBSERVATIONS
0.0	No sheen			8		
641	Heavy rainbow sheen	FS-30 9-10' (soil)		9		
				▼	SW-SM	Dark grey, wet, well-graded sand with silt and gravel, fine to coarse. Possible staining. Hydrcarbon odors.
				10		
				11		
1.6	No sheen			12	SW-SM	Grey, wet, well-graded sand with silt and gravel, fine to coarse, with woody debris and cobbles. No hydrocarbon odors. Driller reports soft drilling may account for poor recovery.
0.1					SW	Grey, wet, well-graded sand with gravel, fine. Gravel (10%). No hydrocarbon odors.
				13		
				14		
				15		
				16		

Notes:
FT BGS = feet below ground surface
ppm = parts per million
--- Dashed contact line in soil description indicates a gradational contact
USCS = Unified Soil Classification System
▼ = denotes groundwater table

Hand Auger Boring Log B-1

Geologic Log



1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Ground water level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.
4. Elevations measured relative to an assumed reference datum of 100.0 feet at top of casing of MW-7.

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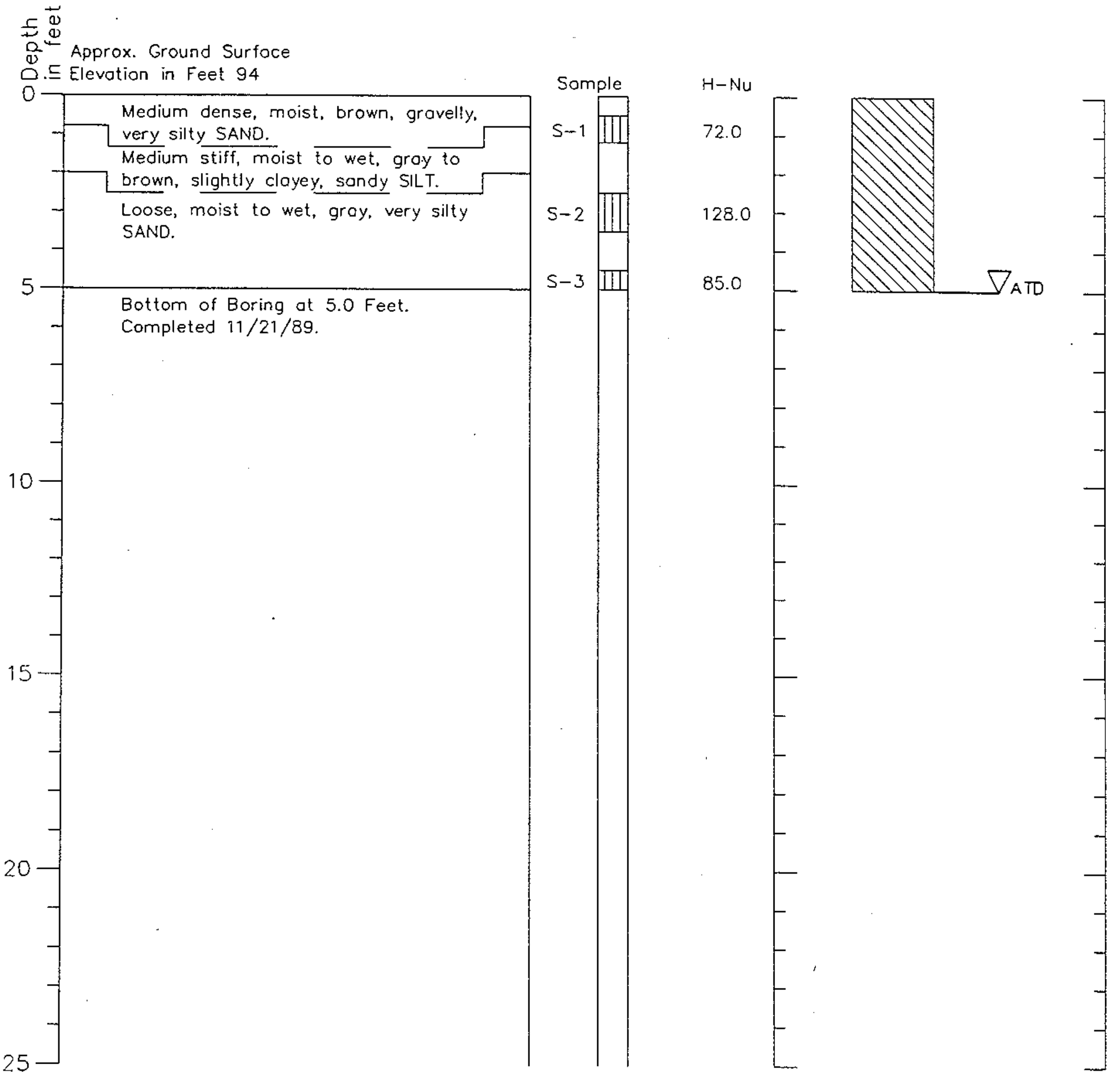
J-2692 **11/89**

Figure A-5

Hand Auger Boring Log B-2

Geologic Log



Approx. Ground Surface Elevation in Feet 94

Medium dense, moist, brown, gravelly, very silty SAND.

Medium stiff, moist to wet, gray to brown, slightly clayey, sandy SILT.

Loose, moist to wet, gray, very silty SAND.

Bottom of Boring at 5.0 Feet.
Completed 11/21/89.

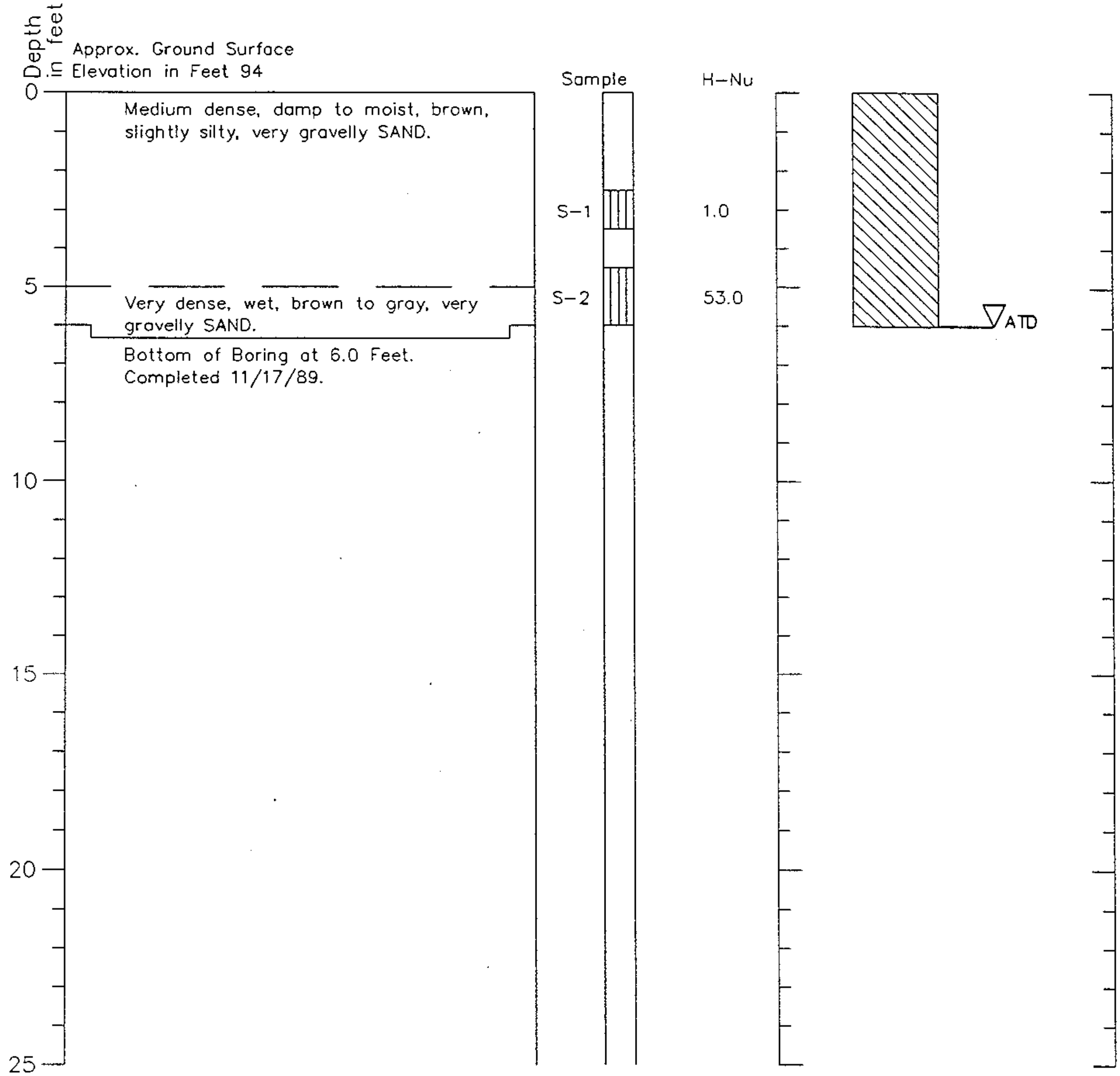
1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Ground water level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.
4. Elevations measured relative to an assumed reference datum of 100.0 feet at top of casing of MW-7.

HARTCROWSER
J-2692 11/89
Figure A-6

Hand Auger Boring Log B-3

Geologic Log

Approx. Ground Surface
Elevation in Feet 94



Medium dense, damp to moist, brown, slightly silty, very gravelly SAND.

Very dense, wet, brown to gray, very gravelly SAND.

Bottom of Boring at 6.0 Feet.
Completed 11/17/89.

1. Refer to Figure A–1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Ground water level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.
4. Elevations measured relative to an assumed reference datum of 100.0 feet at top of casing of MW–7.

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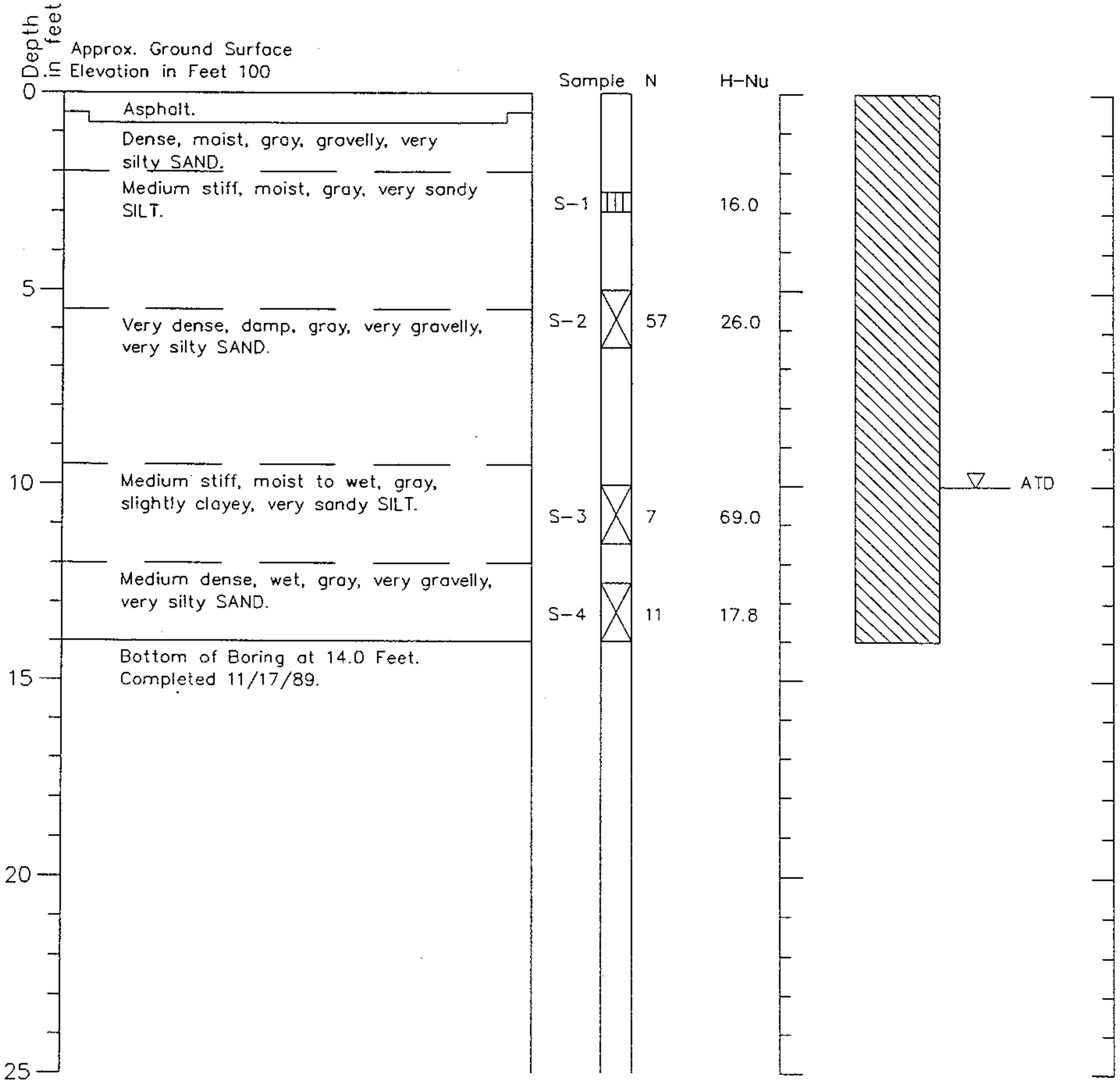
J-2692 **11/89**

Figure A-7

Boring Log B-4

Geologic Log



1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Ground water level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.
4. Elevations measured relative to an assumed reference datum of 100.0 feet at top of casing of MW-7.

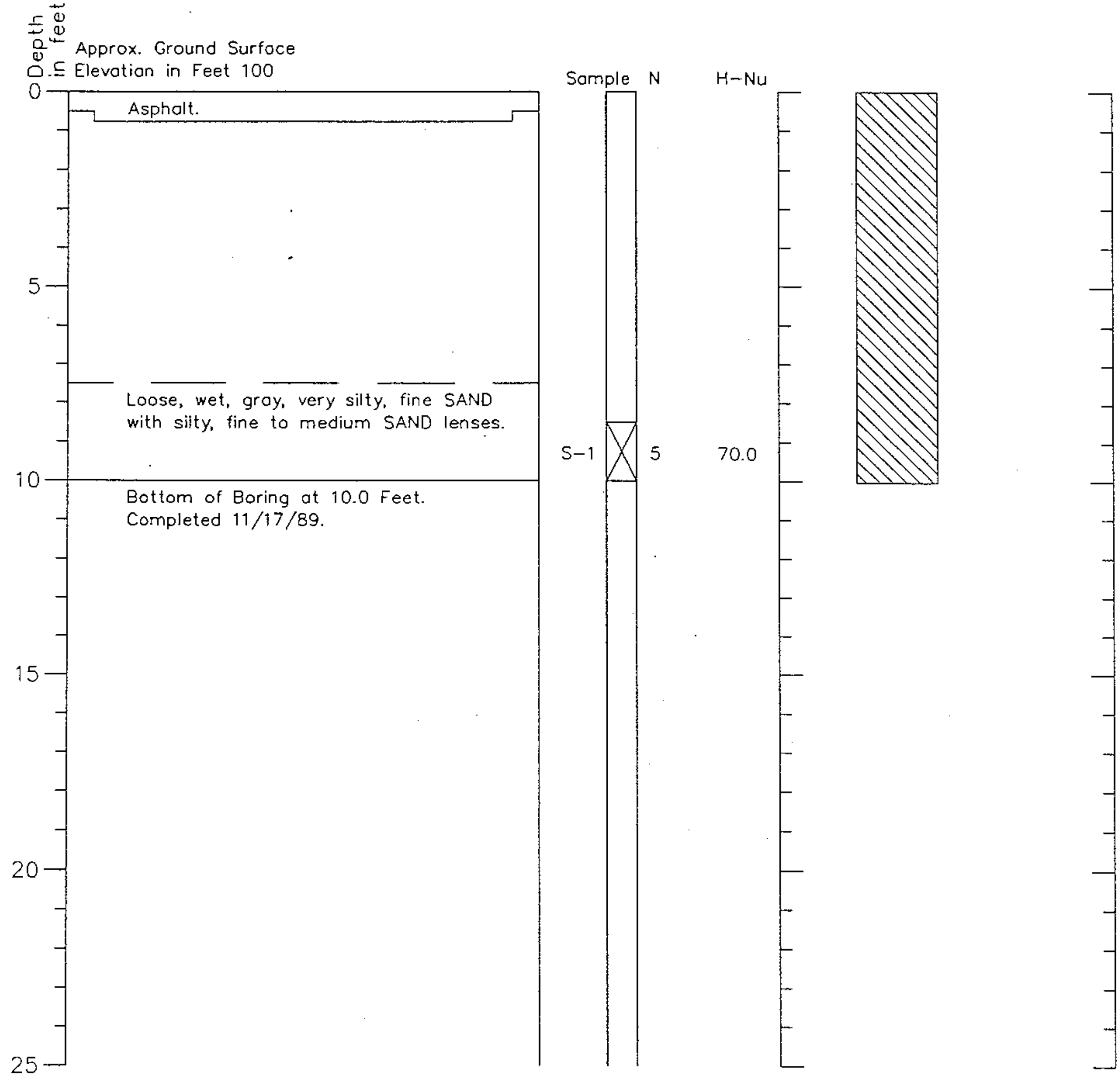
HARTCROWSER

J-2692 **11/89**

Figure A-8

Boring Log B-4A

Geologic Log



1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Ground water level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.
4. Elevations measured relative to an assumed reference datum of 100.0 feet at top of casing of MW-7.

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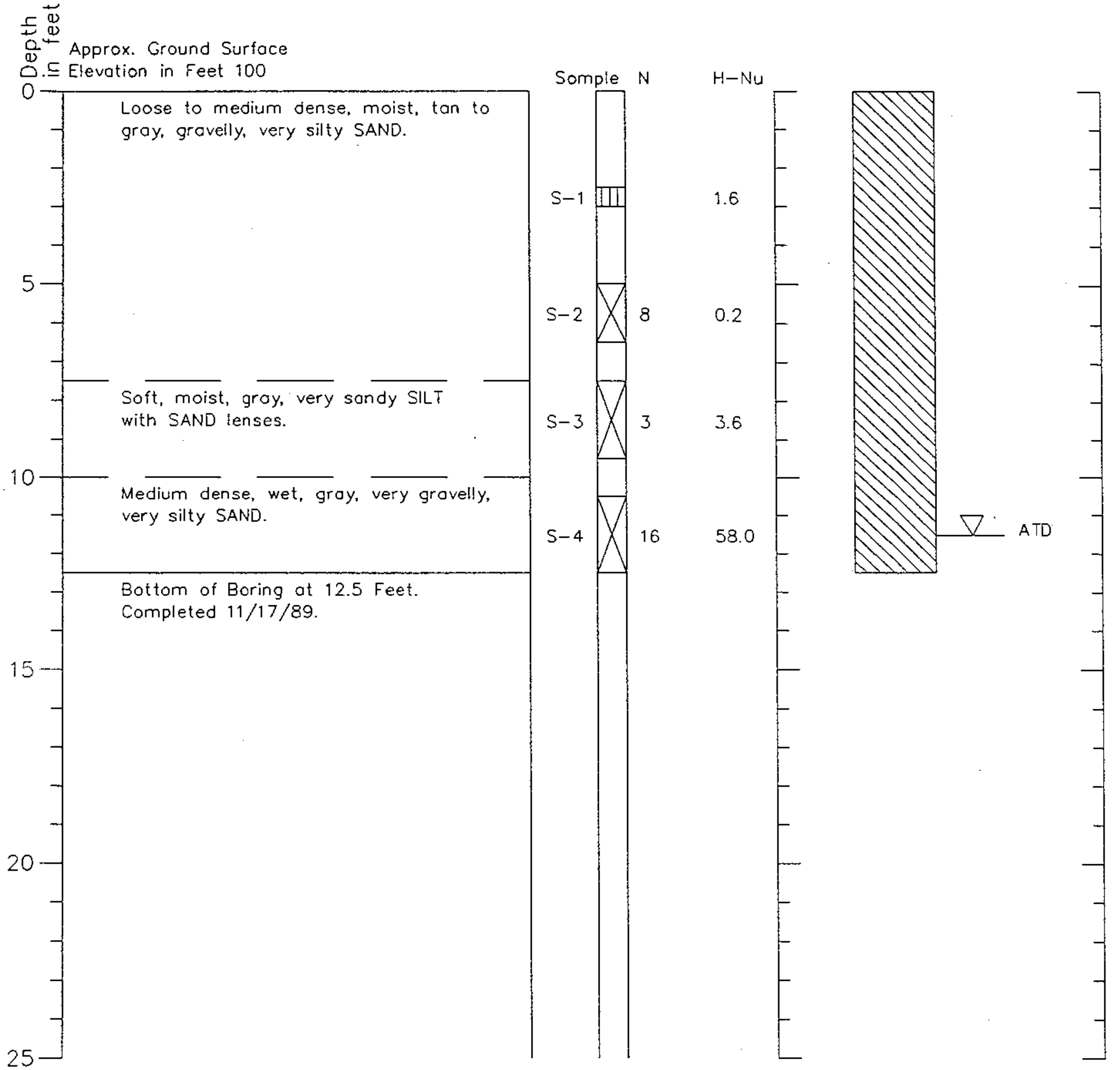
J-2692 **11/89**

Figure A-9

Boring Log B-5

Geologic Log



1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Ground water level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.
4. Elevations measured relative to an assumed reference datum of 100.0 feet at top of casing of MW-7.

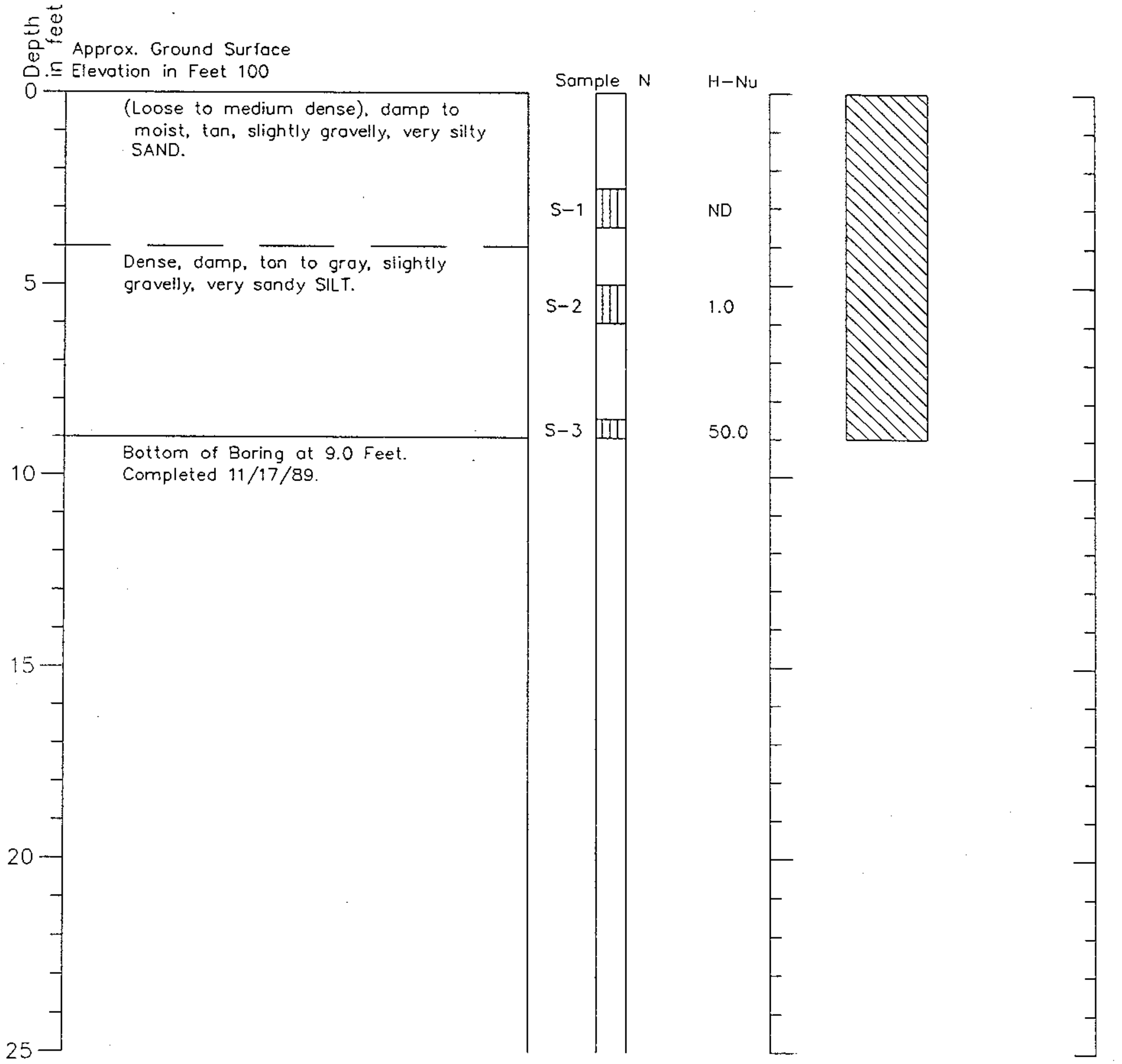
HARTCROWSER

J-2692 11/89

Figure A-10

Hand Auger Boring Log B-6

Geologic Log



(Loose to medium dense), damp to moist, tan, slightly gravelly, very silty SAND.

Dense, damp, tan to gray, slightly gravelly, very sandy SILT.

Bottom of Boring at 9.0 Feet. Completed 11/17/89.

1. Refer to Figure A–1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Ground water level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.
4. Elevations measured relative to an assumed reference datum of 100.0 feet at top of casing of MW–7.

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J-2692 **11/89**

Figure A-11

Marine Trades Area Site
Port Angeles, Washington

Final
Remedial Investigation/ Feasibility Study

Appendix E
Tumwater Creek Delta Sampling Results and Locations

CERTIFICATE OF ANALYSIS

CLIENT: PORT OF PORT ANGELES
P.O. BOX 1350
PORT ANGELES, WA 98362

DATE: 1/16/98
CCIL JOB #: 801001
CCIL SAMPLE #: 1
DATE RECEIVED: 12/31/97
WDOE ACCREDITATION #: C142

CLIENT CONTACT: KENNETH SWEENEY

CLIENT PROJECT ID: TUMWATER CREEK DREDGING
CLIENT SAMPLE ID: 1A & 1B 12/29/97 1630

DATA RESULTS

ANALYTE	METHOD	RESULTS*	UNITS**	ACTION LEVEL***	ANALYSIS DATE	ANALYSIS BY
DICHLORODIFLUOROMETHANE	EPA-8260A	ND(<20)	UG/KG		1/6/98	LRK
CHLOROMETHANE	EPA-8260A	ND(<20)	UG/KG		1/6/98	LRK
VINYL CHLORIDE	EPA-8260A	ND(<20)	UG/KG		1/6/98	LRK
BROMOMETHANE	EPA-8260A	ND(<20)	UG/KG		1/6/98	LRK
CHLOROETHANE	EPA-8260A	ND(<20)	UG/KG		1/6/98	LRK
TRICHLOROFLUOROMETHANE	EPA-8260A	ND(<10)	UG/KG		1/6/98	LRK
ACETONE	EPA-8260A	ND(<150)	UG/KG		1/6/98	LRK
1,1-DICHLOROETHENE	EPA-8260A	ND(<10)	UG/KG		1/6/98	LRK
CARBON DISULFIDE	EPA-8260A	ND(<10)	UG/KG		1/6/98	LRK
METHYLENE CHLORIDE	EPA-8260A	ND(<10)	UG/KG		1/6/98	LRK
ACRYLONITRILE	EPA-8260A	ND(<50)	UG/KG		1/6/98	LRK
TRANS-1,2-DICHLOROETHENE	EPA-8260A	ND(<10)	UG/KG		1/6/98	LRK
1,1-DICHLOROETHANE	EPA-8260A	ND(<10)	UG/KG		1/6/98	LRK
2-BUTANONE	EPA-8260A	ND(<50)	UG/KG		1/6/98	LRK
CIS-1,2-DICHLOROETHENE	EPA-8260A	ND(<10)	UG/KG		1/6/98	LRK
2,2-DICHLOROPROPANE	EPA-8260A	ND(<10)	UG/KG		1/6/98	LRK
BROMOCHLOROMETHANE	EPA-8260A	ND(<10)	UG/KG		1/6/98	LRK
CHLOROFORM	EPA-8260A	ND(<10)	UG/KG		1/6/98	LRK
1,1,1-TRICHLOROETHANE	EPA-8260A	ND(<10)	UG/KG		1/6/98	LRK
1,1-DICHLOROPROPENE	EPA-8260A	ND(<10)	UG/KG		1/6/98	LRK
CARBON TETRACHLORIDE	EPA-8260A	ND(<10)	UG/KG		1/6/98	LRK
1,2-DICHLOROETHANE	EPA-8260A	ND(<10)	UG/KG		1/6/98	LRK
BENZENE	EPA-8260A	ND(<10)	UG/KG		1/6/98	LRK
TRICHLOROETHENE	EPA-8260A	ND(<10)	UG/KG		1/6/98	LRK
1,2-DICHLOROPROPANE	EPA-8260A	ND(<10)	UG/KG		1/6/98	LRK
1,4-DIOXANE	EPA-8260A	ND(<100)	UG/KG		1/6/98	LRK
DIBROMOMETHANE	EPA-8260A	ND(<10)	UG/KG		1/6/98	LRK
BROMODICHLOROMETHANE	EPA-8260A	ND(<10)	UG/KG		1/6/98	LRK
TRANS-1,3-DICHLOROPROPENE	EPA-8260A	ND(<10)	UG/KG		1/6/98	LRK
4-METHYL-2-PENTANONE	EPA-8260A	ND(<50)	UG/KG		1/6/98	LRK
TOLUENE	EPA-8260A	ND(<10)	UG/KG		1/6/98	LRK
CIS-1,3-DICHLOROPROPENE	EPA-8260A	ND(<10)	UG/KG		1/6/98	LRK
1,1,2-TRICHLOROETHANE	EPA-8260A	ND(<10)	UG/KG		1/6/98	LRK
2-HEXANONE	EPA-8260A	ND(<50)	UG/KG		1/6/98	LRK
1,3-DICHLOROPROPANE	EPA-8260A	ND(<10)	UG/KG		1/6/98	LRK

CCI
ANALYTICAL
LABORATORIES, INC.

CERTIFICATE OF ANALYSIS

CLIENT:	PORT OF PORT ANGELES P.O. BOX 1350 PORT ANGELES, WA 98362	DATE:	1/16/98
		CCIL JOB #:	801001
		CCIL SAMPLE #:	1
		DATE RECEIVED:	12/31/97
		WDOE ACCREDITATION #:	C142

CLIENT CONTACT: KENNETH SWEENEY

CLIENT PROJECT ID: TUMWATER CREEK DREDGING
CLIENT SAMPLE ID: 1A & 1B 12/29/97 1630

DATA RESULTS

ANALYTE	METHOD	RESULTS*	UNITS**	ACTION LEVEL***	ANALYSIS DATE	ANALYSIS BY
TETRACHLOROETHYLENE	EPA-8260A	ND(<10)	UG/KG		1/6/98	LRK
DIBROMOCHLOROMETHANE	EPA-8260A	ND(<10)	UG/KG		1/6/98	LRK
1,2-DIBROMOETHANE	EPA-8260A	ND(<10)	UG/KG		1/6/98	LRK
CHLOROBENZENE	EPA-8260A	ND(<10)	UG/KG		1/6/98	LRK
1,1,1,2-TETRACHLOROETHANE	EPA-8260A	ND(<10)	UG/KG		1/6/98	LRK
ETHYLBENZENE	EPA-8260A	ND(<10)	UG/KG		1/6/98	LRK
M+P XYLENE	EPA-8260A	ND(<20)	UG/KG		1/6/98	LRK
STYRENE	EPA-8260A	ND(<10)	UG/KG		1/6/98	LRK
O-XYLENE	EPA-8260A	ND(<10)	UG/KG		1/6/98	LRK
BROMOFORM	EPA-8260A	ND(<10)	UG/KG		1/6/98	LRK
ISOPROPYLBENZENE	EPA-8260A	ND(<10)	UG/KG		1/6/98	LRK
1,1,2,2-TETRACHLOROETHANE	EPA-8260A	ND(<10)	UG/KG		1/6/98	LRK
1,2,3-TRICHLOROPROPANE	EPA-8260A	ND(<10)	UG/KG		1/6/98	LRK
BROMOBENZENE	EPA-8260A	ND(<10)	UG/KG		1/6/98	LRK
N-PROPYL BENZENE	EPA-8260A	ND(<10)	UG/KG		1/6/98	LRK
2-CHLOROTOLUENE	EPA-8260A	ND(<10)	UG/KG		1/6/98	LRK
1,3,5-TRIMETHYLBENZENE	EPA-8260A	ND(<10)	UG/KG		1/6/98	LRK
4-CHLOROTOLUENE	EPA-8260A	ND(<10)	UG/KG		1/6/98	LRK
T-BUTYL BENZENE	EPA-8260A	ND(<10)	UG/KG		1/6/98	LRK
1,2,4-TRIMETHYL BENZENE	EPA-8260A	ND(<10)	UG/KG		1/6/98	LRK
S-BUTYL BENZENE	EPA-8260A	ND(<10)	UG/KG		1/6/98	LRK
P-ISOPROPYLTOLUENE	EPA-8260A	ND(<10)	UG/KG		1/6/98	LRK
1,3 DICHLOROBENZENE	EPA-8260A	ND(<10)	UG/KG		1/6/98	LRK
1,4-DICHLOROBENZENE	EPA-8260A	ND(<10)	UG/KG		1/6/98	LRK
N-BUTYLBENZENE	EPA-8260A	ND(<10)	UG/KG		1/6/98	LRK
1,2-DICHLOROBENZENE	EPA-8260A	ND(<10)	UG/KG		1/6/98	LRK
1,2-DIBROMO 3-CHLOROPROPANE	EPA-8260A	ND(<50)	UG/KG		1/6/98	LRK
1,2,4-TRICHLOROBENZENE	EPA-8260A	ND(<10)	UG/KG		1/6/98	LRK
HEXACHLORO1,3-BUTADIENE	EPA-8260A	ND(<10)	UG/KG		1/6/98	LRK
NAPHTHALENE	EPA-8260A	ND(<10)	UG/KG		1/6/98	LRK
1,2,3-TRICHLOROBENZENE	EPA-8260A	ND(<10)	UG/KG		1/6/98	LRK
BIS(2-CHLOROETHYL)ETHER	EPA-8270	ND(<100)	UG/KG		1/8/98	LRK
PHENOL	EPA-8270	ND(<100)	UG/KG		1/8/98	LRK
2-CHLOROPHENOL	EPA-8270	ND(<100)	UG/KG		1/8/98	LRK

CCI
ANALYTICAL
LABORATORIES, INC.

CERTIFICATE OF ANALYSIS

CLIENT: PORT OF PORT ANGELES
P.O. BOX 1350
PORT ANGELES, WA 98362

DATE: 1/16/98
CCIL JOB #: 801001
CCIL SAMPLE #: 1
DATE RECEIVED: 12/31/97
WDOE ACCREDITATION #: C142

CLIENT CONTACT: KENNETH SWEENEY

CLIENT PROJECT ID: TUMWATER CREEK DREDGING
CLIENT SAMPLE ID: 1A & 1B 12/29/97 1630

DATA RESULTS

ANALYTE	METHOD	RESULTS*	UNITS**	ACTION LEVEL***	ANALYSIS DATE	ANALYSIS BY
1,3-DICHLOROBENZENE	EPA-8270	ND(<100)	UG/KG		1/8/98	LRK
1,4-DICHLOROBENZENE	EPA-8270	ND(<100)	UG/KG		1/8/98	LRK
1,2-DICHLOROBENZENE	EPA-8270	ND(<100)	UG/KG		1/8/98	LRK
BENZYL ALCOHOL/2-METHYLPHENOL	EPA-8270	ND(<200)	UG/KG		1/8/98	LRK
BIS(2-CHLOROISOPROPYL)ETHER	EPA-8270	ND(<100)	UG/KG		1/8/98	LRK
HEXACHLOROETHANE	EPA-8270	ND(<100)	UG/KG		1/8/98	LRK
N-NITROSO-DI-N-PROPYLAMINE	EPA-8270	ND(<100)	UG/KG		1/8/98	LRK
4-METHYLPHENOL	EPA-8270	ND(<100)	UG/KG		1/8/98	LRK
NITROBENZENE	EPA-8270	ND(<100)	UG/KG		1/8/98	LRK
ISOPHORONE	EPA-8270	ND(<100)	UG/KG		1/8/98	LRK
2-NITROPHENOL	EPA-8270	ND(<100)	UG/KG		1/8/98	LRK
2,4-DIMETHYLPHENOL	EPA-8270	ND(<100)	UG/KG		1/8/98	LRK
BENZOIC ACID	EPA-8270	ND(<500)	UG/KG		1/8/98	LRK
BIS(2-CHLOROETHOXY)METHANE	EPA-8270	ND(<100)	UG/KG		1/8/98	LRK
2,4-DICHLOROPHENOL	EPA-8270	ND(<100)	UG/KG		1/8/98	LRK
1,2,4-TRICHLOROBENZENE	EPA-8270	ND(<100)	UG/KG		1/8/98	LRK
NAPHTHALENE	EPA-8270	ND(<100)	UG/KG		1/8/98	LRK
4-CHLOROANILINE	EPA-8270	ND(<100)	UG/KG		1/8/98	LRK
HEXACHLOROBUTADIENE	EPA-8270	ND(<100)	UG/KG		1/8/98	LRK
4-CHLORO-3-METHYLPHENOL	EPA-8270	ND(<100)	UG/KG		1/8/98	LRK
2-METHYLNAPHTHALENE	EPA-8270	ND(<100)	UG/KG		1/8/98	LRK
HEXACHLOROCYCLOPENTADIENE	EPA-8270	ND(<100)	UG/KG		1/8/98	LRK
2,4,6-TRICHLOROPHENOL	EPA-8270	ND(<100)	UG/KG		1/8/98	LRK
2,4,5-TRICHLOROPHENOL	EPA-8270	ND(<100)	UG/KG		1/8/98	LRK
2-CHLORONAPHTHANLENE	EPA-8270	ND(<100)	UG/KG		1/8/98	LRK
2-NITROANILINE	EPA-8270	ND(<100)	UG/KG		1/8/98	LRK
ACENAPHTHYLENE	EPA-8270	ND(<100)	UG/KG		1/8/98	LRK
DIMETHYLPHTHALATE	EPA-8270	ND(<100)	UG/KG		1/8/98	LRK
2,6-DINITROTOLUENE	EPA-8270	ND(<100)	UG/KG		1/8/98	LRK
ACENAPHATHENE	EPA-8270	ND(<100)	UG/KG		1/8/98	LRK
3-NITROANILINE	EPA-8270	ND(<100)	UG/KG		1/8/98	LRK
2,4-DINITROPHENOL	EPA-8270	ND(<1000)	UG/KG		1/8/98	LRK
DIBENZOFURAN	EPA-8270	ND(<100)	UG/KG		1/8/98	LRK
2,4-DINITROTOLUENE	EPA-8270	ND(<100)	UG/KG		1/8/98	LRK
4-NITROPHENOL	EPA-8270	ND(<1000)	UG/KG		1/8/98	LRK

CCI
ANALYTICAL
LABORATORIES, INC.

CERTIFICATE OF ANALYSIS

CLIENT: PORT OF PORT ANGELES
P.O. BOX 1350
PORT ANGELES, WA 98362

DATE: 1/16/98
CCIL JOB #: 801001
CCIL SAMPLE #: 1
DATE RECEIVED: 12/31/97
WDOE ACCREDITATION #: C142

CLIENT CONTACT: KENNETH SWEENEY

CLIENT PROJECT ID: TUMWATER CREEK DREDGING
CLIENT SAMPLE ID: 1A & 1B 12/29/97 1630

DATA RESULTS

ANALYTE	METHOD	RESULTS*	UNITS**	ACTION LEVEL***	ANALYSIS DATE	ANALYSIS BY
FLUORENE	EPA-8270	ND(<100)	UG/KG		1/8/98	LRK
4-CHLOROPHENYL-PHENYLETHER	EPA-8270	ND(<100)	UG/KG		1/8/98	LRK
DIETHYLPHTHALATE	EPA-8270	ND(<100)	UG/KG		1/8/98	LRK
4-NITROANILINE	EPA-8270	ND(<100)	UG/KG		1/8/98	LRK
4,6-DINITRO-2-METHYLPHENOL	EPA-8270	ND(<1000)	UG/KG		1/8/98	LRK
N-NITROSODIPHENYLAMINE	EPA-8270	ND(<100)	UG/KG		1/8/98	LRK
4-BROMOPHENYL-PHENYLETHER	EPA-8270	ND(<100)	UG/KG		1/8/98	LRK
HEXACHLOROBENZENE	EPA-8270	ND(<100)	UG/KG		1/8/98	LRK
PENTACHLOROPHENOL	EPA-8270	ND(<1000)	UG/KG		1/8/98	LRK
PHENANTHRENE	EPA-8270	ND(<100)	UG/KG		1/8/98	LRK
ANTHRACENE	EPA-8270	ND(<100)	UG/KG		1/8/98	LRK
CARBAZOLE	EPA-8270	ND(<100)	UG/KG		1/8/98	LRK
DI-N-BUTYLPHTHALATE	EPA-8270	ND(<100)	UG/KG		1/8/98	LRK
FLUORANTHENE	EPA-8270	ND(<100)	UG/KG		1/8/98	LRK
PYRENE	EPA-8270	ND(<100)	UG/KG		1/8/98	LRK
BUTYLBENZYLPHTHALATE	EPA-8270	ND(<100)	UG/KG		1/8/98	LRK
3,3'-DICHLOROBENZIDINE	EPA-8270	ND(<100)	UG/KG		1/8/98	LRK
BENZO[A]ANTHRACENE	EPA-8270	ND(<100)	UG/KG		1/8/98	LRK
CHRYSENE	EPA-8270	ND(<100)	UG/KG		1/8/98	LRK
BIS(2-ETHYLHEXYL)PHTHALATE	EPA-8270	ND(<100)	UG/KG		1/8/98	LRK
DI-N-OCTYLPHTHALATE	EPA-8270	ND(<100)	UG/KG		1/8/98	LRK
BENZO[B]FLUORANTHENE	EPA-8270	ND(<100)	UG/KG		1/8/98	LRK
BENZO[K]FLUORANTHENE	EPA-8270	ND(<100)	UG/KG		1/8/98	LRK
INDENO[1,2,3-CD]PYRENE	EPA-8270	ND(<100)	UG/KG		1/8/98	LRK
DIBENZ[A,H]ANTHRACENE	EPA-8270	ND(<100)	UG/KG		1/8/98	LRK
BENZO[G,H,I]PERYLENE	EPA-8270	ND(<100)	UG/KG		1/8/98	LRK
ARSENIC	EPA-7060	0.92 ✓	MG/KG		1/9/98	JLB
BARIUM	EPA-7081	26	MG/KG		1/13/98	JLB
CADMIUM	EPA-7130	ND(<0.2)	MG/KG		1/9/98	JLB
CHROMIUM	EPA-7190	14 ✓	MG/KG		1/8/98	JLB
LEAD	EPA-7420	ND(<8)	MG/KG		1/9/98	JLB
MERCURY	EPA-7471MOD	ND(<0.025)	MG/KG		1/13/98	JLB
SELENIUM	EPA-7740	ND(<1)	MG/KG		1/12/98	JLB
SILVER	EPA-7760	ND(<0.4)	MG/KG		1/8/98	JLB

CERTIFICATE OF ANALYSIS

CLIENT: PORT OF PORT ANGELES
P.O. BOX 1350
PORT ANGELES, WA 98362

DATE: 1/16/98
CCIL JOB #: 801001
CCIL SAMPLE #: 1
DATE RECEIVED: 12/31/97
WDOE ACCREDITATION #: C142

CLIENT CONTACT: KENNETH SWEENEY

CLIENT PROJECT ID: TUMWATER CREEK DREDGING
CLIENT SAMPLE ID: 1A & 1B 12/29/97 1630

DATA RESULTS

ANALYTE	METHOD	RESULTS*	UNITS**	ACTION LEVEL***	ANALYSIS DATE	ANALYSIS BY

* "ND" INDICATES ANALYTE NOT DETECTED AT LEVEL ABOVE REPORTING LIMIT REPORTING LIMIT IS GIVEN IN PARENTHESES

** UNITS FOR ALL NON LIQUID SAMPLES ARE REPORTED ON A DRY WEIGHT BASIS

*** ACTIONS LEVELS ARE PROVIDED ONLY WHEN PARAMETER DATA IS USED FOR A GENERALLY CONSISTENT APPLICATION. WHEN PROVIDED, THEY SHOULD BE USED AS GUIDELINES ONLY. THE APPROPRIATE REGULATORY DOCUMENT SHOULD BE CONSULTED BEFORE MAKING ANY DECISIONS BASED ON ANALYTICAL DATA

APPROVED BY: ________________

CCI
ANALYTICAL
LABORATORIES, INC.

CERTIFICATE OF ANALYSIS

CLIENT: PORT OF PORT ANGELES
P.O. BOX 1350
PORT ANGELES, WA 98362

DATE: 1/16/98
CCIL JOB #: 801001
CCIL SAMPLE #: 2
DATE RECEIVED: 12/31/97
WDOE ACCREDITATION #: C142

CLIENT CONTACT: KENNETH SWEENEY

CLIENT PROJECT ID: TUMWATER CREEK DREDGING
CLIENT SAMPLE ID: 2A & 2B 12/29/97 1640

DATA RESULTS

ANALYTE	METHOD	RESULTS*	UNITS**	ACTION LEVEL***	ANALYSIS DATE	ANALYSIS BY
DICHLORODIFLUOROMETHANE	EPA-8260A	ND(<20)	UG/KG		1/6/98	LRK
CHLOROMETHANE	EPA-8260A	ND(<20)	UG/KG		1/6/98	LRK
VINYL CHLORIDE	EPA-8260A	ND(<20)	UG/KG		1/6/98	LRK
BROMOMETHANE	EPA-8260A	ND(<20)	UG/KG		1/6/98	LRK
CHLOROETHANE	EPA-8260A	ND(<20)	UG/KG		1/6/98	LRK
TRICHLOROFLUOROMETHANE	EPA-8260A	ND(<10)	UG/KG		1/6/98	LRK
ACETONE	EPA-8260A	ND(<150)	UG/KG		1/6/98	LRK
1,1-DICHLOROETHENE	EPA-8260A	ND(<10)	UG/KG		1/6/98	LRK
CARBON DISULFIDE	EPA-8260A	ND(<10)	UG/KG		1/6/98	LRK
METHYLENE CHLORIDE	EPA-8260A	ND(<10)	UG/KG		1/6/98	LRK
ACRYLONITRILE	EPA-8260A	ND(<50)	UG/KG		1/6/98	LRK
TRANS-1,2-DICHLOROETHENE	EPA-8260A	ND(<10)	UG/KG		1/6/98	LRK
1,1-DICHLOROETHANE	EPA-8260A	ND(<10)	UG/KG		1/6/98	LRK
2-BUTANONE	EPA-8260A	ND(<50)	UG/KG		1/6/98	LRK
CIS-1,2-DICHLOROETHENE	EPA-8260A	ND(<10)	UG/KG		1/6/98	LRK
2,2-DICHLOROPROPANE	EPA-8260A	ND(<10)	UG/KG		1/6/98	LRK
BROMOCHLOROMETHANE	EPA-8260A	ND(<10)	UG/KG		1/6/98	LRK
CHLOROFORM	EPA-8260A	ND(<10)	UG/KG		1/6/98	LRK
1,1,1-TRICHLOROETHANE	EPA-8260A	ND(<10)	UG/KG		1/6/98	LRK
1,1-DICHLOROPROPENE	EPA-8260A	ND(<10)	UG/KG		1/6/98	LRK
CARBON TETRACHLORIDE	EPA-8260A	ND(<10)	UG/KG		1/6/98	LRK
1,2-DICHLOROETHANE	EPA-8260A	ND(<10)	UG/KG		1/6/98	LRK
BENZENE	EPA-8260A	ND(<10)	UG/KG		1/6/98	LRK
TRICHLOROETHENE	EPA-8260A	ND(<10)	UG/KG		1/6/98	LRK
1,2-DICHLOROPROPANE	EPA-8260A	ND(<10)	UG/KG		1/6/98	LRK
1,4-DIOXANE	EPA-8260A	ND(<100)	UG/KG		1/6/98	LRK
DIBROMOMETHANE	EPA-8260A	ND(<10)	UG/KG		1/6/98	LRK
BROMODICHLOROMETHANE	EPA-8260A	ND(<10)	UG/KG		1/6/98	LRK
TRANS-1,3-DICHLOROPROPENE	EPA-8260A	ND(<10)	UG/KG		1/6/98	LRK
4-METHYL-2-PENTANONE	EPA-8260A	ND(<50)	UG/KG		1/6/98	LRK
TOLUENE	EPA-8260A	ND(<10)	UG/KG		1/6/98	LRK
CIS-1,3-DICHLOROPROPENE	EPA-8260A	ND(<10)	UG/KG		1/6/98	LRK
1,1,2-TRICHLOROETHANE	EPA-8260A	ND(<10)	UG/KG		1/6/98	LRK
2-HEXANONE	EPA-8260A	ND(<50)	UG/KG		1/6/98	LRK
1,3-DICHLOROPROPANE	EPA-8260A	ND(<10)	UG/KG		1/6/98	LRK

CCI
ANALYTICAL
LABORATORIES, INC.

CERTIFICATE OF ANALYSIS

CLIENT: PORT OF PORT ANGELES
P.O. BOX 1350
PORT ANGELES, WA 98362

DATE: 1/16/98
CCIL JOB #: 801001
CCIL SAMPLE #: 2
DATE RECEIVED: 12/31/97
WDOE ACCREDITATION #: C142

CLIENT CONTACT: KENNETH SWEENEY

CLIENT PROJECT ID: TUMWATER CREEK DREDGING
CLIENT SAMPLE ID: 2A & 2B 12/29/97 1640

DATA RESULTS

ANALYTE	METHOD	RESULTS*	UNITS**	ACTION LEVEL***	ANALYSIS DATE	ANALYSIS BY
TETRACHLOROETHYLENE	EPA-8260A	ND(<10)	UG/KG		1/6/98	LRK
DIBROMOCHLOROMETHANE	EPA-8260A	ND(<10)	UG/KG		1/6/98	LRK
1,2-DIBROMOETHANE	EPA-8260A	ND(<10)	UG/KG		1/6/98	LRK
CHLOROBENZENE	EPA-8260A	ND(<10)	UG/KG		1/6/98	LRK
1,1,1,2-TETRACHLOROETHANE	EPA-8260A	ND(<10)	UG/KG		1/6/98	LRK
ETHYLBENZENE	EPA-8260A	ND(<10)	UG/KG		1/6/98	LRK
M+P XYLENE	EPA-8260A	ND(<20)	UG/KG		1/6/98	LRK
STYRENE	EPA-8260A	ND(<10)	UG/KG		1/6/98	LRK
O-XYLENE	EPA-8260A	ND(<10)	UG/KG		1/6/98	LRK
BROMOFORM	EPA-8260A	ND(<10)	UG/KG		1/6/98	LRK
ISOPROPYLBENZENE	EPA-8260A	ND(<10)	UG/KG		1/6/98	LRK
1,1,2,2-TETRACHLOROETHANE	EPA-8260A	ND(<10)	UG/KG		1/6/98	LRK
1,2,3-TRICHLOROPROPANE	EPA-8260A	ND(<10)	UG/KG		1/6/98	LRK
BROMOBENZENE	EPA-8260A	ND(<10)	UG/KG		1/6/98	LRK
N-PROPYL BENZENE	EPA-8260A	ND(<10)	UG/KG		1/6/98	LRK
2-CHLOROTOLUENE	EPA-8260A	ND(<10)	UG/KG		1/6/98	LRK
1,3,5-TRIMETHYLBENZENE	EPA-8260A	ND(<10)	UG/KG		1/6/98	LRK
4-CHLOROTOLUENE	EPA-8260A	ND(<10)	UG/KG		1/6/98	LRK
T-BUTYL BENZENE	EPA-8260A	ND(<10)	UG/KG		1/6/98	LRK
1,2,4-TRIMETHYL BENZENE	EPA-8260A	ND(<10)	UG/KG		1/6/98	LRK
S-BUTYL BENZENE	EPA-8260A	ND(<10)	UG/KG		1/6/98	LRK
P-ISOPROPYLTOLUENE	EPA-8260A	ND(<10)	UG/KG		1/6/98	LRK
1,3 DICHLOROBENZENE	EPA-8260A	ND(<10)	UG/KG		1/6/98	LRK
1,4-DICHLOROBENZENE	EPA-8260A	ND(<10)	UG/KG		1/6/98	LRK
N-BUTYLBENZENE	EPA-8260A	ND(<10)	UG/KG		1/6/98	LRK
1,2-DICHLOROBENZENE	EPA-8260A	ND(<10)	UG/KG		1/6/98	LRK
1,2-DIBROMO 3-CHLOROPROPANE	EPA-8260A	ND(<50)	UG/KG		1/6/98	LRK
1,2,4-TRICHLOROBENZENE	EPA-8260A	ND(<10)	UG/KG		1/6/98	LRK
HEXACHLORO1,3-BUTADIENE	EPA-8260A	ND(<10)	UG/KG		1/6/98	LRK
NAPHTHALENE	EPA-8260A	ND(<10)	UG/KG		1/6/98	LRK
1,2,3-TRICHLOROBENZENE	EPA-8260A	ND(<10)	UG/KG		1/6/98	LRK
BIS(2-CHLOROETHYL)ETHER	EPA-8270	ND(<100)	UG/KG		1/8/98	LRK
PHENOL	EPA-8270	ND(<100)	UG/KG		1/8/98	LRK
2-CHLOROPHENOL	EPA-8270	ND(<100)	UG/KG		1/8/98	LRK

CERTIFICATE OF ANALYSIS

CLIENT: PORT OF PORT ANGELES
P.O. BOX 1350
PORT ANGELES, WA 98362

DATE: 1/16/98
CCIL JOB #: 801001
CCIL SAMPLE #: 2
DATE RECEIVED: 12/31/97
WDOE ACCREDITATION #: C142

CLIENT CONTACT: KENNETH SWEENEY

CLIENT PROJECT ID: TUMWATER CREEK DREDGING
CLIENT SAMPLE ID: 2A & 2B 12/29/97 1640

DATA RESULTS

ANALYTE	METHOD	RESULTS*	UNITS**	ACTION LEVEL***	ANALYSIS DATE	ANALYSIS BY
1,3-DICHLOROBENZENE	EPA-8270	ND(<100)	UG/KG		1/8/98	LRK
1,4-DICHLOROBENZENE	EPA-8270	ND(<100)	UG/KG		1/8/98	LRK
1,2-DICHLOROBENZENE	EPA-8270	ND(<100)	UG/KG		1/8/98	LRK
BENZYL ALCOHOL/2-METHYLPHENOL	EPA-8270	ND(<200)	UG/KG		1/8/98	LRK
BIS(2-CHLOROISOPROPYL)ETHER	EPA-8270	ND(<100)	UG/KG		1/8/98	LRK
HEXACHLOROETHANE	EPA-8270	ND(<100)	UG/KG		1/8/98	LRK
N-NITROSO-DI-N-PROPYLAMINE	EPA-8270	ND(<100)	UG/KG		1/8/98	LRK
4-METHYLPHENOL	EPA-8270	ND(<100)	UG/KG		1/8/98	LRK
NITROBENZENE	EPA-8270	ND(<100)	UG/KG		1/8/98	LRK
ISOPHORONE	EPA-8270	ND(<100)	UG/KG		1/8/98	LRK
2-NITROPHENOL	EPA-8270	ND(<100)	UG/KG		1/8/98	LRK
2,4-DIMETHYLPHENOL	EPA-8270	ND(<100)	UG/KG		1/8/98	LRK
BENZOIC ACID	EPA-8270	ND(<500)	UG/KG		1/8/98	LRK
BIS(2-CHLOROETHOXY)METHANE	EPA-8270	ND(<100)	UG/KG		1/8/98	LRK
2,4-DICHLOROPHENOL	EPA-8270	ND(<100)	UG/KG		1/8/98	LRK
1,2,4-TRICHLOROBENZENE	EPA-8270	ND(<100)	UG/KG		1/8/98	LRK
NAPHTHALENE	EPA-8270	ND(<100)	UG/KG		1/8/98	LRK
4-CHLOROANILINE	EPA-8270	ND(<100)	UG/KG		1/8/98	LRK
HEXACHLOROBUTADIENE	EPA-8270	ND(<100)	UG/KG		1/8/98	LRK
4-CHLORO-3-METHYLPHENOL	EPA-8270	ND(<100)	UG/KG		1/8/98	LRK
2-METHYLNAPHTHALENE	EPA-8270	ND(<100)	UG/KG		1/8/98	LRK
HEXACHLOROCYCLOPENTADIENE	EPA-8270	ND(<100)	UG/KG		1/8/98	LRK
2,4,6-TRICHLOROPHENOL	EPA-8270	ND(<100)	UG/KG		1/8/98	LRK
2,4,5-TRICHLOROPHENOL	EPA-8270	ND(<100)	UG/KG		1/8/98	LRK
2-CHLORONAPHTHANLENE	EPA-8270	ND(<100)	UG/KG		1/8/98	LRK
2-NITROANILINE	EPA-8270	ND(<100)	UG/KG		1/8/98	LRK
ACENAPHTHYLENE	EPA-8270	ND(<100)	UG/KG		1/8/98	LRK
DIMETHYLPHTHALATE	EPA-8270	ND(<100)	UG/KG		1/8/98	LRK
2,6-DINITROTOLUENE	EPA-8270	ND(<100)	UG/KG		1/8/98	LRK
ACENAPHATHENE	EPA-8270	ND(<100)	UG/KG		1/8/98	LRK
3-NITROANILINE	EPA-8270	ND(<100)	UG/KG		1/8/98	LRK
2,4-DINITROPHENOL	EPA-8270	ND(<1000)	UG/KG		1/8/98	LRK
DIBENZOFURAN	EPA-8270	ND(<100)	UG/KG		1/8/98	LRK
2,4-DINITROTOLUENE	EPA-8270	ND(<100)	UG/KG		1/8/98	LRK
4-NITROPHENOL	EPA-8270	ND(<1000)	UG/KG		1/8/98	LRK

CERTIFICATE OF ANALYSIS

CLIENT: PORT OF PORT ANGELES
P.O. BOX 1350
PORT ANGELES, WA 98362

DATE: 1/16/98
CCIL JOB #: 801001
CCIL SAMPLE #: 2
DATE RECEIVED: 12/31/97
WDOE ACCREDITATION #: C142

CLIENT CONTACT: KENNETH SWEENEY

CLIENT PROJECT ID: TUMWATER CREEK DREDGING
CLIENT SAMPLE ID: 2A & 2B 12/29/97 1640

DATA RESULTS

ANALYTE	METHOD	RESULTS*	UNITS**	ACTION LEVEL***	ANALYSIS DATE	ANALYSIS BY
FLUORENE	EPA-8270	ND(<100)	UG/KG		1/8/98	LRK
4-CHLOROPHENYL-PHENYLETHER	EPA-8270	ND(<100)	UG/KG		1/8/98	LRK
DIETHYLPHTHALATE	EPA-8270	ND(<100)	UG/KG		1/8/98	LRK
4-NITROANILINE	EPA-8270	ND(<100)	UG/KG		1/8/98	LRK
4,6-DINITRO-2-METHYLPHENOL	EPA-8270	ND(<1000)	UG/KG		1/8/98	LRK
N-NITROSODIPHENYLAMINE	EPA-8270	ND(<100)	UG/KG		1/8/98	LRK
4-BROMOPHENYL-PHENYLETHER	EPA-8270	ND(<100)	UG/KG		1/8/98	LRK
HEXACHLOROBENZENE	EPA-8270	ND(<100)	UG/KG		1/8/98	LRK
PENTACHLOROPHENOL	EPA-8270	ND(<1000)	UG/KG		1/8/98	LRK
PHENANTHRENE	EPA-8270	ND(<100)	UG/KG		1/8/98	LRK
ANTHRACENE	EPA-8270	ND(<100)	UG/KG		1/8/98	LRK
CARBAZOLE	EPA-8270	ND(<100)	UG/KG		1/8/98	LRK
DI-N-BUTYLPHTHALATE	EPA-8270	ND(<100)	UG/KG		1/8/98	LRK
FLUORANTHENE	EPA-8270	ND(<100)	UG/KG		1/8/98	LRK
PYRENE	EPA-8270	ND(<100)	UG/KG		1/8/98	LRK
BUTYLBENZYLPHTHALATE	EPA-8270	ND(<100)	UG/KG		1/8/98	LRK
3,3'-DICHLOROBENZIDINE	EPA-8270	ND(<100)	UG/KG		1/8/98	LRK
BENZO[A]ANTHRACENE	EPA-8270	ND(<100)	UG/KG		1/8/98	LRK
CHRYSENE	EPA-8270	ND(<100)	UG/KG		1/8/98	LRK
BIS(2-ETHYLHEXYL)PHTHALATE	EPA-8270	ND(<100)	UG/KG		1/8/98	LRK
DI-N-OCTYLPHTHALATE	EPA-8270	ND(<100)	UG/KG		1/8/98	LRK
BENZO[B]FLUORANTHENE	EPA-8270	ND(<100)	UG/KG		1/8/98	LRK
BENZO[K]FLUORANTHENE	EPA-8270	ND(<100)	UG/KG		1/8/98	LRK
INDENO[1,2,3-CD]PYRENE	EPA-8270	ND(<100)	UG/KG		1/8/98	LRK
DIBENZ[A,H]ANTHRACENE	EPA-8270	ND(<100)	UG/KG		1/8/98	LRK
BENZO[G,H,I]PERYLENE	EPA-8270	ND(<100)	UG/KG		1/8/98	LRK
ARSENIC	EPA-7060	1.2	MG/KG		1/9/98	JLB
BARIUM	EPA-7081	27	MG/KG		1/13/98	JLB
CADMIUM	EPA-7130	ND(<0.2)	MG/KG		1/9/98	JLB
CHROMIUM	EPA-7190	11	MG/KG		1/8/98	JLB
LEAD	EPA-7420	ND(<8)	MG/KG		1/9/98	JLB
MERCURY	EPA-7471MOD	ND(<0.025)	MG/KG		1/13/98	JLB
SELENIUM	EPA-7740	ND(<1)	MG/KG		1/12/98	JLB
SILVER	EPA-7760	ND(<0.4)	MG/KG		1/8/98	JLB

CCI
ANALYTICAL
LABORATORIES, INC.

CERTIFICATE OF ANALYSIS

CLIENT: PORT OF PORT ANGELES
P.O. BOX 1350
PORT ANGELES, WA 98362

DATE: 1/16/98
CCIL JOB #: 801001
CCIL SAMPLE #: 2
DATE RECEIVED: 12/31/97
WDOE ACCREDITATION #: C142

CLIENT CONTACT: KENNETH SWEENEY

CLIENT PROJECT ID: TUMWATER CREEK DREDGING
CLIENT SAMPLE ID: 2A & 2B 12/29/97 1640

DATA RESULTS

ANALYTE	METHOD	RESULTS*	UNITS**	ACTION LEVEL***	ANALYSIS DATE	ANALYSIS BY

* "ND" INDICATES ANALYTE NOT DETECTED AT LEVEL ABOVE REPORTING LIMIT. REPORTING LIMIT IS GIVEN IN PARENTHESES

** UNITS FOR ALL NON LIQUID SAMPLES ARE REPORTED ON A DRY WEIGHT BASIS

*** ACTIONS LEVELS ARE PROVIDED ONLY WHEN PARAMETER DATA IS USED FOR A GENERALLY CONSISTENT APPLICATION. WHEN PROVIDED, THEY SHOULD BE USED AS GUIDELINES ONLY. THE APPROPRIATE REGULATORY DOCUMENT SHOULD BE CONSULTED BEFORE MAKING ANY DECISIONS BASED ON ANALYTICAL DATA

APPROVED BY: ______________________

CCI
ANALYTICAL
LABORATORIES, INC.

CERTIFICATE OF ANALYSIS

CLIENT: PORT OF PORT ANGELES
P.O. BOX 1350
PORT ANGELES, WA 98362

DATE: 1/16/98
CCIL JOB #: 801001

DATE RECEIVED: 12/31/97
WDOE ACCREDITATION #: C142

CLIENT CONTACT: KENNETH SWEENEY

CLIENT PROJECT ID: TUMWATER CREEK DREDGING

QUALITY CONTROL RESULTS

SURROGATE RECOVERY

CCIL SAMPLE ID	ANALYTE	SUR ID	% RECV
801001-01	EPA-8260A	1,2-DCE-d4	95
801001-01	EPA-8260A	TOLUENE-d8	114
801001-01	EPA-8260A	4-BFB	114
801001-01	EPA-8270	2-FLUOROPHENOL	56
801001-01	EPA-8270	PHENOL-d5	68
801001-01	EPA-8270	NITROBENZENE-d5	69
801001-01	EPA-8270	2-FLUOROBIPHENYL	83
801001-01	EPA-8270	2,4,6-TRIBROMOPHENOL	56
801001-01	EPA-8270	TERPHENYL-d14	77
801001-02	EPA-8260A	1,2-DCE-d4	99
801001-02	EPA-8260A	TOLUENE-d8	114
801001-02	EPA-8260A	4-BFB	112
801001-02	EPA-8270	2-FLUOROPHENOL	78
801001-02	EPA-8270	PHENOL-d5	79
801001-02	EPA-8270	NITROBENZENE-d5	84
801001-02	EPA-8270	2-FLUOROBIPHENYL	89
801001-02	EPA-8270	2,4,6-TRIBROMOPHENOL	61
801001-02	EPA-8270	TERPHENYL-d14	81

APPROVED BY: ______________________

CCI
Analytical
Laboratories, Inc.

February 6, 1998

Mr Ken Sweeney
Port of Port Angeles
P.O. Box 1350
Port Angeles, WA 98362

Re: Tumwater Creek Dredging Samples

Dear Mr. Sweeney

After our discussion this morning, I spoke to Jim Ross at Ecology's Manchester Lab. It appears that confusion exists regarding the metals method desired and the method actually performed. Per the instructions on the attached Chain of Custody, our laboratory performed total metal determinations on the samples.

It appears the regulatory criteria is based on TCLP metals concentrations. Although we did not perform TCLP extractions on these samples, in this case it is possible to determine what the worst case TCLP concentration would be based on the total metal concentration. This is achieved by dividing the total metal concentration by 20.

I hope this addresses all issues, if not, please don't hesitate to give me a call. I look forward to being able to work with you in the future.

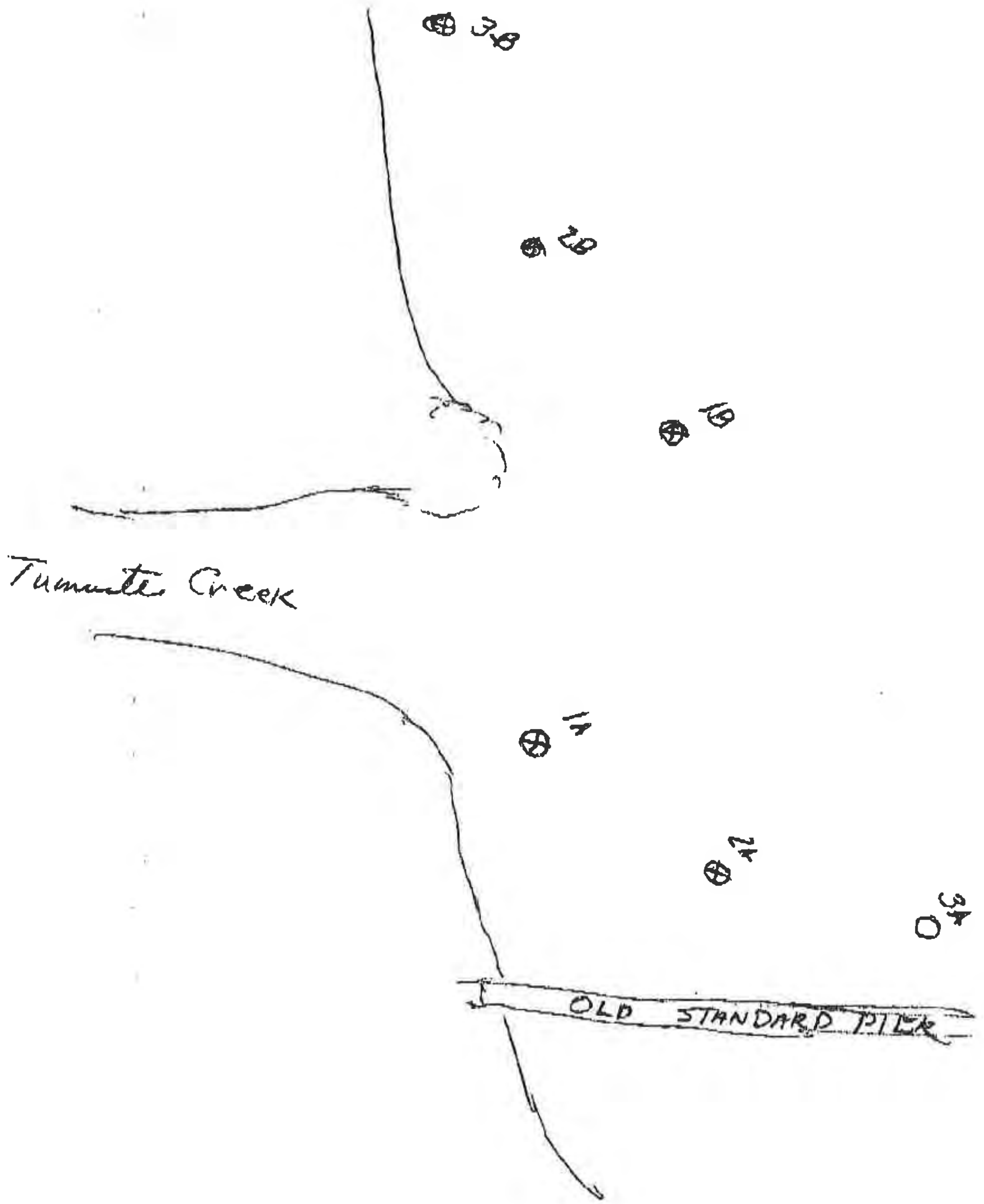
Sincerely,

Chuck Rancatti
Laboratory Director

3229 Pine St. • Everett, WA 98201 • 425 258-4548 • FAX 425 259-6289 • Seattle 206 292-9059

from Ken Sweeney
P of PA
NOV 20, 2000
8.2.30

SAMPLING LOCATIONS
December 1997



Marine Trades Area Site
Port Angeles, Washington

Final
Remedial Investigation/ Feasibility Study

Appendix F
Vapor Modeling Memorandum

10 YEARS 1996-2006
FLOYD | SNIDER
strategy ▪ science ▪ engineering
Two Union Square • 601 Union Street • Suite 600
Seattle, Washington 98101 • tel: 206.292.2078 • fax: 206.682.7867

Memorandum

To: Tom Colligan, F|S
Copies:
From: Megan King, F|S
Date: August 18, 2009
Project No: SJZ-MTA
Re: **Vapor Intrusion Modeling, K-Ply Facility**

As part of the Feasibility Study preparation process, the potential for soil vapor intrusion into the K-Ply facility located adjacent to the Marine Trades Area (MTA) site, and the Platypus Marine shop building was evaluated. The results of this evaluation are included in the following memorandum.

INTRUSION MODEL SELECTION

The common method used to determine inhalation risk to building occupants resulting from soil vapor intrusion is the Johnson and Ettinger Model (J&E Model, USEPA 1991). The model was developed to assess inhalation risk by estimating the mass of volatile contaminants transferred to indoor air from the underlying groundwater.

J&E MODEL LIMITATIONS

The J&E Model calculates mass transfer of contaminant vapors into buildings by assuming an infinite, steady state contaminant mass is present beneath the building of concern. Vapor intrusion is controlled by the rate of diffusion and advection of vapors through the unsaturated soil zone, and into the building. The model often provides a greatly overestimated indoor air concentration by overestimating the groundwater to soil vapor release mechanism that can occur while the plume is migrating beneath the building. In addition, the J&E Model is limited in application by the set input parameters. The model was developed to evaluate two different building constructions: the first is cement slab on grade construction, the second, buildings with a sub-grade basement, also constructed of concrete. While the Platypus Marine shop building is constructed on a concrete slab, the K-Ply facility is wood plank construction, with an above ground crawl space. The crawl space is dirt floor. The J&E model was not developed to appropriately evaluate vapor intrusion under the existing site conditions. Since the J&E model assumes vapor intrusion through cement building slabs, cracks and seams, this inconsistency with the actual K-Ply building construction limits the applicability of the model to the site.

GROUNDWATER MASS FLUX MODEL

An alternative to the J&E Model, referred to as the Groundwater Flux Model (McHugh, 2003), was evaluated for the K-Ply and Platypus Marine building. Like the J&E Model, the Groundwater Flux Model is a screening level tool developed to evaluate contaminant volatilization from contaminated groundwater into occupied structures. Unlike the J&E Model, the Groundwater Flux Model considers the mass balance between groundwater and vapor phases beneath the building, providing a more reasonable model of actual mass transfer and volatilization of groundwater contaminants. With the Groundwater Flux Model, as groundwater passes beneath the building, the contaminant mass migrates to the vapor phase of the overlying soil zone via diffusion and subsequently moves upward into the overlying structure. During the time period of plume migration beneath the building, the vertical mass flux from the groundwater plume to the unsaturated soil zone is assumed to be limited only by vertical diffusion and dispersion of contaminants through the groundwater-bearing unit. The groundwater seepage velocity (which is not accounted for in the J&E Model) influences the vertical mass flux by determining a residence time for the contaminated plume beneath the building. The following paragraphs discuss the applicability of this method to the K-Ply facility.

MODEL ASSUMPTIONS AND APPLICABILITY

The Groundwater Flux Model makes the conservative assumptions that no impedance to vapor transport is caused by the unsaturated soils above the groundwater plume, or the building foundation. Essentially, the model assumes that all contaminants volatilized beneath the building will enter the indoor air, and the foundation construction of the building is irrelevant. The GFM also assumes that the attenuation factor of unsaturated soils is equal to 1. Vapor entering the building is assumed to mix immediately and completely, as is assumed with the J&E Model. The model remains conservative, but also limits the over-prediction of potential indoor air concentrations by recognizing that the total max flux of contaminants from the groundwater plume to the vapor phase cannot exceed the total mass loss occurring from the impacted groundwater plume due to vertical diffusion to the top of the plume during the groundwater's residence time beneath the building (McHugh, 2003). The following section describes the input values used by the Groundwater Flux Model to calculate a groundwater concentration protective of indoor air.

INPUT PARAMETERS

Factors affecting the screening level groundwater concentration protective of indoor air resulting from the GFM include the following parameters:

Parameter	Value	Units	Symbol	Source
Maximum Allowable Indoor Air Benzene Concentration	$3.2x10^{-3}$	mg/m^3	C_{ia}	MTCA Method C Target Indoor Air Limit
K-Ply Mill Building Volume	199,448	m^3	BV	Estimated using site drawings, and information from the onsite facilities manager
Platypus Marine Building Volume	2,523	m^3	BV	Estimated using site drawings, and information collected during site visits.

K-Ply Mill Indoor Air Exchange Rate	25	day^{-1}	ER	Estimated based on State ventilation requirements, assumed half the rate of required garage/repair shop ventilation.
Platypus Marine Indoor Air Exchange	16	day^{-1}	ER	Estimated based on State ventilation requirements, assumed to be rate required for office buildings.
K-Ply Mill Building width, perpendicular to the groundwater flow direction	98	m	w	Estimated from site drawings, and current groundwater monitoring data
Platypus Marine Building width, perpendicular to the groundwater flow direction	37	m	w	Estimated from site drawings, and current groundwater monitoring data
Porosity of the saturated aquifer	0.38	-	n	Laboratory value of samples collected during geotechnical evaluation, value selected based on soil type, and depth
Molecular diffusion rate of Benzene in water	8.47×10^{-5}	m^2/day	Dm	Published value from USEPA 2002 Draft Subsurface Vapor Intrusion Guidance
K-Ply Mill Building length, parallel to the groundwater flow direction	183	m	L	Estimated from site drawings, and current groundwater monitoring data
Platypus Marine Building length, parallel to the groundwater flow direction	22	m	L	Estimated from site drawings, and current groundwater monitoring data
Groundwater seepage velocity	0.0244	m/day	v	Calculated in Floyd|Snider July 2007 Draft Memo to Ecology RE: Conclusions Regarding 2006 F|S Report.
Vertical diffusion coefficient in groundwater	2.85×10^{-3}	m^2/day	Da	Estimated by $Da = \alpha_z * v + n^{1/3} * Dm$, where α_z is vertical dispersivity, approximated as 0.0625% of L, and $n^{1/3}$ represents tortuosity in the saturated aquifer.

The following equation calculates the groundwater concentration screening level protective of a given indoor air concentration. In this case, the USEPA Target Indoor Air Limit, also applied as the MTCA Method C Industrial Indoor Air cleanup level, of 3.2×10^{-3} mg/m^3 was used.

$$\text{Concentration in groundwater (mg/L)} = \frac{\frac{1}{2} * C_{ia} * BV * ER}{w * n * \sqrt{(Da * L * v/\pi)}}$$

The K-Ply building specific groundwater concentration protective of indoor air from the above equation is 3,362 mg/L.

The concentration protective of indoor air for the Platypus Marine shop building based on this calculation is 586 mg/L.

EVALUATION AND APPLICATION OF THE CALCULATED SCREENING LEVEL

Historical groundwater sampling of monitoring wells at the K-Ply facility identified no samples with benzene concentrations above the Groundwater Flux Model screening level for either the K-Ply or Platypus Marine facility. The highest concentration detected onsite was in a sample from monitoring well PP-03 in March 1988 containing 14 mg/L benzene. Semi-annual sampling at the site has resulted in concentrations consistently below both the K-Ply building and Platypus Marine building-specific GFM screening levels of 3,300 mg/L, and 575 mg/L respectively. The most current investigation conducted in January, 2009 by Landau identified benzene concentrations in groundwater beneath the K-Ply facility ranging from non-detect to 11 mg/L.

There are no current groundwater data from monitoring wells indicating concentrations of benzene in the Cedar Street Plume beneath the K-Ply building exceed the calculated screening level protective of indoor air. Groundwater samples collected during geoprobe soil boring activities in 2005 and 2006 performed as part of the MTA Remedial Investigation were also below the screening level in boring locations along Cedar Street to the west of the K-Ply facility. The results of geoprobe groundwater samples, however, are not as representative of actual benzene concentrations, as samples collected from properly installed and developed monitoring wells. Geoprobe groundwater samples are collected using a retractable screen over a short depth interval, often resulting in highly turbid samples that are not representative of the entire aquifer sampled. Highly turbid samples tend to bias results high due to the contribution of petroleum compounds entrained on soil particles, and results are not reproducible, as soil borings are temporary. While useful in characterizing groundwater contamination, geoprobe groundwater samples are not as reliable for assessing risk, for which monitoring well data is preferable.

Available benzene groundwater sampling results from beneath the Platypus Marine shop building indicate benzene is present at concentrations less than approximately 1.0 mg/L. Monitoring well MW-33, to the west of the Platypus Marine building was installed in February 2008. A sample collected from MW-33 contained a benzene concentration of 0.083 mg/L. Due to the limited monitoring well data from the vicinity of the Platypus Marine building, benzene concentrations are estimated based on geoprobe groundwater samples, groundwater flow directions, and plume concentration contouring, in addition to results from nearby monitoring well MW-33. Despite the limitations of geoprobe groundwater samples noted above, their use for the Platypus Marine shop building is conservative because geoprobe groundwater samples are typically biased high. This concentration range is less than the building-specific GFM screening level of 575 mg/L.

The concentrations of benzene in groundwater beneath the K-Ply facility and the Platypus Marine shop building do not appear to present a vapor intrusion risk greater than the USEPA target indoor air concentration based on modeling results. Although modeling provides an effective method to determine the potential for concern, modeling results can only be confirmed by analytical sampling. In this case, the existing concentrations present onsite do not appear to present a vapor concern, as the levels present in current groundwater samples are less than the calculated screening level.

LIMITATIONS

Calculation of a groundwater screening level relies on multiple parameters, the majority of which are estimated, based on known site conditions, and common estimated values. Variations in modeling results may occur from modification of the input parameters.

The model accounts for diffusion and dispersion of contaminants from the dissolved plume only, and does not account from vapor generated from contaminated unsaturated soils, or free-phase product. Evaluation of soil contamination impacting indoor air quality is discussed in the following section. There is a known NAPL plume beneath the K-Ply building, however this plume consists primarily of hydraulic oil, and does not contain substantial concentrations of benzene. Analytical results from monitoring wells containing NAPL did not contain concentrations of benzene above the calculated groundwater screening level.

The calculated groundwater screening levels for the K-Ply and Platypus Marine shop are applicable only to the respective facilities, as the concentrations are determined based on building and contaminant characteristics beneath the associated structures. Contaminated groundwater could potentially present a vapor intrusion risk to new construction on the site; however, there are currently no plans for additional construction at the MTA or K-Ply facility. Vapor intrusion into new construction will require evaluation during building design to determine a building-specific screening level based on the plume characteristics and building structure.

VADOSE ZONE SOIL CONTAMINATION EVALUATION

Investigation of the Cedar Street Benzene Plume, conducted by Landau in 2009 identified soil contamination beneath the footprint of the K-Ply facility in vadose zone soils. Prior to this investigation, benzene soil contamination had not been encountered at the K-Ply facility.

The maximum concentration of benzene in vadose zone soils detected during the Landau investigation was 24 mg/kg, from boring B-16 at a depth of 5.5 to 6.5 feet beneath the floor slab. Benzene was detected in vadose zone soils in the southern portion of the K-Ply facility at three other boring locations. The southern portion of the K-Ply facility is constructed on an elevated slab, 4.5 feet above ground surface. For the reasons discussed in the previous sections regarding the applicability of the J&E Model to the site, the model is not an accurate representation of existing conditions, however, can be used to provide a conceptual level estimate on the potential for exposure risk through inhalation of indoor air. Since the majority of the building is constructed of a plank wood floor with crawlspace, and only the bottom portion of the building is constructed of an above ground slab-on-grade, the model is again, not developed for modeling of the site conditions present at the K-Ply facility. To conduct a screening level evaluation, the J&E Model was used to conduct a conceptual level evaluation of the potential for vapor risk to the K-Ply facility from underlying vadose zone soils.

The J&E Model was conducted using the same assumptions used in the groundwater evaluation above. The building construction was modeled as slab-on-grade, with a building footprint of only the area where the foundation is constructed as slab-on-grade. This assumption is conservative, as it does not account for dilution of vapors throughout the whole building, and instead assumes that the area over the slab is an enclosed space. The other model input parameters used included default values, and site specific information as available.

The model calculated that a soil concentration protective of indoor air quality (using the MTCA Method C Industrial value for indoor air of 3.2E-3 mg/m^3) is approximately 1.2 mg/kg. Results of this conceptual evaluation indicate if the existing K-Ply building becomes occupied in the future, or if the building is demolished, and new construction is placed over the area of vadose zone soil contamination, additional investigation into the vapor pathway should be conducted.

REFERENCES

McHugh, Thomas E, et al. 2003. *A Groundwater Mass Flux Model For Groundwater-To-Indoor-Air Vapor Intrusion.* Proceedings of the Seventh International In Situ and On-Site Bioremediation Symposium, Orlando, FL, June 2003.

Floyd|Snider 2007. Memorandum to Lisa Pearson, Washington State Department of Ecology, Re: “Conclusions Regarding 2006 Floyd|Snider Report, Marine Trades Area and K-Ply Mill Site, Port Angeles, WA”, Landau Associates, June 1, 2007. September 12.

Landau Associates, 2003. Geotechnical Engineering Services Report, Proposed Westport Shipyard Manufacturing Faclity, Port Angeles, WA. January 27.

Landau Associates, 2005. K-Ply Hydraulic Oil Recovery System Monitoring Project. Second Quarter 2005 Monitoring Report. July 20.

Landau Associates, 2009. Cedar Street Benzene Plume Investigation Report. Former K-Ply Facility, Port Angeles, WA. April 3.

Washington State Department of Ecology, Clarc Database. https://fortress.wa.gov/ecy/clarc/Reporting/CLARCReporting.aspx

Marine Trades Area Site
Port Angeles, Washington

Final
Remedial Investigation/ Feasibility Study

Appendix G
Terrestrial Ecological Evaluation

Table 749-1

Simplified Terrestrial Ecological Evaluation - Exposure Analysis Procedure under WAC 173-340-7492 (2)(a)(ii).[a]

Estimate the area of contiguous (connected) undeveloped land on the site or within 500 feet of any area of the site to the nearest 1/2 acre (1/4 acre if the area is less than 0.5 acre). "Undeveloped land" means land that is not covered by existing buildings, roads, paved areas or other barriers that will prevent wildlife from feeding on plants, earthworms, insects or other food in or on the soil.

1) From the table below, find the number of points corresponding to the area and enter this number in the box to the right. 4

Area (acres)	Points
0.25 or less	4
0.5	5
1.0	6
1.5	7
2.0	8
2.5	9
3.0	10
3.5	11
4.0 or more	12

3

2) Is this an industrial or commercial property?

See WAC 173-340-7490 (3)(c). If yes, enter a score of 3 in the box to the right. If no, enter a score of 1. 3

3) Enter a score in the box to the right for the habitat quality of the site, using the rating system shown below[b]. (High = 1, Intermediate = 2, Low = 3) 2

4) Is the undeveloped land likely to attract wildlife? If yes, enter a score of 1 in the box to the right. If no, enter a score of 2. See footnote c. 4

5) Are there any of the following soil contaminants present:

Chlorinated dioxins/furans, PCB mixtures, DDT, DDE, DDD, aldrin, chlordane, dieldrin, endosulfan, endrin, heptachlor, benzene hexachloride, toxaphene, hexachlorobenzene, pentachlorophenol, pentachlorobenzene? If yes, enter a score of 1 in the box to the right. If no, enter a score of 4. 12

6) Add the numbers in the boxes on lines 2 through 5 and enter this number in the box to the right. If this number is larger than the number in the box on line 1, the simplified terrestrial ecological evaluation may be ended under WAC 173-340-7492 (2)(a)(ii).

Footnotes:

a It is expected that this habitat evaluation will be undertaken by an experienced field biologist. If this is not the case, enter a conservative score (1) for questions 3 and 4.

b Habitat rating system. Rate the quality of the habitat as high, intermediate or low based on your professional judgment as a field biologist. The following are suggested factors to consider in making this evaluation:

Low: Early successional vegetative stands; vegetation predominantly noxious, nonnative, exotic plant species or weeds. Areas severely disturbed by human activity, including intensively cultivated croplands. Areas isolated from other habitat used by wildlife.

High: Area is ecologically significant for one or more of the following reasons: Late-successional native plant communities present; relatively high species diversity; used by an uncommon or rare species; priority habitat (as defined by the Washington department of fish and wildlife); part of a larger area of habitat where size or fragmentation may be important for the retention of some species.

Intermediate: Area does not rate as either high or low.

c Indicate "yes" if the area attracts wildlife or is likely to do so. Examples: Birds frequently visit the area to feed; evidence of high use by mammals (tracks, scat, etc.); habitat "island" in an industrial area; unusual features of an area that make it important for feeding animals; heavy use during seasonal migrations.

Marine Trades Area Site
Port Angeles, Washington

Final
Remedial Investigation/ Feasibility Study

Appendix H
Cost Estimate Worksheets

Bulkhead Cleanup Area Cost Estimate Summary

	Alternative B2	**Alternative B3**[1]	**Alternative B3** ***West Side Only*** [1]	**Alternative B4**
Capital	$660,000	$770,000	$540,000	$1,300,000
30% Contingency	$198,000	$231,000	$162,000	$390,000
Capital with Contingency	$858,000	$1,001,000	$702,000	$1,690,000
Annual O&M	$111,000	$91,000	$73,000	$108,000
PV O&M (30 yrs)	$1,710,000	$1,400,000	$1,120,000	$1,660,000
PV Total	$2,570,000	$2,400,000	$1,820,000	$3,350,000

1 Estimate includes soil vapor extraction (SVE) system.

Bulkhead Cleanup Area
Alternative B2: Groundwater Recovery and Ex-Situ Treatment

CAPITAL AND CONSTRUCTION COSTS

Item		**Quantity**	**Unit**	**Unit Cost**	**Cost**	**Assumptions**
Predesign Studies						
	Aquifer Pumping Tests	1	LS	20000	$ 20,000	Determine aquifer properties for extraction system design
	Hydrogeologic Modeling	1	LS	30000	$ 30,000	Hydrogeologic measurements, model construction/validation, application for design
Engineering and Permitting						
	Design Report	1	LS	75000	$ 75,000	Does not include electrical system design
	Plans and Specs	1	LS	40000	$ 40,000	
	Bidding	1	LS	10000	$ 10,000	
	Permitting	1	LS	10000	$ 10,000	NPDES, state, county and local shoreline construction and grading permits if applicable
Groundwater Recovery System						
	Mobilization	1	LS	10000	$ 10,000	
	Utility Clearance	8	HR	125	$ 1,000	Includes travel
	Vactor clearance	1	DAY	3000	$ 3,000	Vactor borings to 5 feet per safety requirements; assumes 7/day, includes disposal of soil.
	Groundwater Extraction Well Installation	7	EA	5500	$ 38,500	Drilling cost, assumes 6" wells, 20 foot deep, with stainless steel V-wire screens, includes mobilization
	Precast Concrete Well Vaults	7	EA	2000	$ 14,000	Based on heavy duty vaults with covers for heavy loading capacity (Todd Shipyards)
	Well Development	28	HR	125	$ 3,500	Subcontractor cost, assumes 4 hours/well
	Submersible Pumps	7	EA	2200	$ 15,400	4" Submersible Pump, 8-14 gpm, Head <= 80', 1/3 hp, with controls and down-hole wiring and connections (after B&L Woodwaste Engineer's estimate).
	Surveying	3	DAY	1500	$ 4,500	Based on quote from Barghausen
	Electrical System Design and Installation	1	EA	60000	$ 60,000	Assumes water level sensor pump control system programmable for tidal variation
	Electrical Lines to/from System	700	LF	10	$ 7,000	Shared trench with piping to/from system. Assumes electrical wire, 2" PVC conduit, connections, control boxes only; earthwork included with piping cost
	Collection Lines/Trench to/from System	700	LF	35	$ 24,500	Material and labor to install, assumes lines configured in series, with trunk line to treatment system
	Discharge Line to Outfall	200	LF	50	$ 10,000	Material and labor to install 8" HDPE effluent pipe to depths of 8 feet bgs to discharge in Port Angeles Harbor
	Outfalls	1	EA	25000	$ 25,000	Assumes labor and materials to install pipe, tidal gate, remove and place riprap for armoring (after B&L Woodwaste interceptor trench outfall contractor bids)
Groundwater Recovery and Treatment						
	Storage Shed Construction	1	LS	20000	$ 20,000	Includes framing, sheathing, concrete slab, and electrical connections
	Storage Tank	1	EA	10000	$ 10,000	Vendor quote for 2,000 gallon cylindrical tank
	Transfer Pump/Filters	1	EA	1500	$ 1,500	
	Activated Carbon Filter	2	EA	3200	$ 6,400	
	System Piping and Connections	1	LS	1500	$ 1,500	
	Installation Labor	1	LS	10000	$ 10,000	Assumes assembly of system parts and initial startup
Site Closeout					$ -	
	Soil Transport and Disposal	28	DRUM	200	$ 5,600	Assumes contaminated soil cuttings at 4 drums/well, includes transporation, disposal, characterization sampling and oversight labor
	Water Transport and Disposal	21	DRUM	300	$ 6,300	Assumes contaminated water from well development and decon at 3 drums/well, includes transporation, disposal, characterization sampling
	System Testing and Commissioning	1	LS	3500	$ 3,500	
	Surface Restoration, Paving	2700	SF	12	$ 32,400	Assumes 900 LF pipe/electrical trenching, 3 feet wide. Cost assumes heavy load rating to match paving at Bulkhead for travel-lift. 9" AC (asphalt) paving ($8/SF), with subgrade preparation, or 8" PCC.
Oversight and Construction Management						
	Well installation oversight	5	DAY	1400	$ 7,000	Assumes oversight for installation and development, 1 FTE at 10 hours/day plus travel and accomodations
	Field oversight	5	WEEK	7500	$ 37,500	Assumes 1 FTE for 10 hour days at $135/hr plus travel and per diem
	Construction management		%	10	$ 31,360	Assumes 10% of construction costs
	Completion Report	1	EA	25000	$ 25,000	Per MTCA requirements. Includes as-built drawings, O&M manual
Subtotal					$ 599,460	
Sales tax (8.4%)		%			$26,342	
Surcharge on subcontractors (10%)		%			$31,360	
Capital Cost Subtotal					**$ 660,000**	
Contingency		30%			$ 198,000	
Capital Cost with Contingency					**$ 858,000**	
ANNUAL OPERATIONS, MAINTENANCE, AND LONG TERM MONITORING COSTS						
Item		Quantity	Unit	Unit Cost	Cost	Assumptions
	Groundwater and Water Level Monitoring Field Labor	2	EVENT	5000	$ 10,000	2 staff for 2 10-hour days plus per diem, travel, mobilization/demobilization
	Groundwater and Water Level Monitoring Analytical	2	EVENT	1500	$ 3,000	10 wells sampled for BTEX, TPH-G, and TPH-D per event
	Groundwater and Water Level Monitoring Reporting	2	EVENT	8000	$ 16,000	Semiannual compliance monitoring report
	System O&M	52	DAY	900	$ 46,800	Includes labor, repair, and system maintenance costs, 1 day/week by onsite employee, plus annual iron fouling maintenance.
	Carbon Replacement and Disposal	2	EA	5000	$ 10,000	Assumes 2 x 1000 lb vessels replaced 2 times per year, new material and disposal included
	Electricity	12	MO	500	$ 6,000	Estimated
	Annualized equipment replacement costs	1	YEAR	4000	$ 4,000	Assumes replacement and reinstallation of submersible pumps ($20000), tank ($10,000) and misc system components ($10,000) at 10 year intervals; 10-year costs are annualized.
	NPDES Monthly Monitoring and Reporting	12	MO	850	$ 10,200	Includes labor for monthly discharge monitoring (4 hours) and reporting (6 hours) monthly by onsite employee
	NPDES Discharge Permitting Fees	1	LS	1200	$ 1,200	NPDES discharge permitting annual fee, plus agency communications
Subtotal					$ 107,200	
Sales Tax (8.4%)		%			$2,537	
Surcharge on Subcontractors (10%)		%			$1,000	
Annual O&M Cost Total					**$ 111,000**	
Net Present Value of 30-year O&M Cost					**$ 1,710,000**	**Net discount rate of 5% used based on 2009 Port of Seattle RI/FS protocol. 5% net discount rate implies an 8% rate of return and an inflation rate of 3%, or equivalent.**
Total Present Value Cost for Alternative					**$ 2,570,000**	

Bulkhead Cleanup Area
Alternative B3: Air Sparge Curtain

CAPITAL AND CONSTRUCTION COSTS						
Item		**Quantity**	**Unit**	**Unit Cost**	**Cost**	**Assumptions**
Predesign Studies						
	Pilot Study	1	LS	60000	$ 60,000	Field testing to determine radius of influence, air distribution and flow rates, volatilization rate, safety hazards, etc.
Engineering and Permitting						
	Design Report	1	LS	60000	$ 60,000	
	Plans and Specs	1	LS	40000	$ 40,000	
	Bidding	1	LS	10000	$ 10,000	
	Permitting	1	LS	6000	$ 6,000	ORCAA air permit, state, county and local shoreline construction and grading permits if applicable
Air Sparge/SVE System						
	Mobilization	1	LS	10000	$ 10,000	
	Utility Clearance	8	HR	125	$ 1,000	Includes travel
	Vactor clearance	6	DAY	3000	$ 18,000	Vactor borings to 5 feet per safety requirements; assumes 10/day, includes disposal of soil.
	Well Installation	61	EA	1350	$ 82,350	Assumes 2 rows with 25-foot centers, drilling and materials cost for air sparge wells; assumes direct-push installation
	Well Vaults	61	EA	500	$ 30,500	Assumes heavy duty vaults with covers for heavy loading capacity
	Surveying	3	DAY	1500	$ 4,500	Based on quote from Barghausen
	Soil Vapor Extraction Piping	1855	LF	8	$ 14,840	Assumes 1 SVE pipe installed per air sparge transect, installed in same trench as air supply lines.
	Air Supply Piping	1855	LF	20	$ 37,100	Assumes trenching/backfill, PVC secondary containment pipe, hose, installed at wellheads
	Air Sparge System	1	EA	50000	$ 50,000	Assumes 30 rotary vane compressors @ $500/ea ($15,000; 20 CFM each or 10 CFM per sparge well), manifolds, flow meters, misc. connections, electrical control panel ($5000), installation.
	SVE System	1	ES	75000	$ 75,000	SVE blowers ($10,000), vapor treatment system (assumes 300 cfm catox; $40,000), controls, installation
	Air Sparge System Startup	1	LS	8000	$ 8,000	Assumes one week by technician
	Storage Shed Construction	1	EA	20000	$ 20,000	Includes framing, sheathing, concrete slab, and electrical connections
Site Closeout					$ -	
	Soil Transport and Disposal	30	DRUM	225	$ 6,750	Assumes soil cuttings at 2 wells/drum, includes transportation, disposal, characterization sampling and oversight labor.
	Water Transport and Disposal	12	DRUM	300	$ 3,600	Assumes contaminated water from decon, includes transporation, disposal, characterization sampling and oversight labor
	Surface Restoration, Paving	3000	SF	12	$ 36,000	Assumes 1000 LF trenching in paved areas, 3 feet wide in paved areas. Cost assumes heavy load rating to match existing pavement. 9" AC (asphalt) paving ($8/SF), with subgrade preparation, or 8" PCC.
Oversight and Construction Management						
	Well installation oversight	15	DAY	1400	$ 21,000	Assumes oversight for installation, 1 FTE at 10 hours/day plus travel and accomodations
	Field oversight - system installation	5	WEEK	7500	$ 37,500	Assumes 1 FTE for 10 hour days at $135/hr plus travel and per diem
	Construction management		%	10	$ 35,129	Assumes 10% of construction costs, minus waste T&D
	Completion report	1	EA	25000	$ 25,000	Per MTCA requirements. Includes as-built drawings, O&M manual
Subtotal					$ 692,269	
Sales tax (8.4%)		%			$33,402	
Surcharge on Subcontractors (10%)		%			$39,764	
Capital Cost Total					**$ 770,000**	
Contingency		30%			$ 231,000	
Capital Cost with Contingency					**$ 1,001,000**	
ANNUAL OPERATIONS, MAINTENANCE, AND LONG TERM MONITORING COSTS						
Item		Quantity	Unit	Unit Cost	Cost	Assumptions
	Groundwater and Water Level Monitoring Field Labor	2	EVENT	5000	$ 10,000	2 staff for 2 10-hour days plus per diem, travel, mobilization/demobilization
	Groundwater and Water Level Monitoring Analytical	2	EVENT	1750	$ 3,500	10 wells sampled for BTEX, TPH-G, and TPH-D per event; 1 annual air sample for VOCs
	Groundwater and Water Level Monitoring Reporting	2	EVENT	8000	$ 16,000	Semiannual compliance monitoring report. Includes air reporting.
	System O&M	52	DAY	750	$ 39,000	Includes labor, repair, and system maint costs, 1 day/week by onsite employee, includes monthly PID readings for catox, annual air sample
	Electricity	12	MO	500	$ 6,000	Estimated
	Annualized equipment replacement costs	1	YEAR	8000	$ 8,000	Assumes replacement and reinstallation of compressors (10 year life assumed), blowers (5 year), catox (10 year), misc. components at 10 year intervals; 10-year costs are annualized.
	Annual air permit fees	1	YEAR	200	$ 200	Local air discharge fees, if applicable.
Subtotal					$ 82,700	
Sales Tax (8.4%)		%			$4,452	
Surcharge on Subcontractors (10%)		%			$3,900	
Annual O&M Cost Total					**$ 91,000**	
Net Present Value of 30-year O&M Cost					**$ 1,400,000**	**Net discount rate of 5% used based on 2009 Port of Seattle RI/FS protocol. 5% net discount rate implies an 8% rate of return and an inflation rate of 3%, or equivalent.**
Total Present Value Cost for Alternative					**$ 2,400,000**	

Bulkhead Cleanup Area
Alternative B3: Air Sparge Curtain - *West Side of MTA Site Only*

CAPITAL AND CONSTRUCTION COSTS

Item		**Quantity**	**Unit**	**Unit Cost**	**Cost**	**Assumptions**
Predesign Studies						
	Pilot Study	1	LS	50000	$ 50,000	Field testing to determine radius of influence, air distribution and flow rates, volatilization rate, safety hazards, etc.
Engineering and Permitting						
	Design Report	1	LS	40000	$ 40,000	
	Plans and Specs	1	LS	27000	$ 27,000	
	Bidding	1	LS	10000	$ 10,000	
	Permitting	1	LS	6000	$ 6,000	ORCAA air permit, state, county and local shoreline construction and grading permits if applicable
Air Sparge/SVE System						
	Mobilization	1	LS	10000	$ 10,000	
	Utility Clearance	8	HR	125	$ 1,000	Includes travel
	Vactor clearance	4	DAY	3000	$ 12,000	Vactor borings to 5 feet per safety requirements; assumes 10/day, includes disposal of soil.
	Well Installation	35	EA	1350	$ 47,250	Assumes 2 rows with 25-foot centers, drilling and materials cost for air sparge wells; assumes direct-push installation
	Well Vaults	35	EA	500	$ 17,500	Assumes heavy duty vaults with covers for heavy loading capacity
	Surveying	2	DAY	1500	$ 3,000	Based on quote from Barghausen
	Soil Vapor Extraction Piping	1055	LF	8	$ 8,440	Assumes 1 SVE pipe installed per air sparge transect, installed in same trench as air supply lines.
	Air Supply Piping	1055	LF	20	$ 21,100	Assumes trenching/backfill, PVC secondary containment pipe, hose, installed at wellheads
	Air Sparge System	1	EA	35000	$ 35,000	Assumes 20 rotary vane compressors @ $500/ea ($10,000; 20 CFM each or 10 CFM per sparge well), manifolds, flow meters, misc. connections, electrical control panel ($5000), installation.
	SVE System	1	ES	50000	$ 50,000	SVE blowers ($7,000), vapor treatment system (assumes 250 cfm catox; $35,000), controls, installation
	Air Sparge System Startup	1	LS	6000	$ 6,000	Assumes one week by technician
	Storage Shed Construction	1	EA	16000	$ 16,000	Includes framing, sheathing, concrete slab, and electrical connections
Site Closeout					$ -	
	Soil Transport and Disposal	20	DRUM	250	$ 5,000	Assumes soil cuttings at 2 wells/drum, includes transportation, disposal, characterization sampling and oversight labor.
	Water Transport and Disposal	10	DRUM	300	$ 3,000	Assumes contaminated water from decon, includes transporation, disposal, characterization sampling and oversight labor
	Surface Restoration, Paving	2700	SF	12	$ 32,400	Assumes 1000 LF trenching in paved areas, 3 feet wide in paved areas. Cost assumes heavy load rating to match existing pavement. 9" AC (asphalt) paving ($8/SF), with subgrade preparation, or 8" PCC.
Oversight and Construction Management						
	Well installation oversight	9	DAY	1400	$ 12,600	Assumes oversight for installation, 1 FTE at 10 hours/day plus travel and accomodations
	Field oversight - system installation	3	WEEK	7500	$ 22,500	Assumes 1 FTE for 10 hour days at $135/hr plus travel and per diem
	Construction management		%	10	$ 26,769	Assumes 10% of construction costs, minus waste T&D
	Completion report	1	EA	25000	$ 25,000	Per MTCA requirements. Includes as-built drawings, O&M manual
Subtotal					$ 487,559	
Sales tax (8.4%)		%			$22,486	
Surcharge on Subcontractors (10%)		%			$26,769	
Capital Cost Total					**$ 540,000**	
Contingency		30%			$ 162,000	
Capital Cost with Contingency					**$ 702,000**	

ANNUAL OPERATIONS, MAINTENANCE, AND LONG TERM MONITORING COSTS

Item		Quantity	Unit	Unit Cost	Cost	Assumptions
	Groundwater and Water Level Monitoring Field Labor	2	EVENT	3000	$ 6,000	2 staff for 1 10-hour days plus per diem, travel, mobilization/demobilization
	Groundwater and Water Level Monitoring Analytical	2	EVENT	1100	$ 2,200	6 wells sampled for BTEX, TPH-G, and TPH-D per event; 1 annual air sample for VOCs
	Groundwater and Water Level Monitoring Reporting	2	EVENT	8000	$ 16,000	Semiannual compliance monitoring report. Includes air reporting.
	System O&M	52	DAY	600	$ 31,200	Includes labor, repair, and system maint costs, 1 day/week by onsite employee, includes monthly PID readings for catox, annual air sample
	Electricity	12	MO	500	$ 6,000	Estimated
	Annualized equipment replacement costs	1	YEAR	5000	$ 5,000	Assumes replacement and reinstallation of compressors (10 year life assumed), blowers (5 year), catox (10 year), misc. components at 10 year intervals; 10-year costs are annualized.
	Annual air permit fees	1	YEAR	200	$ 200	Local air discharge fees, if applicable.
Subtotal					$ 66,600	
Sales Tax (8.4%)		%			$3,545	
Surcharge on Subcontractors (10%)		%			$3,120	
Annual O&M Cost Total					**$ 73,000**	
Net Present Value of 30-year O&M Cost					**$ 1,120,000**	**Net discount rate of 5% used based on 2009 Port of Seattle RI/FS protocol. 5% net discount rate implies an 8% rate of return and an inflation rate of 3%, or equivalent.**
Total Present Value Cost for Alternative					**$ 1,820,000**	

Bulkhead Cleanup Area
Alternative B4: Barrier Wall with Active Interceptor Trench and Ex-Situ Treatment

CAPITAL AND CONSTRUCTION COSTS						
Item		**Quantity**	**Unit**	**Unit Cost**	**Cost**	**Assumptions**
Predesign Studies						
	Aquifer Pumping Tests	1	LS	20000	$ 20,000	Determine aquifer properties for interceptor trench design
	Geotechnical Study	1	LS	36000	$ 36,000	Borings and geotechnical analyses for barrier wall design
	Hydrogeologic Modeling	1	LS	30000	$ 30,000	Hydrogeologic measurements, model construction/validation, application for design
Engineering and Permitting						
	Design Report	1	LS	100000	$ 100,000	
	Plans and Specs	1	LS	50000	$ 50,000	
	Bidding	1	LS	10000	$ 10,000	
	Permitting	1	LS	10000	$ 10,000	NPDES, state, county and local shoreline construction and grading permits if applicable
Groundwater Collection Trench and Barrier Installation					$ -	
	Mobilization	1	LS	75000	$ 75,000	
	Utility Clearance	8	HR	125	$ 1,000	Includes travel
	Groundwater Interceptor Trench Installation	1100	LF	90	$ 99,000	Assume 15-feet deep, geotextile-wrapped rock permeable collection trench w/ 6" HDPE pipe (bottom 5-feet), cleanouts, backfill and compaction (top 10 feet). Assumes vertical sidewalls excavated using trench boxes. Cost adjusted to reflect 400 feet of excavation soil that is assumed to be suitable for backfill.
	Dewatering	1100	LF	15	$ 16,500	Engineer's estimate
	Lift stations	4	EA	15000	$ 60,000	Based on contractor-provided information (B&L Woodwaste contractor bids)
	Electrical System Design and Installation	1	EA	60000	$ 60,000	Assumes water level sensor pump control system (based on B&L Woodwaste interceptor trench electrical system contractor bids)
	Electrical Lines to/from System	280	LF	10	$ 2,800	Shared trench with piping to/from system. Assumes electrical wire, 2" PVC conduit, connections, control boxes only; earthwork included with piping cost.
	Piping Trench from Lift Stations to Treatment Plant	280	LF	35	$ 9,800	Material and labor to install 6' PVC force main, 2006 The Guide DIV 2-9, 2625.15 and electrical piping in same trench near surface
	Discharge Line to Outfall	200	LF	50	$ 10,000	Material and labor to install 8" HDPE effluent pipe to depths of 8 feet bgs to discharge in Port Angeles Harbor
	Outfall	1	EA	25000	$ 25,000	Assumes labor and materials to install pipe, tidal gate, remove and place riprap for armoring (after B&L Woodwaste interceptor trench outfall contractor bids)
	Surveying	3	DAY	1500	$ 4,500	Based on quote from Barghausen
	Barrier Wall Installation	26400	SF	5	$ 132,000	Assumes 24-foot deep, soil-bentonite slurry wall, 1100 LF, based on contractor-provided information. Assumes impacted soil suitable for use in backfill.
Groundwater Recovery and Treatment					$ -	
	Storage Shed Construction	1	LS	20000	$ 20,000	Includes framing, sheathing, concrete slab, and electrical connections
	Storage Tank	1	EA	10000	$ 10,000	Vendor quote for 2,000 gallon cylindrical tank
	Transfer Pump/Filters	1	EA	1500	$ 1,500	
	Activated Carbon Filter	2	EA	3200	$ 6,400	
	System Piping and Connections	1	LS	1500	$ 1,500	
	Installation Labor	1	LS	7500	$ 7,500	
Site Closeout					$ -	
	Soil Transport and Disposal	1633	TON	57	$ 93,081	Assumes 700 of 1100 LF of groundwater interceptor trench (15 feet deep with vertical sidewalls) produce contaminated soil requiring disposal. Assumes contaminated barrier wall soil is suitable for backfill. Transport and disposal quote from Cemex (formerly Rinker), assumes material trans. by truck/ferry (32 tons/truck) to Everett (5 hr RT including load/unload, $115/hr with tax), non-hazardous disposal at $34/ton with tax, 1.4 tons/CY.
	System Testing and Commissioning	1	LS	3500	$ 3,500	
	Surface Restoration, Paving	7400	SF	12	$ 88,800	Assumes 1100 feet of barrier wall trench and 1100 feet of interceptor trench, and outfall trenching, 3 feet wide, plus three vaults (800 SF each) requiring patching. Cost assumes heavy load rating. 9" AC (asphalt) paving ($8/SF), with 8" subgrade preparation ($4/SF), or 8" PCC.
Oversight and Construction Management						
	Field Oversight	12	WEEK	7500	$ 90,000	Assumes 1 FTE for 10 hour days at $135/hr plus travel and per diem
	Construction Management		%	10	$ 63,480	Assumes 10% of construction costs, minus waste T&D
	Completion Report	1	EA	25000	$ 25,000	Per MTCA requirements; includes as-built drawings, O&M manual
Subtotal					$ 1,162,361	
Sales Tax (8.4%)		%			$ 61,142	Note that tax for waste T&D is included in price
Surcharge on Subcontractors (10%)		%			$72,788	Surcharge for T&D costs excluded
Capital Cost Total					**$ 1,300,000**	
Contingency		30%			$ 390,000	
Capital Cost with Contingency					**$ 1,690,000**	
ANNUAL OPERATIONS, MAINTENANCE, AND LONG TERM MONITORING COSTS						
Item		Quantity	Unit	Unit Cost	Cost	Assumptions
	Groundwater and Water Level Monitoring Field Labor	2	EVENT	5000	$ 10,000	2 staff for 2 10-hour days plus per diem, travel, mobilization/demobilization
	Groundwater and Water Level Monitoring Analytical	2	EVENT	1500	$ 3,000	10 wells sampled for BTEX, TPH-G, and TPH-D per event
	Groundwater and Water Level Monitoring Reporting	2	EVENT	8000	$ 16,000	Semiannual compliance monitoring report
	System O&M	52	DAY	900	$ 46,800	Includes labor, repair, and system maintenance costs, 1 day/week by onsite employee, plus annual iron fouling maintenance.
	Carbon Replacement and Disposal	2	EA	5000	$ 10,000	Assumes 2 x 1000 lb vessels replaced 2 times per year, new material and disposal included
	Annualized equipment replacement costs	1	YEAR	2500	$ 2,500	Assumes replacement and reinstallation of lift station pumps, switches, and controls ($15000), and misc system components ($10,000) at 10 year intervals; 10-year costs are annualized.
	Electricity	12	MO	400	$ 4,800	Estimated
	NPDES Monthly Monitoring and Reporting	12	MO	850	$ 10,200	Includes labor for monthly discharge monitoring (4 hours) and reporting (6 hours) monthly by onsite employee
	NPDES Discharge Permitting Fees	1	LS	1200	$ 1,200	NPDES discharge permitting annual fee, plus agency communications
Subtotal					$ 104,500	
Sales Tax (8.4%)		%			$2,310	
Surcharge on Subcontractors (10%)		%			$1,000	
Annual O&M Cost Total					**$ 108,000**	
Net Present Value of 30-year O&M Cost					**$ 1,660,000**	**Net discount rate of 5% used based on 2009 Port of Seattle RI/FS protocol. 5% net discount rate implies an 8% rate of return and an inflation rate of 3%, or equivalent.**
Total Present Value Cost for Alternative					**$ 3,350,000**	

Pettit Oil Cleanup Area Cost Estimate Summary

	Alternative P2	Alternative P3
Capital	$296,000	$1,109,000
30% Contingency	$89,000	$333,000
Capital with Contingency	$385,000	$1,442,000
Annual O&M	$157,000	$8,000
PV O&M (10 yrs)	$1,210,000	$60,000
PV Total	$1,595,000	$1,502,000

Pettit Oil Cleanup Area
Alternative P2: Active Product Recovery

CAPITAL AND CONSTRUCTION COSTS

Item		Quantity	Unit	Unit Cost	Cost	Assumptions
Additional Site Delineation						
	Utility Clearance	6	HR	125	$ 800	Assumes standard utility location,travel included
	Soil Boring Installation	10	EA	500	$ 5,000	Assumes borings installed with Geoprobe, 10 locations in one day
Engineering and Permitting						
	Design Report	1	LS	25000	$ 25,000	Design for excavation and disposal
	Plans and Specs	1	LS	15000	$ 15,000	Assumes plans and specs completed in conjunction with Bulkhead remedy
	Bidding	1	LS	4000	$ 4,000	Assumes bidding completed in conjunction with Bulkhead remedy
System Installation						
	Mobilization/Demobilization	1	EA	10000	$ 10,000	
	Extraction Well Installation	4	EA	4000	$ 16,000	Includes mobilization, labor, materials and oversight, HSA well installation
	Trenching	35	CY	10	$ 400	Assumes common trench, 2'x3'x150'
	Install vaults	7	EA	3000	$ 21,000	
	Groundwater and LNAPL piping	525	LF	16	$ 8,300	Assumes 15-foot well spacing, farthest located 120 feet from system
	Electrical Connection/Wiring	525	LF	10	$ 5,400	Assumes electrical cased, and laid in common trench with well piping
	Trench Backfill and Compaction	35	CY	47	$ 1,700	Includes surface restoration, material haul and place, compaction
	Asphalt Patching	50	SY	36	$ 1,800	Assumes patching over trench 150'x3'
LNAPL System Components						
	System Shed Installation/Construction	1	EA	15000	$ 20,000	
	System Installation and Connection	1	EA	10000	$ 10,000	Estimated
	LNAPL Extraction Pumps/Skimmers	7	EA	4000	$ 28,000	Vendor estimated
	LNAPL Storage Tank	1	EA	10000	$ 10,000	1000-gallon AST
	High Level Sensors / Controllers	2	EA	500	$ 1,000	Estimated
Groundwater Extraction Components						
	Groundwater Extraction Pumps	7	EA	3500	$ 24,500	
	Batch Tank	1	EA	4000	$ 4,000	500-gallon AST
	Transfer Pump	1	EA	1500	$ 1,500	
	Carbon Filter	2	EA	3200	$ 6,400	
	Totalizer	1	EA	2300	$ 2,300	
Oversight and Construction Management						
	Field Oversight - Drilling	1	WEEK	7500	$ 7,500	Assumes 1 FTE for 10 hour days at $135/hr plus travel and per diem
	Construction Management		%	10	$ 17,230	Assumes 10% of construction costs
	Completion Report	1	EA	16000	$ 16,000	Assumes reporting in conjection with reporting costed in Bulkhead CAA
	Subtotal				$ 262,830	
	Sales Tax (8.4%)				$ 14,960	
	Surcharge on Subcontractors (10%)				$ 17,810	
	Capital Cost Subtotal				$ 296,000	
	Contingency (30% Capital)				$ 89,000	
	Total Project Capital				**$ 385,000**	

OPERATIONS, MAINTENANCE, AND LONG TERM MONITORING COSTS

Item		Quantity	Unit	Unit Cost	Cost	Assumptions
Permitting						
	Sewer Discharge Permitting and Fees	2102400	GAL	0.03	$ 63,100	Assumes 4 gpm groundwater extraction, operating 24 hrs/day
	Discharge Monitoring	12	EA	1350	$ 16,200	Includes labor and laboratory analyses for influent and carbon effluent samples
	Quarterly Reporting	4	EA	2000	$ 8,000	Assumes 20 hrs. Geologist, 10 hrs. Sr. Hydro, and 10 hrs. Proj. Assistant
Operations & Maintenance						
	System Maintenance, Filter Replacement	52	EA	750	$ 39,000	Assumes 1 field staff, 8 hours/week for system upkeep and maintenance
	Carbon Changeout	4	EA	2500	$ 10,000	Assumes 2 1,000lb vessels, carbon replaced 2 times per year each
	LNAPL Tank Emptying	32	HR	150	$ 4,800	Assumes product removed from tank by vacuum truck, 8 hrs/event, 1/quarter
	LNAPL Disposal Fee	2000	GAL	2	$ 4,000	Assumes 500 gallon tank emptied once per quarter
	Electricity	12	MO	150	$ 1,800	
Subtotal					$ 146,900	
Sales Tax (8.4%)		%			$ 5,006	
Surcharge on Subcontractors (10%)		%			$ 5,380	
Annual O&M Cost Total					**$ 157,000**	
Net Present Value of 10-year O&M Cost					**$ 1,210,000**	**Net discount rate of 5% used based on 2009 Port of Seattle RI/FS protocol. 5% net discount rate implies an 8% rate of return and an inflation rate of 3%, or equivalent.**

Total Present Value Cost for Alternative	**$ 1,595,000**	

Pettit Oil Cleanup Area
Alternative P3: Source Removal

Capital

Item		Quantity	Unit	Unit Cost	Cost	Assumptions
Additional Site Delineation						
	Utility Clearance	6	HR	125	$ 800	Assumes standard utility location, mobilization/demobilization included
	Soil Boring Installation	10	EA	500	$ 5,000	Assumes borings installed with Geoprobe, 10 locations in one day
Engineering and Permitting						
	Design Report	1	LS	25000	$ 25,000	Assumes single design report for both phases of excavation and disposal
	Plans and Specs	1	LS	15000	$ 15,000	Assumes plans and specs completed in conjunction with Bulkhead remedy
	Bidding	1	LS	4000	$ 4,000	Assumes bidding completed in conjunction with Bulkhead remedy
Monitoring Well Abandonment						
	Abandonment by Licensed Driller	3	EA	800	$ 2,400	Assumes abandonment by bentonite and concrete plug, by licensed driller, includes materials and mot
Phase 1 Soil Removal						
	Mobilization/Demobilization	1	EA	5000	$ 5,000	
	Stockpile area preparation	1	EA	5000	$ 5,000	
	Excavation and stockpiling	2266	CY	15	$ 34,000	5 days (per diem for 2 @ 140/day, travel 6-hr @ 100/hr); assumes area 170' x 30' x 12' deep.
	Vacuum Truck Extraction of LNAPL	16	HR	200	$ 3,200	Assumes open excavation will be vac-ed to remove LNAPL, dewatered repeatedly for 2 days,
	LNAPL/Groundwater Disposal	2000	GAL	6	$ 11,100	Assumes material transported by truck (1,000 gal/truck to Olympia for treatment/disposal (6 hr RT)
	Loading	2266	CY	5	$ 11,400	
	Soil Waste Transport & Disposal	3172	TON	57	$ 180,900	Assumes 1.4 tons/cubic yard. Assumes material transported by truck (32 tons/truck to Olympia (6 hr RT 1hr load/unload, $85/hr), transfer to rail for non-hazardous disposal
	Backfill and Compaction	2266	CY	15	$ 34,000	21 miles RT to local quarry, includes material, haul, and 12" layer compaction with roller
Phase 2 Soil Removal						Assumes all necessary demolition by others
	Mobilization/Demobilization	1	EA	5000	$ 5,000	
	Stockpile area preparation	1	EA	5000	$ 5,000	
	Excavation and stockpiling	4533	CY	15	$ 68,000	10 days (per diem for 2 @ 140/day, travel 6-hr @ 100/hr); assumes area 10200 square feet' x 12' deep. Cost includes stockpiling and loading.
	Vacuum Truck Extraction of LNAPL	24	HR	200	$ 4,800	Assumes open excavation will be vac-ed to remove LNAPL, dewatered repeatedly for 2 days,
	LNAPL/Groundwater Disposal	3000	GAL	5	$ 16,100	Assumes material transported by truck (1,000 gal/truck to Olympia for treatment/disposal (6 hr RT)
	Soil Waste Transport & Disposal	6346	TON	57	$ 361,800	Assumes 1.4 tons/cubic yard. Assumes material transported by truck (32 tons/truck to Olympia (6 hr RT 1hr load/unload, $85/hr), transfer to rail for non-hazardous disposal
	Backfill and Compaction	4533	CY	15	$ 68,000	21 miles RT to local quarry, includes material, haul, and 12" layer compaction with roller
Monitoring Well Installation						
	Well Installation	3	EA	3000	$ 9,000	Includes site mobilization, oversight, and materials
Oversight and Construction Management						
	Field Oversight	5	WEEK	7500	$ 37,500	Field oversight for both excavation phases. Assumes 1 FTE for 10 hour days at $135/hr plus travel and per diem
	Construction Management		%	10	$ 27,960	Assumes 10% of construction costs not includes soil disposal
	Completion Report	1	EA	16000	$ 16,000	Assumes reporting in conjection with reporting costed in Bulkhead CAA
	Subtotal				$ 955,960	
	Sales Tax (8.4%)				$ 69,762	
	Surcharge on Subcontractors (10%)				$ 83,050	
	Capital Cost Subtotal				$ 1,109,000	
	Contingency (30% Capital)				$ 333,000	
	Total Project Capital				**$ 1,442,000**	

Long Term Monitoring

Item		Quantity	Unit	Unit Cost	Cost	Assumptions
	Confirmation Monitoring	4	EA	200	$ 800	Assumed monitoring of compliance wells (3), monitored for presence of NAPL only; conducted in conjunction with site monitoring
	Semiannual vacuum-enhanced recovery (VER) events	2	EA	3000	$ 6,000	Assumes all costs for surfactants, vactor truck and disposal of 500 gallons water/LNAPL in Olympia ($1000, $2/gal), tax and surcharge, field oversight ($1100),
	Reporting	4	EA	200	$ 800	Reporting of absence/presence of NAPL included in semiannual groundwater monitoring reporting
				Subtotal	*$ 7,600*	
	Annual Operations and Maint. Cost				**$ 8,000**	
Net Present Value of 10-year O&M Cost					**$ 60,000**	**Net discount rate of 5% used based on 2009 Port of Seattle RI/FS protocol. 5% net discount rate implies an 8% rate of return and an inflation rate of 3%, or equivalent.**

Total Present Value Cost for Alternative	**$ 1,502,000**

Upgradient Cleanup Area Cost Estimate Summary

	Alternative U2	Alternative U3
Capital	$690,000	$4,120,000
30% Contingency	$207,000	$1,236,000
Capital w/contingency	$900,000	$5,360,000
Annual O&M	$0	$0
PV O&M	$0	$0
PV Total	$900,000	$5,360,000

Upgradient Cleanup Area
Alternative U2: Capping, Monitoring, and Institutional Controls

CAPITAL AND CONSTRUCTION COSTS						
Item		Quantity	Unit	Unit Cost	Cost	Assumptions
Engineering and Permitting						
	Design Report	1	LS	20000	$ 20,000	Design for new stormwater downspout system (K-Ply) catch basin system and grading and paving (Westport parking lot).
	Plans and Specs	1	LS	15000	$ 15,000	Assumes plans and specs completed in conjunction with Bulkhead CAA remedy.
	Bidding	1	LS	3000	$ 3,000	Assumes bidding completed in conjunction with Bulkhead CAA remedy.
	Permitting	1	LS	5000	$ 5,000	Assumes modification of existing NPDES permit for existing stormwater outfall. State, county and local shoreline construction and grading permits included with Bulkhead CAA cost.
Institutional Controls						
	Legal and consulting fees	1	LS	30000	$ 30,000	Cost assumed.
Capping and Westport parking lot stormwater upgrades						
	Paving	41300	SF	10	$ 413,000	Cost assumes heavy load rating to match paving at Bulkhead. Assumes existing subgrade engineered for travel-lift. 9" AC (asphalt) paving ($8/SF), with subgrade preparation, or 8" PCC.
	Catch basins	4	EA	1500	$ 6,000	
	Catch basin installation labor	4	EA	2000	$ 8,000	
	Storm drain	400	LF	50	$ 20,000	Assumes 18" reinforced concrete pipe (RCP) drains from new catch basins in paved area tie into existing stormwater system and drain to existing outfall.
	Storm drain installation labor	400	LF	35	$ 14,000	
K-Pl;y Downspout Modification						
	Downspout upgrades	1	LS	10000	$ 10,000	Cost assumed.
Oversight and construction management						
	Field oversight - stormwater upgrades and paving	2	WEEK	7500	$ 15,000	Assumes 1 FTE for 10 hour days at $135/hr plus travel and per diem
	Construction management		%	10	$ 47,100	Assumes 10% of construction costs
	Completion report	0	EA	36000	$ -	Assumes cost included in Bulkhead Cleanup Area.
Subtotal					$ 606,100	
Sales tax (8.4%)		%			$39,564	
Surcharge on subcontractors (10%)		%			$47,100	
Capital Cost Subtotal					**$ 690,000**	
Contingency		30%			**$ 207,000**	
Capital Cost Total					**$ 900,000**	

ANNUAL OPERATIONS, MAINTENANCE, AND LONG TERM MONITORING COSTS						
Item		Quantity	Unit	Unit Cost	Cost	Assumptions
	Groundwater and water level monitoring field labor	0	EVENT	6000	$ -	Groundwater monitoring costs are included in the Bulkhead Cleanup Area remedy.
	Groundwater and water level monitoring analyticals	0	EVENT	2400	$ -	Groundwater monitoring costs are included in the Bulkhead Cleanup Area remedy.
	Groundwater and water level monitoring reporting	0	EVENT	10000	$ -	Groundwater monitoring costs are included in the Bulkhead Cleanup Area remedy.
Subtotal					$ -	
Sales tax (8.4%)		%				
Surcharge on subcontractors (10%)		%				
Annual O&M Cost Total					**$ -**	
Net present value of 30-year O&M Cost					**$ -**	

Total present value cost for alternative	**$ 900,000**

Upgradient Cleanup Area
Alternative U3: Accessible Source Removal, Monitoring, and Institutional Controls

CAPITAL AND CONSTRUCTION COSTS						
Item		Quantity	Unit	Unit Cost	Cost	Assumptions
Engineering and Permitting						
	Design Report	1	LS	60000	$ 60,000	Design for bulkhead and Tumwater Creek shoring, excavation and disposal, new stormwater downspout system (K-Ply) catch basin system and grading and paving (Westport parking lot).
	Plans and Specs	1	LS	20000	$ 20,000	Assumes plans and specs completed in conjunction with Bulkhead Cleanup Area remedy.
	Bidding	1	LS	6000	$ 6,000	Assumes bidding completed in conjunction with Bulkhead Cleanup Area remedy.
	Permitting	1	LS	6000	$ 6,000	Assumes modification of existing NPDES permit for existing stormwater outfall. State, county and local shoreline construction and grading permits included with Bulkhead Cleanup Area cost.
Institutional Controls						
	Legal and consulting fees	1	LS	30000	$ 30,000	Cost assumed.
Excavation						
	Mobilization/demob and site setup	1	LS	75000	$ 75,000	Assumes no overlap with barrier wall remedy; cost may be reduced in conjunction with barrier wall construction. Assumes setup of BMPs for protecting surface water, bermed stockpile area, stormwater controls, tire wash, etc.
	Monitoring well decommissioning	9	EA	800	$ 7,200	Assumes decommissioning of monitoring wells in planned excavatation area by licensed driller.
	Monitoring well installation	9	EA	2500	$ 22,500	Assumes replacement of decommissioned monitoring wells by licensed driller.
	Utility clearance	1	LS	1500	$ 1,500	8 hours, private utility contractor.
	Installation of temporary shoring	14000	SF	45	$ 630,000	Assumes installation of temporary, 30-foot deep sheetpile structure to reinforce bulkhead and 20-foot sheetpile to reinforce Tumwater Creek bank retaining wall. Based on contractor-provided estimate.
	Removal of temporary shoring	1	LS	20000	$ 20,000	Based on contractor-provided estimate.
	Decontaminate shoring	14000	SF	3.25	$ 45,500	Based on contractor-provided estimate.
	Excavation, stockpile management, and loading	31000	CY	15	$ 465,000	Assumes excavation of accessible smear zone contamination (4 ft thickness) north of Westport Marine, plus vadose zone contamination (8 feet thickness) excavated from area near FS-17. Vertical sidewalls assumed. Assumes stockpiling of 19409 CY clean overburden.
	Excavation dewatering	1	LS	60000	$ 60,000	Assumes dewatering in excavated area during excavation, conveyance to onsite treatment system.
	Transportation and disposal of contaminated soil	15400	TON	57	$ 877,800	Assumes material trans. by truck (33 tons/truck) to Olympia (6 hr RT 1hr load/unload, $85/hr), transfer to rail for non-haz disposal, 1.4 tons/CY.
	Onsite treatment and discharge of contaminated water	2500000	GAL	0.08	$ 200,000	Assumes on site treatment for turbidity, organic contaminants with rented system for contaminated water from excavation dewatering and decon. Includes approximately $100,000 for system rental, setup/demob of system and discharge point, permitting, plus $0.04/gal for operation labor, consumable materials (e.g. GAC, filters), disposal of spent materials. Volume assumes 4-foot smear zone is saturated, with 0.25 porosity (500,000 initial gallons), and recharges 4 times.
	Backfill and compaction - onsite source	20000	CY	9	$ 180,000	Assumes 19409 CY material not transported offsite for disposal is suitable for backfill.
	Backfill and compaction - offsite source	11000	CY	15	$ 165,000	Imported material from local quarry, placement, and compaction in 12" layers with roller.
	Paving to replace bulkhead roadway	25000	SF	10	$ 250,000	Cost assumes heavy load rating to match paving at Bulkhead. Assumes existing subgrade engineered for travel-lift. 9" AC (asphalt) paving ($8/SF), with subgrade preparation, or 8" PCC.
	Catch basins	3	EA	1500	$ 4,500	
	Catch basin installation labor	3	EA	2000	$ 6,000	
	Storm drain	200	LF	50	$ 10,000	Assumes 18" reinforced concrete pipe (RCP) drains from replacement catch basins in paved area tie into existing stormwater system and drain to existing outfall.
	Storm drain installation labor	200	LF	35	$ 7,000	
K-Ply Downspout Modification						
	Downspout upgrades	1	LS	10000	$ 10,000	Cost assumed.
Oversight and construction management						
	Field oversight	8	WEEK	7500	$ 60,000	Assumes 1 FTE for 10 hour days at $135/hr plus travel and per diem
	Analytical costs	98	EA	85	$ 8,330	Includes confirmational sampling (50 soil samples for TPH-G/BTEX), 16 TPH-G/BTEX soil analyses for stockpile characterization, waste profiling, 32 water samples for TPH-G/BTEX.
	Construction management		%	10	$ 303,700	Assumes 10% of construction costs, not including transportation and disposal of contaminated materials or vendor costs for in situ treatment.
	Completion report	1	EA	30000	$ 30,000	Assumes reporting in conjection with reporting costed in Bulkhead Cleanup Area.
Subtotal					$ 3,561,030	
Sales tax (8.4%)		%			$255,808	
Surcharge on subcontractors (10%)		%			$304,533	
Capital Cost Subtotal					**$ 4,120,000**	
Contingency		30%			**$ 1,236,000**	
Capital Cost Total					**$ 5,360,000**	
ANNUAL OPERATIONS, MAINTENANCE, AND LONG TERM MONITORING COSTS						
Item		Quantity	Unit	Unit Cost	Cost	Assumptions
	Groundwater and water level monitoring field labor	0	EVENT	6000	$ -	Groundwater monitoring costs are included in the Bulkhead Cleanup Area remedy.
	Groundwater and water level monitoring analyticals	0	EVENT	2400	$ -	Groundwater monitoring costs are included in the Bulkhead Cleanup Area remedy.
	Groundwater and water level monitoring reporting	0	EVENT	10000	$ -	Groundwater monitoring costs are included in the Bulkhead Cleanup Area remedy.
Subtotal					$ -	
Sales tax (8.4%)		%				
Surcharge on subcontractors (10%)		%				
Annual O&M Cost Total					**$ -**	
Net present value of 30-year O&M Cost					**$ -**	

Total present value cost for alternative	**$ 5,360,000**