K Ply Site

Remedial Investigation/ Feasibility Study

Prepared for

Port of Port Angeles
338 West First Street
Port Angeles, Washington 98362

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FINAL

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K Ply Site Remedial Investigation/Feasibility Study

GEOLOGIST CERTIFICATION

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Acronym/ Abbreviation	Definition
AO	Agreed Order
APH	Aliphatic petroleum hydrocarbon
ARAR	Applicable or Relevant and Appropriate Requirements
AST	Aboveground storage tank
bgs	Below ground surface
BMP	Best management practice
BTEX	Benzene, toluene, ethylbenzene, and xylenes
CFN	Commercial Fueling Network
CLARC	Cleanup Levels and Risk Calculations
cm	Centimeter
COC	Contaminant of concern
COPC	Contaminant of potential concern

Acronym/ Abbreviation	Definition
cPAH	Carcinogenic polycyclic aromatic hydrocarbon
CPOC	Conditional point of compliance
CSL	Cleanup Screening Level
CSM	Conceptual Site Model
CSWGP	Construction Stormwater General Permit
CUL	Cleanup level
CY	Cubic yards
DRO	Diesel-range organics
Ecology	Washington State Department of Ecology
ft/ft	Feet per foot
GRO	Gasoline-range organics
HRA	Historical Research Associates, Inc.
IAWP	Interim Action Work Plan
ISCO	In situ chemical oxidation
ITT Rayonier	ITT Rayonier, Inc.
K Ply	K Ply Inc.
Landau	Landau Associates
l/kg	Liters per kilogram
LNAPL	Light non-aqueous phase liquid
LPAH	Low molecular weight polycyclic aromatic hydrocarbons
LUST	Leaky underground storage tank
MDI	Diphenylmethane diisocyanate
µg/kg	Micrograms per kilogram
µg/L	Micrograms per liter
mg/kg	Milligrams per kilogram
MNA	Monitored Natural Attenuation
Mobil	Mobil Oil Corporation
MTA	Marine Trades Area
MTCA	Model Toxics Control Act
NAPL	Non-aqueous phase liquid
NPDES	National Pollutant Discharge Elimination System
NRWQC	National Recommended Water Quality Criteria
ORC	Oxygen-releasing compound

Acronym/ Abbreviation	Definition
ORCAA	Olympic Region Clean Air Agency
ORO	Oil-range organics
PAH	Polycyclic aromatic hydrocarbon
PCB	Polychlorinated biphenyl
PCP	Pentachlorophenol
Peninsula Fuels	Peninsula Fuels Company, Inc.
pg/g	Picograms per gram
PID	Photoionization detector
POC	Point of compliance
POL	Petroleum-based oil and lubricant
Port	Port of Port Angeles
POTW	Publicly-owned treatment works
ppm	Parts per million
PRB	Permeable reactive barrier
PVC	Polyvinyl chloride
RAO	Remedial Action Objectives
RCW	Revised Code of Washington
RI/FS	Remedial Investigation/Feasibility Study
SAP	Sampling and Analysis Plan
SCO	Sediment cleanup objective
SEACOR	SEACOR Marine
Site	K Ply Site
SMS	Sediment Management Standards
SPI	Sediment profile imaging
SQS	Sediment Quality Standard
SVE	Soil vapor extraction
SVOC	Semivolatile organic compound
TBT	Tributyltin
TCLP	Toxicity characteristic leaching procedure
TEE	Terrestrial ecological evaluation
TEPH	Total extractable petroleum hydrocarbons
TEQ	Toxicity equivalency quotient
TESC	Temporary Erosion Sediment Control Plan

Acronym/ Abbreviation	Definition
TPH	Total petroleum hydrocarbons
USCS	United Soil Classification System
USEPA	U.S. Environmental Protection Agency
UST	Underground storage tank
UV	Ultraviolet
VER	Vacuum enhanced recovery
VOC	Volatile organic compound
WAC	Washington Administrative Code
WPAHG	Western Port Angeles Harbor Group
WSPCC	Washington State Pollution Control Commission

1.0 Introduction

This Remedial Investigation/Feasibility Study (RI/FS) report was prepared per the requirements of Agreed Order (AO) No. DE 9546 between the Washington State Department of Ecology (Ecology) and the Port of Port Angeles (Port) [1]. The K Ply Site (Site) is located at 439 W. Marine Drive in Port Angeles, Washington (Figure 1.1.) Beginning in the 1940s, the K Ply mill (formerly called PenPly) produced plywood in a mill located on the industrial waterfront of Port Angeles. Contamination consisting of gasoline, pentachlorophenol (PCP), and hydraulic oil under the mill was first documented in the late 1980s. The mill was permanently closed in 2011 and was demolished by the Port in 2013. The RI field activities followed mill demolition and were completed in early 2014.

1.1 PURPOSE AND OBJECTIVES OF REPORT

The purpose of this report is to present a RI/FS consistent with the requirements of the Model Toxics Control Act (MTCA) Cleanup Regulations (Chapter 173-340 of the Washington Administrative Code [WAC]). In particular, this report aims to meet the following objectives:

- Fully describe soil, groundwater, and sediment quality at the Site using all available data.
- Evaluate exposure pathways to chemicals found in the environmental media listed above.
- Present a Conceptual Site Model (CSM).
- Define Remedial Action Objectives (RAOs), Applicable or Relevant and Appropriate Requirements (ARARs), and cleanup levels (CULs) appropriate to the Site contaminants of concern (COCs).
- Identify areas of the Site where cleanup actions are necessary to meet the RAOs.
- Define and evaluate remedial action alternatives for cleanup of these areas.
- Present a preferred remedial action for the Site.

1.2 RELATION TO THE MARINE TRADES AREA SITE

Prior to 2012, the Site was included within the boundaries of the adjacent Marine Trades Area (MTA) Site. In 2012, the source and extent of the groundwater contamination at the Site was determined by Ecology to be distinct and separate from the contamination resulting from the former bulk plants that once occupied the western half of the MTA Site. In order to promote a more expeditious cleanup of the MTA and K Ply Sites, the Port requested that the K Ply Site be split off as a separate site, as described in the AO.

One of the primary objectives of this RI study was to identify the full extent and primary source of the gasoline contamination found under the mill and to fill data gaps following mill demolition. Additionally, Ecology requested that the quality of Port Angeles Harbor (Harbor) sediments in front of the Site be characterized.

1.3 PUBLIC PARTICIPATION

A public participation plan was prepared by Ecology in 2012. The plan explained the RI/FS activities to be conducted at the 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 MTCA.

1.4 ORGANIZATION OF RI/FS REPORT

The remainder of this RI/FS is organized as follows:

- **Section 2.0 – Background:** Provides information on the location, ownership, and historical land use at the Site.
- **Section 3.0 – Previous Investigations and Interim Remedial Actions:** Presents previous soil, groundwater, and sediment investigations and remedial actions that have been conducted at the Site. Presents soil and groundwater investigation activities that were conducted at the Site as part of an Interim Action Work Plan (IAWP) in 2012 and 2013 related to mill demolition.
- **Section 4.0 – Remedial Investigation Activities:** Presents a description of the uplands soil and groundwater investigation procedures work including sampling design, field methods, and analytical methods. Field activities described include soil sampling, groundwater monitoring well installation, test pit excavations, and assessment of light non-aqueous phase liquid (LNAPL).
- **Section 5.0 – Remedial Investigation Findings:** Describes the site setting and presents site geology and hydrogeology, and a description of type, concentration, and extent of contamination.
- **Section 6.0 – Conceptual Site Model:** Presents exposure pathway and receptors, and identifies contaminants of potential concern (COPCs). Presents the primary site COCs based on exceedances of CULs and identifies the points of compliance (POCs).
- **Section 7.0 – Remedial Action Objectives and Cleanup Areas:** Presents the RAOs and cleanup areas, and identifies the site-specific ARARs for the Site.
- **Section 8.0 – Identification and Screening of Remedial Technologies:** Identifies and screens potential remedial technologies for the COCs in each cleanup area.
- **Section 9.0 – Alternatives Evaluation and Disproportionate Cost Analysis:** Evaluates in detail the most applicable remedial alternatives for soil and groundwater alternatives against the MTCA requirements for a cleanup remedy per WAC 173-340-360.
- **Section 10.0 – Preferred Cleanup Action:** Presents the preferred alternative for cleanup of the Site.
- **Section 11.0 – References:** Presents the reference information for materials cited in the RI/FS document.

2.0 Background

2.1 SITE OWNERSHIP, LOCATION, AND ZONING

The address for the former K Ply mill is 439 Marine Drive, Port Angeles, Washington 98362 (Figure 1.1). The Site is located on level ground directly west of downtown Port Angeles. It is bounded by West Marine Drive to the south, the Harbor to the north, the vacated Pine Street to the east, and the MTA Site to the west. To the north of the Site are approximately 4.7 acres of aquatic land (tidelands and filled tidelands) owned by Washington State Department of Natural Resources and managed by the Port within the Port Management Agreement Parcel 2. Since the 1920s, the Site has been used to support the wood products industry (i.e., log storage, debarking, lumber, and plywood mills) but was primarily used for plywood manufacture. Various companies operated the plywood mill[1] between its years of operation (1941 to 2011), including ITT Rayonier, Inc. (ITT Rayonier), K Ply Inc. (K Ply), and Peninsula Plywood Company (PenPly).

The Site is zoned as "Industrial Heavy" by the City of Port Angeles [2], and is approximately 18.6 acres in size and is owned by the Port.

2.2 SITE DEFINITION AND DESCRIPTION OF STUDY AREA

In this document, the word "Site" is generally used to refer to the initial geographic area encompassing the footprint of the former mill structure as defined in the AO (Figure 2.1). This is the area where prior contamination has been well documented in both soil and groundwater. The purpose of the RI was to better define this initial Site boundary, which under MTCA is defined by where "contamination has come to lie." The study area for the RI included the larger area surrounding the Site where investigation activities occurred. This larger area included the sediments off shore of the mill, the log debarker operation to the east of the Site, and the now inactive Peninsula Fuels Company, Inc. (Peninsula Fuels) upgradient of the former mill.

2.2.1 Site Development History

The following paragraphs detail the history of the Site. Figures 2.2A through D show the locations of some of the historical features described below. Figure 2.3 shows the historical locations of various site features and operations and Figure 2.4 shows the historical mill building layout, which includes locations of buildings, major machines, and process areas. Figure 2.5 and Table 2.1 present the Areas of Potential Concern that were identified in the RI/FS Work Plan.

2.2.1.1 Site Fill History

Prior to development, the Site was originally a tidal flat. The first development occurred when the Chicago, Milwaukee, St. Paul and Pacific Railroad (also known as the Milwaukee Road) built an elevated trestle and rail line along the current bulk head and riprap slope to the north. Tidal water was able to flow unimpeded underneath the trestle [3].

The Site was filled inland of the rail trestle around 1926 using hydraulic fill dredged from the Harbor for the development of Terminal 1. Approximately 5 to 15 feet of fill was placed on the tideland surface [3] after first constructing a bulkhead wall shoreward of the railroad trestle and then placing the hydraulic fill material behind the bulkhead wall. The bulkhead wall extended east from the Port dock and then extended inland at the edge of what would eventually be the mill log

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[1] Unless specifically referring to a particular mill owner, throughout this document "the mill" is referring to the K Ply mill.

pond [3]. A second bulkhead wall was constructed at the same time on the south side of the future mill building, along the alley between S. Cedar Street and Pine Street. The area in between the two bulkheads was filled to a new grade for development in this manner.

2.2.1.2 Log Pond Fill

To the east of the filled area was a log pond that was built by the Port following signing of the lease with PenPly in 1941. Rock fill was placed along the rail trestle to create a tidally influenced pond. The pond had an entrance to receive rafted logs and was shared by PenPly and a local sawmill.

Between 1946 and 1988, periodic filling of the log pond occurred by the various mill operators. The fill primarily consisted of soil and rock material with some wood debris [4]. In 1988, the log pond was reduced to approximately 4.2 acres in size. Beginning in the early 1990s, the Port and K Ply began working together to acquire the permits necessary to fill in the remaining log pond and create additional upland industrial land. This change in land use was desired because K Ply adjusted their operations to use cottonwood logs, which primarily arrived via truck, instead of cedar logs, which primarily arrived via water. This change required on-site log storage and necessitated the filling of the log pond. To mitigate for the loss of habitat in the log pond, the Port and K Ply proposed to create the Valley Creek Estuary [5].

In 1977, approval was given by the Port Angeles City Council to fill 30,700 square feet, or 14 percent, of the log pond. The final fill event was first approved by the Port Angeles City Council in 1991 and was revised in 1993 to require mitigation of the Valley Creek Estuary Project. A 1992 report by Shannon and Wilson detected several contaminants in the log pond, but none were detected at concentrations greater than the Washington Sediment Quality Standards [6] that existed at that time. Additionally, the Shannon and Wilson study showed very high levels of total organic carbon, which they concluded acted to prevent contaminant leaching from soil [6]. Project approval was granted in August 1996 to fill the 4.3-acre pond with approximately 130,000 cubic yards (CY) of fill. Fill sources included the excavated soil from the Valley Creek Estuary, the U.S. Coast Guard Station Runway Excavation, the Airport Industrial Park, dredged material from the City of Port Angeles Pier, the downtown sidewalk demolition, dredged material from the mouth of Tumwater Creek, and excavated soil from the Larry Doyle residence at East Front Street and North Race Street [7].

Additionally, boiler ash material from the mill was evaluated for suitability as fill material by Shannon and Wilson in 1993 [8]. The evaluation included the review of chemical analyses and a geotechnical evaluation. It was concluded that the ash material could be used as fill material because there were no metals exceedances greater than MTCA Method A CULs, or toxicity characteristic leaching procedure (TCLP) failures. However, Clallam County required further testing to be done on the ash and K Ply instead disposed of the boiler ash at the Port Angeles landfill. It is understood that 6,000 CY of ash was disposed at the City of Port Angeles-operated landfill at 3501 W 18th Street. This landfill closed in 2006 and is now the site of a City of Port Angeles-operated transfer station [9].

2.2.1.3 Estuary

The portion of land east of Valley Street was historically the location where Valley Creek discharged to the Harbor. In 1954, Valley Creek was routed into an 84-inch concrete culvert pipe [10] and the railroad trestle located between Valley Street and Oak Street was filled with “truck” fill, and the upland area was filled with hydraulic fill to support development as industrial use.

In 1996 and 1997, the portion of land between Valley Street and Cherry Street, and W. Marine Drive and the Harbor was excavated to mitigate for the loss of the log pond. This mitigation project removed the portion of land that was the historical location of a small lumber mill (Olympic Lumber Mill) and log storage operation east of Valley Street. The soil dug out of the estuary was used to fill the log pond. During the excavation, the Valley Creek culvert was removed north of W. Marine Drive and habitat was added [5].

2.2.2 Site Uses Prior to 1941

Between 1926, when the Site was first filled, and 1941, when the plywood mill was built, there was a small lumber mill that operated on the Site. Little or no information is known about this mill, other than references on Sanborn Maps. The “M.R. Alleman” mill was located directly south of the K Ply mill building. Its years of operation are not known. There are no other known operations that occurred at the Site prior to 1941.

2.2.2.1 Railroad Development

In 1915 the Milwaukee Road built railroad service between Port Angeles and Port Townsend. Various spur lines were built over the next several years to transport logs from the forest to the mills. The rail was later operated by Chicago, Milwaukee, and St. Paul Railway Company [11].

The main rail line that went through Port Angeles was historically located directly north of the mill on a pile-supported trestle built on tidelands. When the Site was filled in 1926, riprap was placed on the waterward side of the constructed bulkhead. The piling and railroad trestle timbers were primarily creosote treated [12]. Refer to Figure 2.3.

A rail spur from the main rail line extended across the MTA Site to the south side of the K Ply mill where wood products from the mill were loaded on rail cars. The rail cars were transported from Port Angeles to Port Townsend, where they were loaded on barges to be transported to Seattle [13].

2.2.3 Historical Operations and Site Uses

The primary historical operation at the Site was plywood manufacture. Site-wide operations to support this included the mill operations itself, log storage in the log yard and log pond, log rafting in the Harbor, hog fuel burning, log debarking, log peeling, site maintenance, and other miscellaneous operations, including a plywood retail store located across W. Marine Drive. The following table lists the mill owners and operators of the mill by year.

Mill Owners and Operators by Year

Date Range	Mill Owner/Operator
1941–1971	Peninsula Plywood Corporation (called PenPly)
1971–1989	ITT Rayonier (called PenPly)
1989–2007	K Ply Inc., a subsidiary of Klukwan, Inc. (called K Ply)
2010–2011	Peninsula Plywood Company LLC (called PenPly)

Site operations began in 1941 when PenPly leased 7.5 acres of land (later extended to 12 acres) from the Port and constructed the PenPly mill building. PenPly was an employee-owned company that operated the mill from 1941 to 1971. Mill construction began on May 20, 1941. By late summer 1941 the machine shop and the main mill building were finished. The first plywood was transported off-site via rail on November 24, 1941. PenPly had an initial plywood production goal of 6 million square feet per month. Because the opening of the mill coincided with the United States entry to World War II, the mill was required to follow industry-wide controls for plywood production and distributions [14]. During the first year of production, 90 percent of the plywood produced was sold to the U.S. government.

In 1971, the mill was purchased by ITT Rayonier who operated the mill as the Peninsula Plywood Corporation from 1971 to 1989 [14]. In 1989, the mill was purchased by Klukwan, Inc., an Alaskan Native-owned village corporation, who operated the mill as K Ply from 1989 to 2007. The mill was closed from 2007 until 2010 when the mill was reopened by the Peninsula Plywood Group LLC. The mill closed permanently in 2011.

2.2.3.1 Plywood Manufacturing Operations

Based on review of historical documents, the plywood operations appear to be essentially identical between the various owners, given that the majority of the Site operations were mechanical in nature and used existing large machinery. The most detailed summary of operations that occurred at the mill is provided in a 2011 Peninsula Plywood Group LLC Olympic Region Clean Air Agency (ORCAA) application [15]; the text below, which describes operations, is paraphrased from that ORCAA document.

The majority of the products produced at K Ply were plywood but also included siding and paneling. Mill equipment operations included veneer equipment (i.e., lathes to peel logs), saws, hot presses, dryers, sanders, patching machines, chip equipment, conveyors and transfer equipment, and boiler equipment [16].

The first step in plywood manufacture was log pre-processing. This included receiving, sorting, storage, debarking, cutting, and green veneer peeling of logs in the log yard. This step also included chipping and hog fuel production. Logs historically arrived at the Site via truck and barge and were stored until use. Bark from logs was reduced to hog fuel and transported to a hog fuel pile via a belt conveyor.

Following debarking, logs were cut and peeled into continuous veneer using one of three lathes (10-foot lathe, Bamford/8-foot lathe, and the 4-foot lathe). The green veneer was transported to the main mill building on carts for drying in one of the three veneer dryers. The veneer dryers were either indirect steam-heated veneer dryers or Coe drying lines.

Dried veneer sheets were patched to remove knots using football-shaped biscuits, as necessary, in the cureline area of the mill. Small sheets were assembled into larger sheets using the phenol-formaldehyde exterior grade glue in a veneer welder. Once transferred to the press area, resin-impregnated kraft paper sheets were stapled to veneers and placed in the presses. A phenolic resin-impregnated paper was used as the final surface for overlay plywood sheets. The plywood glue used at the mill was composed of phenol- and formaldehyde-based resin, modal, soda ash, caustic soda, and flour. The resin components were purchased in bulk and mixed on-site. Raw resin was stored in a 10,000-gallon storage tank before being pumped to the mixing room to make the plywood resin. Final panels were typically 0.25 inch to 2 inches thick and consisted of nine layers.

The assembled sheets were heated and pressed in one of three steam-powered Lamb hot presses. The press applied 175 pounds per square inch at 280 °F. Following pressing, the sheets were cut to size. For some products, the plywood edges would be sealed by spaying edge sealing paint on the plywood in the paint spray room. Concrete form plywood required the application of form oil to the plywood surfaces. The application of form oil was done with the panel oiler.

Wood residuals were transported through the mill pneumatically using steam produced by the mill's two boilers.

2.2.3.1.1 Presses

Presses No. 1 and No. 3 were in operation from when the mill was constructed in 1941, and Press No. 2 was added in 1947. The original foundations for Presses No. 1 and No. 3 did not have an integral containment structure to catch and hold leaking hydraulic oil, but a containment structure was added to Press No. 1 when it was moved to a new location in 1974 [17]. Press No. 2 did have an integral containment system when initially constructed. In 1989, following the discovery of significant hydraulic oil on the groundwater table under the presses, the Press No. 1 containment system was planned to be upgraded to better control future releases [17]. The construction of a containment structure for Press No. 3 was underway in March 1989 and finished by 1991 [17]. An engineering study completed in 1991 by ITT Rayonier of the adequacy of all three press containment structures concluded that the "oil containment pits were large enough to contain a complete leakage of all hydraulic oil from their respective oil delivery systems, provided that the source(s) of the leakage are from directly over, or are entirely directed to, the containment pits" [18].

2.2.3.1.2 Wood Types

Veneer used in the mill was sourced from a variety of wood types, including cottonwood, fir, hemlock, and cedar. Initially, Douglas fir was primarily used, and by 1952 hemlock was also used [13]. Cedar was introduced in 1962. By 1974, cedar represented 85 percent of production. The primary wood used was cedar until the late 1980s when logging regulations changed and a switch to cottonwood was made. In February 1992, K Ply consumed 2.1 million feet of cottonwood, 219,000 feet of cedar, and 131,000 feet of fir [19]. In 2010, PenPly produced approximately 16-to 20-million board feet of plywood and veneer per year [20].

2.2.3.1.3 Other Nearby Mills

The Olympic Lumber Company sawmill was built in 1968 to the east of the Site, between the log pond and Cherry Street. Operations at the sawmill began with the manufacture of sliced veneer but then changed to the manufacture of dimensional lumber. The sawmill operated until 1986, when it was dismantled. The land where this sawmill was located was excavated to create the Valley Creek Estuary.

2.2.3.2 Log Pond

The log pond was located in the north central portion of the Site. The log pond was used to store logs that were intended for the manufacturing of plywood. A tide gate was built between the log pond and the Harbor in 1945 and was designed to hold the water elevation in the log pond at 6 feet during all tides. The tide gate also prevented the entry of seawater in and out of the pond when the gate was closed. Peninsula Plywood Corporation stopped bringing logs into the log pond through the tide gate in the 1980s, and by 1988 the gate was typically kept closed. As previously described, the log pond was progressively filled to make room for upland operations and by 1997 was completely filled in.

2.2.3.3 Log Rafting

The years that log rafting occurred along the shoreline in front of the Site are not well known. The log rafts are primarily shown in the aerial photographs taken in the 1950s and 1960s. During K Ply's operation of the mill, cottonwood was primarily used and was trucked in instead of rafted in, as described above. According to the Port, no log rafting occurred at the mill after the mill was closed by K Ply in 2007 [21].

In addition to log rafting, an over-water conveyor transported imported chip material from a barge to use as hog fuel (Figure 2.3). These were the only over-water activities at the mill (with the exception of activities in the log pond). If chips were spilled to the water, they were skimmed off [22].

2.2.3.4 Hog Fuel Boilers

The mill used two 1938 Riley hog fuel fired steam boilers that combusted hog fuel produced on-site, consisting primarily of bark, other wood waste, and wood dust. Hog fuel was also occasionally purchased for supplemental fuel. Only wood fuel was used. The boilers originally vented through the 175-foot-tall stack, but later pollution controls were added and a smaller stack was used. By 2004, an air pollution control system consisting of a multiclone separator and baghouse was shared by the two boilers [15]. In 2011, the mill was purchasing approximately 33 percent of hog fuel consumed annually. The purchased fuel consisted of fir bark and sawdust from other local mills [15].

In the early 1990s, K Ply was having issues with opacity of the stack. The causes appeared to be collection equipment problems, poor fuel quality, and combustion problems. A series of recommendations were made by a consultant to reduce opacity. These recommendations included reducing the salts in the fuel supply [23].

When the mill reopened in 2010, only salt-free wood was used in the boilers because log rafting had stopped in 2007.

2.2.3.5 Products and Chemicals Used and Hazardous Waste Generated

Various products and chemicals were used at the Site during the manufacture of plywood. These primarily included glues, fillers, and wood preservatives, and a variety of other miscellaneous products such as caustics, oils, paints, and solvents. Some of these materials were classified as hazardous substances or required reporting on the Site (Spill Prevention Control and Countermeasures Plan [SPCCP]) [22]. In the 1980s, Ecology conducted multiple dangerous waste inspections and Peninsula Plywood Corporation subsequently completed multiple actions to come into compliance with the regulations. This included adding improvements to the chemical storage areas, labeling, and waste handling procedures [24]. Other than the small fuel reservoirs attached to equipment and underground storage tanks (USTs) or aboveground storage tanks (ASTs) located on-site, chemicals and lubricants were stored in the oil storage house into the 1970s.

2.2.3.5.1 Petroleum-Based Oils and Lubricants

Petroleum-based oils and lubricants (POLs) were used in the hydraulic presses, the panel oiler, the three lathes, and the ring barker. The Bamford/8-foot lathe was located over a bermed loading dock concrete pad. There were two 150-gallon tanks associated with the Bamford/8-foot lathe. The ring barker had a 400-gallon and 50-gallon hydraulic oil tank. A pond saw with 2 gallons of hydraulic oil was built on a wooden float and used in the log pond through the 1970s. In 1987, kerosene cleaner was still used to clean parts in the maintenance department. The used kerosene was dumped on the hog fuel pile every 4 to 8 weeks. Waste oil and hydraulic fluid with too much water contamination was used for chain lubrication [25].

Hydraulic oil was used at the Site for multiple operations, but primarily for the operations of the presses. The presses were not initially designed to capture leaking hydraulic oil, as the two original hydraulic presses (Presses No. 1 and No. 3), which were installed in 1941, did not have containment structures. It was estimated in 1989 by Landau Associates (Landau) that as much as 12,000 gallons of free petroleum product (mixed hydraulic oil and gasoline) was present in the soil above the groundwater surface [17]. A 1990 remedial order between ITT Rayonier and Ecology described the planned remedial action by ITT Rayonier for hydraulic oil recovery [26]. When K Ply purchased the mill in 1989, ITT Rayonier maintained responsibility for the hydraulic oil cleanup as described in the 1990 Remedial Action Order [26]. A blue dye was added to the hydraulic oil when Peninsula Plywood Company operated the mill between 2010 and 2011 to distinguish any leakage due to their operations.

2.2.3.5.2 Underground Storage Tanks and Aboveground Storage Tanks

USTs and ASTs were historically used at the Site for fuel storage, but most had been removed by 1985 (refer to Figure 2.3 for the historical locations). A 1,000-gallon gasoline UST and a 6,000-gallon fuel oil AST, both with concrete containment, were located near the 8-foot lathe building. The containment structure around the fuel oil tank historically did not have a concrete floor. A leak test performed by ITT Rayonier in 1970 showed that the 1,000-gallon gasoline UST did not leak [27]. The 1,000-gallon UST was removed in 1984, but it is not known when the 6,000-gallon AST was removed. A 500-gallon AST that contained diesel was historically located near the ring barker; it is not known when this AST was removed. There was a 300-gallon UST that used to hold diesel and gasoline that was located near the tide gate along the bulk head before being removed in 1984 [4]. The petroleum form oil that was used for the panel oiler was stored in two USTs located west of the panel oiler.

2.2.3.5.3 Pentachlorophenol

Pentachlorophenol (PCP) was historically used on-site as a wood preservative or “form oil” for the manufacture of concrete forms and was associated with the panel oiler. The PCP was stored in an 8,000-gallon UST located on the west side of the Site, near the panel oiler. The tank was used from sometime prior to 1952 through sometime between 1979 and 1984 [4]. Historical research indicates that PCP was discontinued for use as form oil and replaced by petroleum oils, as discussed above, but the date of the switch between products is not known.

2.2.3.5.4 Polychlorinated Biphenyls

Transformer oil containing polychlorinated biphenyls (PCBs) was detected in two transformers at the Site during the hazardous materials survey conducted prior to demolition [28]. Additionally, containers labeled “transformer oil” were found in Room 14 and the Green Veneer Chipper Room (refer to Figures 2.4 and 2.5). There were no other operations at the Site that indicated the use of PCB-containing devices or oils.

2.2.3.5.5 Phenol-formaldehyde Resin

Phenol-formaldehyde resin was used at the mill as glue to adhere the layers of veneer together in plywood sheets. The primary components of the resin were caustic soda (sodium hydroxide solution) and uncured phenol-formaldehyde resin. Both were stored in ASTs located west of the mill building near the glue loft [4]. There were two 8,000-gallon resin tanks and one 8,000-gallon caustic soda tank. By the late 1980s, the tanks were all located over concrete subsurface vaults that were removed as part of mill demolition. Historically (date not known), a 5,600-gallon steel caustic tank had been stored in an area without secondary containment, and the tank had some small leaks. When the tank was removed in the early 1980s, some soil and crystallized caustic soil were excavated and disposed of. There were also small spills of resin to soil, which was the subject of a remedial action and small cleanup action by ITT Rayonier. A small amount of resin and resin-impregnated soil was excavated and disposed of. The waste resin was not properly designated by ITT Rayonier prior to disposal, and ITT Rayonier was fined $5,000 by Ecology in 1984 [29]. The waste was determined by Ecology to be corrosive and contained 0.16 percent formaldehyde. Spill prevention measures in the glue loft were employed in 1984.

2.2.3.5.6 Polyurethane

Polyurethane was used during manufacturing as knot filler. Beginning in the mid-1970s, diphenylmethane diisocyanate (MDI) was used to make polyurethane knot filler. The polyurethane was made by combining the MDI with an oily liquid called “Part A.” The Part A liquid contained lead up through 1986, and the materials were purchased and stored in drums. Spray guns and the mixer used to apply the polyurethane were typically cleaned with a solvent. Methylene chloride was used as the solvent from approximately 1977 to 1985 and 1,1,1-trichloroethane was used for 3 to 4 months in 1985. During this time, the waste solvent products were distilled for solvent recovery on-site in a simple homemade still made from 55-gallon drums and heated water [30]. The still bottoms, which included polyurethane, solvent, and the lead catalyst from the polyurethane, were incinerated on-site in the hog fuel boiler. By the end of 1985, Peninsula Plywood Corporation started to use water to flush the glue, and the use of methylene chloride and 1,1,1-trichloroethane ceased.

2.2.3.6 Environmental Processes

2.2.3.6.1 Historical Wastewater and Stormwater Control and Discharges

Wastewater discharges and stormwater control at the Site were permitted under various National Pollutant Discharge Elimination System (NPDES) waste discharge permits and stormwater permits from 1975 to present. Waste discharge permits were issued to the mill as early as 1958 by the Washington State Pollution Control Commission (WSPCC), but the details of the permits are not known. Wastewater and stormwater was discharged directly to the Harbor, the log pond, and the publicly-owned treatment works (POTW).

Prior to the 1968 sewer interceptor connection, wastewater was discharged directly to the Harbor. For example, glues wastes were discharged to the Harbor at a rate of approximately 5 to 10 gallons per minute [31]. The heavy solids from a glue water settling tank were pumped from the large compartment and disposed on “waste land” one or two times per month. In 1966, the WSPCC requested PenPly use secondary treatment for the glue waste effluent. In a letter to WSPCC, PenPly stated that “primary treatment for glue waste is provided and the requirements of secondary treatment and additional outfall sewer are unnecessary because of the negligible amount of waste involved and the large body of water available for disposal” [32]. It is understood that wastes were later (at least by 1976) discharged to the POTW under the Waste Discharge Permit, but it is unknown if primary treatment was required.

During a 1989 site assessment of K Ply operations by Kennedy/Jenks/Chilton [25], it was identified that K Ply was discharging several sources of wastewater to the log pond that weren’t specified in the NPDES permit. These included soluble oils from maintenance and metal grinding operations. Additionally, the same report identified that cleaning of vehicles and cleaning of parts with solvents (type unknown) was occurring over a sump outside the jitney shop (exact location at the mill unknown). It was suspected that oil, solids, and solvents were discharged directly to the Harbor.

A 1993 Ecology inspection report noted that two major sources of wastewater from K Ply were boiler blowdown (greater than 80 °C and with a pH of 12) and the air emission scrubber water (50 °C, pH 7) [33]. The scrubber water contained 400 to 500 milligrams per liter of total suspended solids from the scrubbing of the black fly ash. Both wastewater streams traveled through a series of small detainment ponds for settling of solids and cooling prior to being discharged to the log pond. The inspection noted that the age of the mill and numerous additions of equipment and buildings contributed to accumulated debris and potentially to stormwater problems. The inspection noted that the mill had a lack of any best management practices (BMPs) and the log pond was used as a “catch all for debris from the mill area” and was not used for log storage. The inspection report noted that the Site was sloppy and accumulated debris may contribute to stormwater problems. It recommended that the leaking oils from multiple sources be resolved. Ecology did note that the log pond provided detainment of settleable and floatable solids, and oils and pH buffering. Prior to this 1993 inspection, stormwater was not included in the Site permits but was included in future permits.

2.2.3.6.2 Known Spills and Releases

There are several documented spills to the log pond and Harbor from the Site, including the following:

- A 25- to 30-gallon hydraulic oil spill to the log pond occurred in September 1988 after a hydraulic seal on the veneer lath ruptured. Absorbent pads were used to contain the spill and mitigate the incident [34].
- An 80-gallon spill of hydraulic oil to the log pond occurred in 1983 when a line on the hydraulic unit for the Bamford/8-foot lathe broke. The spill was contained with an absorbent boom and did not reach the Harbor [35].
- A 3-gallon release of phenol to the Harbor occurred in March 1990. The phenol reportedly dissolved in the water and no further action was taken [36].
- 50 gallons of phenol-formaldehyde resin was spilled to the ground and drained to the city sewer and the Harbor in June 1983 [37].
- A citizen faxed a complaint to Ecology in 1993 of unspecified “toxic waste” being discharged to the Harbor after which “ITT Rayonier hired a diving company to repair the pipe.” No information on the type of discharge, extent, or location of the pipe was reported[2] [38].

Additionally, as discussed below in Section 3.0, there were three remedial actions completed by ITT Rayonier to clean up resin-impregnated soil, soil contaminated with PCP, and hydraulic oil.

According to anecdotal information, spills of methylene chloride and 1,1,1-trichloroethane may have occurred near the curelines where the knot filler was applied [4].

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[2] Although the report indicates ITT Rayonier as the violator, the mill was operated by K Ply at that time.

2.2.3.6.3 Manhole Explosion and City Sewer Interceptor

In June and July 1968, the City of Port Angeles began installing a sanitary sewer main along W. Marine Drive that was to collect sewage that had formerly been discharged directly to the Harbor. The collected sewage was to be diverted to a new municipal POTW. During the trench excavation in the area of W. Marine Drive and Tumwater Street (part of the MTA Site), infiltration of gasoline into the excavation was noted [39]. Petroleum-impacted soil was excavated and removed to allow the completion of the sewer main in that area [40, 41].

As part of this area-wide upgrade, sanitary sewage from PenPly's operations was diverted to the interceptor sewer via a new sewer line installed along Cedar Street, along with sealing off existing manholes. Mill wastewater, however, continued to be discharged to the Harbor.

In 1969, there was a mild explosion from the ignition of fuel vapors in a sewer manhole in the PenPly machine shop [42, 43]. Following the explosion, Peninsula Plywood Corporation blocked off two main incoming lines that connected to the manhole[3]. PenPly also installed a vent system to carry any remaining vapors to a point above the roof. Around this time there were also vapors and visible diesel oil in the drains during heavy storm runoffs and at high tides. In 1970, diesel odors were still observed by Peninsula Plywood Corporation employees. That same year, the petroleum vapor problem was investigated by the Washington State Department of Labor & Industries, which found volatile vapors in hazardous quantities in the sewer manhole [44].

During investigation of the vapors, Washington State Department of Labor & Industries reminded Peninsula Plywood Corporation that they had gasoline storage and dispensing facilities adjacent to the machine shop that may be the principal source of vapors. Peninsula Plywood Corporation completed a leak test on the gasoline storage tank by measuring the level of gasoline from the top of the tank over an 8-day period, and found it to not be leaking [27].

2.2.3.6.4 Air Emissions

In 1986, the Olympic Air Pollution Control Agency had Ecology perform particulate tests on the stack. The emissions were out of compliance, and the mill replaced the scrubber in 1987.

K Ply reported to ORCAA in the early 1990s that "the veneer drying process caused significant [air] emissions of particulate matter and volatile organic compounds." The particulate emissions were condensed volatile organic compounds (VOCs), including terpene compounds, phenol, and formaldehyde.

2.2.4 Adjacent Properties

The Site is surrounded by other industrial activity. The Port's Terminal 1 is located to the northwest of the Site and MTA is located directly west of the Site. MTA was developed on land with several former bulk petroleum tank farms. Additionally, there are current and historical gas stations and historical tank farms located adjacent to and upgradient of the former mill.

There are six properties located south and adjacent to the Site where petroleum fuels are currently stored or were historically stored. Based on the groundwater flow direction, these locations are considered upgradient and include a Conoco 76 gas station (formerly Jackpot Gasoline and Time Oil), a Chevron gas station (formerly the Exxon Marine Drive Mart and Tozzer Distributors), Ace Auto Repair (formerly Brian's Automotive Shop and the PenPly Retail Office), the Commercial

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[3] Note that these two lines were no longer in use after being blocked off as part of the interceptor sewage work.

Fueling Network (CFN) gas station (formerly the Port Angeles Truck Stop Chevron and Kardlock Gas Station), the former Peninsula Fuels tank farm, and the D&D Distributors/Phillip 66 gas station and tank farm. These locations are shown on Figure 2.3.

Ecology's online database was searched for information that was readily available for these properties as described in the following paragraphs. These adjacent properties were found not to be sources of contamination to the Site based on RI results presented in Section 5.0 and summarized in the CSM in Section 6.1.

2.2.4.1 Time Oil Property

The Time Oil property is located at 331 West 1st Street and is now occupied by a Conoco 76 gas station. The site was developed as a service station in 1971 and originally had three USTs. When the USTs were removed in 1991, there were apparently no holes in the tanks, but the soils were hydrocarbon stained [45]. Ecology was notified and groundwater and soil testing was completed at the UST location under the Voluntary Cleanup Program. Three new USTs were installed at the same time in a new location. Six groundwater wells were installed to monitor groundwater quality.

A soil vapor extraction (SVE) remediation system was operated at the site from 1996 to 1997 to address the petroleum contamination. Approximately 1,000 pounds of petroleum hydrocarbons were removed with the SVE system, which was estimated to be 90 percent of the petroleum hydrocarbons present prior to remediation [46, 47]. The site was given a No Further Action letter on March 20, 2001. Based on this information, there does not appear to be any environmental concerns with this property.

2.2.4.2 Marine Drive Exxon

The Marine Drive Exxon Site is located at 402 W. Marine Drive. The site is the former Exxon Marine Drive Mart and Gas Station and is now operating as a Chevron Gas Station. The site is listed on Ecology's database as "cleanup started." The Ecology database indicates that contamination was discovered in 1994, and leaky underground storage tank (LUST) reports were submitted to Ecology in 1995 and 1996. An initial investigation was completed in 2011, but the scope and extent are not known. The Ecology database lists the site as having benzene and other non-halogenated organics in soil at concentrations greater than the CUL. The site is also suspected for having lead in soil and has been remediated to concentrations less than the CUL for diesel. Based on this information, there is the potential for contaminated groundwater to exist on this site.

2.2.4.3 Former PenPly Retail Office

The former PenPly Retail Office was located at 430 W. Marine Drive and is currently occupied by Ace Auto Repair. There were two USTs at the PenPly retail store as well. According to past employees, these tanks were used to dispense discount fuel to PenPly employees. The retail store operated between 1961 and 1973 [4]. The tanks were 10,000- and 12,000-gallon USTs with a pump island directly above them. Soil samples were collected during UST removal for total petroleum hydrocarbons (TPH) and benzene, toluene, ethylbenzene, and xylenes (BTEX). BTEX was not detected and TPH was detected at a concentration of 18 milligrams per kilogram (mg/kg) [48]. Based on this information, there is limited potential for contaminated soil and groundwater to exist on this site.

2.2.4.4 Former Port Angeles Truck Stop Chevron

The former Port Angeles Truck Stop Chevron or Kardlock Gas Station is located at 501 W. Marine Drive, directly adjacent to the K Ply property. The site is now occupied by the CFN station owned by Pettit Oil. In 1988, it was reported that seven USTs between 500 and 6,000 gallons were present on the property [4]. The property is currently listed in Ecology's database as an independent cleanup site. A LUST notification and report was received by Ecology in April 1998 and soil sample concentrations were confirmed to be greater than CULs. No other information on this property is known. A walk over of the site did not indicate the presence of groundwater monitoring wells. Based on this information, there is the potential for contaminated groundwater to exist on this site.

2.2.4.5 Peninsula Fuels Company, Inc.

The Peninsula Fuels site was formerly used as a bulk petroleum storage site, though few details are available concerning historical operations. Records indicate that the site was operated by the General Petroleum Corporation beginning in 1938. The site was then operated by Mobil Oil Corporation (Mobil), a successor to General Petroleum, in the late 1960s, as depicted on a 1967 Ryan and Hayworth map showing barge receiving lines and planned changes to pipeline routes due to the closing of Terminal 1 to fuel barges by the Coast Guard [49]. In about 1967, the U.S. Coast Guard ordered the Port to shut down use of Pier 1 as a fuel terminal. In conjunction with the shutdown of Pier 1, a 1967 Area Plan shows what appears to be Pipeline 8 leading from Terminal 1 to Peninsula Fuels [49]. The Area Plan states that two pipes comprising Pipeline 8 were "to be isolated and abandoned." Based on the Area Plan, it is assumed that Pipeline 8 was decommissioned and was no longer able to be used around 1967. New Pipeline 5, constructed in 1968, became the petroleum pipeline serving the ARCO bulk plant, D&D Distributors, and the Peninsula Fuels property from the west side. Pipeline 5 received fuel from the dock owned by Standard Oil.

In 1985, Mobil conveyed the property to Peninsula Fuels, a family business. Peninsula Fuels was sold in 1988 to Ralph Bauman [50], who continued the operation for a short time before closing and removing the ASTs, but the property was retained by Peninsula Fuels.

Sanborn maps indicate that at least four ASTs were present while the site was operated by General Petroleum Corporation. The Peninsula Fuels site is assumed to have been serviced by Pipeline 8 from approximately 1938 until the apparent decommissioning of Pipeline 8 in approximately 1969. At this time, the petroleum pipeline[4] serving the site was transferred to a new east-west bearing pipeline, referred to as Pipeline 5 [49]. The historical Pipeline 8 ran underneath the K Ply mill from the Port's Terminal 1 to the former Peninsula Fuels facility directly south of the Site. The flanges for Pipeline 5 are still visible at the northwest corner of the site; however, most of Pipeline 5 was removed by Von's Petroleum on behalf of the Port in 1989. A short section running under S. Cedar Street was left in place, however [51].

As described in Section 3.0, an investigation in 1988 identified petroleum-impacted soil and groundwater in the alley between Peninsula Fuels and K Ply, in the vicinity of both Pipeline 8 and Pipeline 5. The document record includes speculation that a possible unknown source of the gasoline beneath K Ply was associated with Peninsula Fuels. For example, the 1988 investigation report by ITT Rayonier notes that there was likely a petroleum release at Peninsula Fuels in the late 1960s that may have resulted in petroleum entering the storm sewer and causing the sewer manhole explosion at the Site [4]. Peninsula Fuels was evaluated as a potential source of the

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[4] Use of the term Pipeline in this document may refer to a series of parallel individual pipes collectively termed a "Pipeline".

gasoline-range organics (GRO) and/or benzene beneath K Ply as part of the MTA RI [52] as well as by Landau in 2009 [53, 54]. Both studies concluded that Peninsula Fuels was not a likely source of the Cedar Street Benzene Plume but could be contributing to elevated GRO in groundwater north of the Peninsula Fuels property. Neither study included samples from the Peninsula Fuels property. More recent data collected as part of this RI/FS, which include borings at the Peninsula Fuels property, indicate that GRO in groundwater at the Site, including the alley south of the mill, likely did not originate on the Peninsula Fuels property and is distinct from contamination identified there. Additional information is presented with the RI results presented in Section 5.4 and the CSM discussion presented in Section 6.1.

Prior to this RI/FS, sampling of soil has occurred on two occasions within Peninsula Fuels. The first sampling event occurred in 1989 by Mickelson’s Construction Company after the six ASTs were removed. Three samples were collected at two locations from inside the tank farm and one was collected near the pump house. Reported sample depths ranged from 10 to 16 feet, but the methodology as to how the samples were collected is not documented. Samples were tested for TPH by the older U.S. Environmental Protection Agency (USEPA) 418.1 methodology and also for BTEX using USEPA Method 8020. Results indicate no detectable BTEX and low levels of TPH.

A second set of samples was collected in 2010 after a late 2009 flooding event in which Tumwater Creek overflowed and flooded the site [55]. It was estimated the 30 gallons of oil were released from either vehicles or drums. Nine surface samples were collected after the released oil was skimmed off and the flood waters had drained. Two samples showed oil-range hydrocarbons at concentrations greater than the MTCA Method A CUL. Minor amounts of diesel-range organics (DRO) and GRO were detected, but results were less than the CULs. No BTEX compound was detected. It was reported that the oil detections were the releases of past spills and not from oils released during the flood event.

2.2.4.6 Former D&D Distributors/Phillip 66

Phillips Petroleum Company, and later D&D Distributors, operated a bulk plant at 617 W. Marine Drive. The Port purchased the former D&D Distributors/Phillips 66 bulk plant by 1984. The property has since been redeveloped by Platypus Marine and is within the boundaries of the MTA Site.

3.0 Previous Investigations and Interim Remedial Actions

3.1 ENVIRONMENTAL INVESTIGATIONS

Prior environmental investigations in the area are summarized by media in this section, based on a review of available records. Boring and well locations from prior investigations are shown on Figure 3.1. The current environmental condition of the Site and surrounding area is summarized in Section 5.0 based on the results of all of these investigations. Appendix A contains copies of selected prior investigation reports.

3.1.1 Previous Soil Investigations

In excess of 100 soil samples have been collected across the Site prior to the RI. Samples were tested for a variety of contaminants. These samples point to a variety of petroleum products being released in several areas of the Site.

3.1.1.1 Landau Associates 1988–1989

In 1988, ITT Rayonier conducted the first environmental evaluation on the mill site [4]. A limited number of soil and groundwater samples were collected from various locations throughout the facility as a part of that study and submitted for analysis for potential contaminants that were used in the plywood manufacturing process. Significant amounts of hydraulic fluid, gasoline, and diesel contamination were detected in subsurface soils beneath the facility. It was estimated that as much as 12,000 gallons of petroleum LNAPL were present in the soil above the water table surface in the area of the hydraulic presses, as a mixture of hydraulic oil spilled from the hydraulic presses and gasoline from an unknown source. Testing of the hydraulic oil did not indicate the presence of PCBs [17].

Also, GRO and DRO (diesel to heavy oil) were identified in soil near the former plywood panel oiler, beneath the southwest corner of the facility. 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 soil containing common gasoline constituents (BTEX) and methylene chloride [4]. Fuel oil or diesel product was observed on the groundwater surface exposed by the test pits. Sampling near two former form oil tanks 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, and in the panel oiler area 4,300 mg/kg GRO was detected in soil above the water table.

GRO was also identified in soil beneath the mill. A soil sample from Well PP-3, located southeast of the hydraulic presses, contained 1,600 parts per million (ppm) GRO but also contained hydraulic oil.

Further sampling occurred in 1989 as part of a remedial action plan for the PCP-contaminated soils beneath the former panel oiler location. Results indicated that PCP was detected at concentrations up to 840 ppm in soil. Available records indicate that, following the 1991 remedial excavation (described in more detail in Section 3.2 below), soil was left in place with concentrations of PCP up to 840 mg/kg, and bis(2-ethylhexyl)phalate of up to 310 mg/kg. Low concentrations (i.e., less than the MTCA Method C CUL of 2 mg/kg) of polycyclic aromatic hydrocarbons (PAHs; fluoranthene, fluorene, 2-mehtylnapthalene, naphthalene, phenanthrene, and chrysene) were detected in samples of soil left in place on all four walls of the excavation [56].

3.1.1.2 Shannon and Wilson 1992

Three soil/sediment samples were collected from the log pond in 1992 and analyzed for TPH [6]. The sample with the highest levels of TPH was also analyzed for PAHs. TPH concentrations by USEPA Methods 418.1 and 8015 modified ranged from 210 to 21,000 mg/kg.

3.1.1.3 Floyd|Snider 2005–2006

As part of the MTA Site RI/FS, several soil borings were advanced at the Site to investigate specific data gaps and a benzene plume that was identified in S. Cedar Street in 2005. The investigations, which included soil sampling in addition to collection of groundwater samples, were initially intended to determine the eastern extent of the benzene plume beneath the MTA Site, assess the potential for an upgradient source of benzene in groundwater at the Site, and assess contamination in the vicinity of the former D&D Distributors/Phillips 66 Bulk Plant. In October 2005, a soil sample was collected from the smear zone in a boring advanced at the southern edge of the Site, at the property boundary with Peninsula Fuels (SB-92). The results from this boring indicated concentrations of GRO at 2,110 mg/kg, DRO at 11,800 mg/kg, and benzene at 0.279 mg/kg. Six soil samples from three nearby borings adjacent to the former D&D Distributors/Phillips 66 Bulk Plant did not contain exceedances of criteria for GRO and DRO.

Following the discovery of a benzene plume that apparently extended from the mill building into S. Cedar Street, referred to as the “Cedar Street Benzene Plume,” additional rounds of investigation borings were conducted. In November and December 2005, 18 soil samples were collected from direct-push boring locations along S. Cedar Street. Between May 30 and June 1, 2006, an additional phase of direct-push probe soil and groundwater investigation was conducted along both sides of S. Cedar Street (including on the K Ply facility) and along a section of the MTA and K Ply bulkheads, during which four soil samples were collected. Soil results were non-detect for petroleum compounds, except for detections of 791 mg/kg GRO and 530 mg/kg DRO at a depth of 6 to 8 feet bgs in SB-210 near the K Ply bulkhead, and low-level detections of GRO (19.4 mg/kg) and DRO (46.7 mg/kg) near the former form oil tanks, adjacent to the former mill on the west side of the Site.

3.1.1.4 Landau Associates 2009

To address continuing uncertainty over the source of the Cedar Street Benzene Plume, additional investigation was undertaken by Landau Associates on behalf of ITT Rayonier between January and February 2009 [53, 54]. The investigation included direct-push probing beneath the mill and through the raised concrete pad at the south end of the mill. A total of 75 soil samples were collected in areas of the Site where data gaps had been identified to assess concentrations of benzene, GRO, and DRO. In addition, test pit explorations with soil samples were completed near the former form oil USTs, between the mill building and S. 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. The results indicated a broad area of GRO and BTEX contamination in soil in the southern end of the former mill, including beneath the concrete pad, with shallow (vadose zone) contamination concentrated in the southwest corner of the building footprint and smear zone contamination extending further to the east and south into the alley. Very low concentrations of GRO and BTEX were detected in the area of the former form oil USTs. Landau stated that it was likely the Cedar Street Benzene

Plume originated from multiple contaminant release events. Based on its findings, Landau noted that likely sources of the GRO and BTEX beneath the former mill were thought to be either Pipeline 8, Peninsula Fuels, the abandoned sanitary sewer that ran under the alley, or possibly other unidentified sources. Based on further investigation conducted as part of this RI/FS, the release in the area of the former mill building and alley appears to be related to fuel leakage from Pipeline 8 during its active operation. Additional information is presented with the remedial investigation results in Section 5.4 and the CSM discussion in Section 6.1.

3.1.1.5 Floyd|Snider 2013 Interim Action Work Plan Sampling

In November 2012 and February 2013, soil investigation activities were conducted at K Ply as part of an Interim Action Work Plan (IAWP) [57] related to mill demolition and required by the current Agreed Order. As part of this action, two soil samples were collected from each of three soil borings advanced along the shoreline as part of well installation activities. Field evidence of contamination was observed in soil at depths below the water table in PP-17 and PP-18. There were no detections of BTEX, GRO, DRO, or oil-range TPHs, with the exception of a sample collected below the water table in Soil Boring PP-18. This sample had a detection of benzene and GRO at levels slightly greater than the MTCA Method A CULs.

Following mill demolition, a Site Assessment was conducted as part of the IAWP to evaluate the presence of surface contamination and evaluate the potential effect of increased stormwater infiltration [58]. A total of 18 surface soil samples were collected in specific areas of potential concern and in general characterization areas. Select samples were analyzed for GRO, DRO, BTEX, PCBs, metals, VOCs, semivolatile organic compounds (SVOCs), and formaldehyde. There were no detections of GRO, BTEX, or solvents in the surface soil samples collected. There were elevated concentrations of DRO and oil-range organics (ORO) detected in soil in the area of the panel oiler, the glue loft (located next to the hydraulic presses), and under the cureline dryer concrete pad. Metals and PAHs were detected in select samples but not at levels of concern. Formaldehyde was detected in a sample of dried resin that was collected. PCBs were detected in a solids sample collected from the transformer pad, but the detections were less than action levels.

3.1.2 Groundwater

Releases of ORO (i.e., hydraulic oil) and gasoline to groundwater were originally identified beneath the K Ply mill in 1989 by Landau and confirmed via subsequent groundwater data collected as part of the MTA RI and other efforts. In sum, these prior investigations have confirmed that hydraulic oils, gasoline, and BTEX compounds in groundwater at the Site are persistent and extensive. The following sections summarize the prior investigations of groundwater.

3.1.2.1 Landau Associates 1989

In 1989, 10 shallow groundwater wells were installed beneath the mill building to determine if the ORO contamination found under the presses was present in recoverable amounts. Measurable quantities of hydraulic oil, ranging from 0.2 to 2.1 feet in thickness, were encountered. The hydraulic oil in Well PP-3, southeast of the hydraulic presses, contained a mixture of hydraulic oil and gasoline [17]. Groundwater samples were analyzed for a range of constituents, including GRO, VOCs, total oil and grease, phenolic compounds including PCP, and inorganics including metals and cyanide. In addition to measured free product in these wells, sample results from these wells indicated elevated levels of GRO and BTEX in groundwater under the mill. Other constituents detected include low levels of methylene chloride (which was attributed to laboratory contamination), and low concentrations of iron, manganese, zinc, lead, chromium, and copper. The VOC 1,1,2-trichloro-1,2,2-trifluoroethane (Freon 113) was detected in groundwater at the southern property boundary. Total oil and grease, phenols, PCP, arsenic, cadmium, mercury, nickel, silver, and cyanide were tested for but not detected [59].

As part of sampling in 1989, which was completed as part of a remedial action plan for the PCP-contaminated soils beneath the former panel oiler location, it was concluded that PCP contamination had not reached the groundwater at concentrations exceeding regulatory cleanup levels.

3.1.2.2 Floyd|Snider 2005–2007

Groundwater investigative activities were conducted by Floyd|Snider in the vicinity of the Site as part of the MTA Site RI/FS. Groundwater screening samples were initially collected from three upgradient areas in 2005 to evaluate potential sources of gasoline and BTEX under the mill, including the area east of the Platypus Marine facility (to evaluate the former D&D Distributors/Phillips 66 Bulk Plant facility), along S. Cedar Street, and in front of Peninsula Fuels.

The results of this initial round of delineation samples confirmed the existence of a significant benzene plume along S. Cedar Street (refer to figures in Appendix A), with benzene concentrations most elevated immediately adjacent to the K Ply mill. An additional phase of direct-push probe investigation was conducted in 2006. The objectives of this additional site characterization were to define the full extent of the Cedar Street Benzene Plume; confirm the potential source area; and define the extent of benzene contamination along the K Ply bulkhead which lies downgradient of the area of hydraulic oil mixed with gasoline. A total of 24 groundwater screening samples were collected from locations along both sides of S. Cedar Street (including on the mill) and along a section of the MTA and K Ply bulkheads that provided a very detailed picture of the plume extent outside the mill.

Additionally, Floyd|Snider sampled a limited number of K Ply wells as part of the MTA Site RI/FS activities. Samples were submitted for analysis of GRO by NWTPH-G, DRO by NWTPH-Dx, and BTEX compounds by USEPA Method 8021B. Some wells were also sampled for formaldehyde at Ecology's request. However, no formaldehyde was detected.

3.1.2.3 Landau Associates 2009

Additional soil and groundwater investigation and piezometer installation activities were conducted to address the source of the Cedar Street Benzene Plume using a direct-push probe between January and February 2009 [53, 54]. Over 30 groundwater screening samples were collected in areas of the Site and tested for GRO/BTEX. A number of piezometers were installed within the mill building itself to better define groundwater flow direction. Results were inconclusive as to the specific source of the benzene plume, but a location within the mill building, under the raised concrete shipping platform (location B16), was identified as being near a "point of release" of gasoline. Peninsula Fuels was not considered to be a significant source of the benzene plume but was considered a possible contributing source to elevated GRO in groundwater north of the Peninsula Fuels property. No borings were advanced at Peninsula Fuels as part of the 2009 study. More recent data collected as part of this RI/FS, which include borings at Peninsula Fuels, indicate that GRO in groundwater at the Site, including the alley south of the mill, did not originate on the Peninsula Fuels and is distinct from contamination identified there. Additional information is included with the RI results presented in Section 5.4 and the CSM discussion presented in Section 6.1.

3.1.2.4 Interim Action Work Plan Activities

As part of investigative activities conducted at the Site for the mill demolition interim action (refer to the IAWP [57]), three new groundwater monitoring wells (PP-17, PP-18, and PP-19) were installed along the bulkhead at the northern edge of the Site in November 2012. The three new wells and five existing monitoring wells at the Site (PZ-6, PP-15, PP-13, PZ-12, and PZ-13) were sampled on a quarterly basis beginning in November 2012. Samples were submitted for analysis of BTEX, GRO, and DRO.

Approximately 0.45 foot of petroleum product similar to gasoline was measured using an interface probe in Well PZ-6 in November 2012, and 1.15 feet of product was measured in February 2013. Elevated concentrations of GRO (3,700 mg/kg) had been detected in soil samples collected during installation of the well by Landau, and highly elevated concentrations of GRO (53,000 micrograms per liter [µg/L]) were detected in the groundwater sample collected from the boring. Benzene was detected at a concentration of 2,800 µg/L in groundwater in PP-15 during the second quarterly monitoring event, which is greater than the historical maximum for that well. The benzene concentrations measured in groundwater in the other wells monitored as part of the IAWP are consistent with previous data. Appendix A contains copies of all IAWP sampling reports.

3.1.3 Harbor Sediment

Several sediment samples have been collected between the K Ply bulkhead and the south side of Terminal 1 beginning in 1991 by TetraTech [60]. Refer to Figure 3.1 for sediment sample locations. The TetraTech sample was found to exceed Washington Sediment Cleanup Screening Level for three low molecular weight polycyclic aromatic hydrocarbons (LPAHs; typically associated with POLs), six high molecular weight polycyclic aromatic hydrocarbons (HPAHs; typically derived from combustion byproducts), and 2-methylphenol. In addition, the sample was found to exceed the cleanup screening level criteria for phenanthrene, 2-methylphenol, and total LPAHs. The report attributed the exceedances to shipping activities and nearby industrial activities. Metals concentrations were found not to be elevated in the sediment sample.

Three additional samples (PA-SS2-002-SS-0, PA-SS1-001-SS-0, and PA-SS3-003-SS-0) were collected from surface sediments immediately offshore of the former K Ply log pond also in 1991 in preparation for filling of the pond. The samples were submitted for TPH analyses by USEPA Method 418.1 and total extractable petroleum hydrocarbons (TEPH) by USEPA Method 8015-modified. TEPH was measured at concentrations between 7 and 600 mg/kg, and TPH was measured at concentrations between 38 and 530 mg/kg [6].

The recent Port Angeles Harbor Sediment Characterization study [61] presents data for surface sediment grab samples (0 to 10 centimeters [cm]) and subsurface sediment core samples (maximum 12 feet) throughout the Harbor. Two of these samples were located in the vicinity of the Site: surface samples KP01 and KP02. Subsurface sediment core samples were also collected from location KP02 to depths of 66 inches. All surface samples were analyzed for a broad suite of contaminants including SVOCs, resin acids, pesticides, PCBs, dioxins/furans, DRO, metals, and bioassay. The motor oil fraction of TPH was also reported for all samples, but benzene and GRO were not analyzed. Subsurface samples from KPO2 were not analyzed for TPH.

There were no exceedances of any chemical sediment criteria in sediment samples collected by Ecology in the vicinity of the Site. Tributyltin (TBT) was detected at concentrations less than the sediment criteria at 40 micrograms per kilogram (µg/kg) at Station KP-01. Larval bioassay results from both KP-01 and KP-02 exceeded the Sediment Quality Standard (SQS)/Lowest Apparent Effects Threshold (LAET) criteria for mean normal survivorship (%) relative to reference for *Dendraster excentricus*.

Concentrations of DRO were less than a detection limit of 31 mg/kg dry weight in sediments in the two locations in the vicinity of the Site. TPH motor oil was detected in low concentrations in these sediments. Detected concentrations were 66 mg/kg and 97 mg/kg in KP-01 and KP-02, respectively. Although there are no cleanup criteria available for comparison for TPH in marine sediments, these concentrations are substantially less than MTCA Method A soil cleanup criteria. These concentrations are consistent with other detections of TPH motor oil throughout Harbor sediment, including locations far from potential near-shore petroleum sources.

It is worth noting that stormwater sampled at the Site outfall for the NPDES Construction Stormwater General Permit (CSWGP) in support of mill demolition was submitted for BTEX, NWTPH-G, and NWTPH-Dx analysis in November 2012 and February 2013. There were no detections of the tested analytes in the stormwater samples for either event.

3.1.4 Utility Investigations

A utility survey was conducted at the Site in June 2013 by Floyd|Snider to determine the locations of Pipeline 5 and Pipeline 8, to video the abandoned sanitary sewer line, and to investigate utilities on the Peninsula Fuels property [62]. Conductible steel, which was presumed to be Pipeline 8, was located using a radio frequency detector under the alleyway between Peninsula Fuels and K Ply. The signal was lost to the south of the alley, at the property line of Peninsula Fuels. The line was able to be traced to the northwest under the raised concrete pad and under the former mill until the signal was lost near the current fence line, just south of the concrete pavement of the travel lift near Terminal 1. Also, a 60-foot section of the pipeline was found to be missing under the footprint of the caustic/resin tank area. It presumably had been cut and disposed of to allow construction of the concrete vault housing those tanks.

Pipeline 5 was traced from its two visible flanges within the northwest corner of Peninsula Fuels until it was found to terminate on the west side of S. Cedar Street, as discussed in Section 2.1.5.5.

The survey of the abandoned sewer line was conducted at the manhole in the former K Ply machine shop. The manhole is approximately 12 feet deep and of brick and mortar construction. Three pipes terminate or originate in the manhole. The first is a 12-inch concrete pipe that extends north to an outfall at the Harbor. The second pipe is an 8-inch line that enters the manhole from the southwest. The third pipe is a 4-inch line that enters the manhole from the southeast (refer to Figure 3.1). The manhole served as the point where until around 1968 waste waters from the 8-inch line and the 4-inch line combined to flow into the 12-inch discharge line. At the time of inspection, both these lines were observed to be plugged, whereas the 12-inch discharge line was unplugged. Following removal of the plug from the 4-inch line, a strong gasoline odor emanated from the water that was released behind the plug. The water flow gradually subsided and the plug was replaced. During the time the water was flowing, a green fluorescence dye was added to the discharge line. About 15 to 20 minutes after the dye was added, a small dye plume was seen emanating from the base of the riprap slope into the Harbor; however, the outfall could not be visibly located.

The 12-inch line was videotaped for approximately 100 feet toward the Harbor until hitting an offset in one of the clay pipe segments. No connections were noted in this segment. The 4-inch line was unable to be videotaped because the line was too small for the tractor camera, but a sonde cable was pushed into the line, allowing the line to be traced on the surface. The line was traced back to the southeast until encountering an obstruction 20 feet northwest of the existing public sewer manhole located between CFN and the K Ply office (Figure 2.2B). The 8-inch line was not able to be videotaped because of a 6-inch reducer on the line right at the manhole. The sonde cable was able to be inserted and traced the 8-inch line back to where it suddenly stopped under the pavement in the alley. This area was investigated during the RI activities and no logical termination point for the stopping of the sonde (such as a buried manhole) was able to be identified.

Subsurface pipes were also surveyed on the interior of the Peninsula Fuels property. Three pipes were identified at the southern end of the facility that may have been used to supply a small self-service area. A previously unknown pipe was found that originated at the valve box near the pump house and led northeast to the alley, where it terminated. Several supply lines were visible aboveground at the old fueling rack, and all were traced back to the piping found inside the pump house.

3.1.5 Pipeline 8 Trench and Pressure Test Results

As described above, the section of Pipeline 8 not covered by the alley or concrete pad was exposed for inspection and pressure testing (KT-1 and KT-2). This was done by trenching and installing a test pit: (1) a trench section between the concrete pad and the caustic tank area; (2) a second trench section between the caustic tank area and the end near the bulkhead;[5] and (3) a test pit KT-1 located at Peninsula Fuels to expose the flanged ends of the two 4-inch pipes that comprise Pipeline 8. No signs of contamination (visual, olfactory, or photoionization detector [PID]) were observed along the length of the exposed pipeline and the exposed sections of Pipeline 8 appeared to be in good condition (i.e., no obvious corrosion or damage). The ends of each 4-inch pipeline that were historically cut in the resin/caustic tanks area were found to be plugged with a concrete/grout mix.

A pressure test was performed on the two remaining sections of each pipe. This was done by (1) locating the ends of the pipe; (2) drilling a small hole in the pipe and connecting a pressure meter and pump to the pipe; (3) pressurizing the pipe with compressed air to approximately 10 pounds per square inch (psi); and (4) monitoring to test for loss of pressure, which indicates a leak. When the test was started, the ends of the pipe and each exposed weld in the pipe were sprayed with a soapy water solution to check for leaks. The ends of the pipe that were filled with concrete/grout were initially found to leak and were sealed before finishing the pressure test.

After the desired pressure was reached in each line, it was noted that the pressure rapidly declined in three of the four pipe sections, including both segments under the concrete pad, indicating that there was likely a leak in the east and west pipelines of Pipeline 8 somewhere underneath the concrete pad or alley (refer to Section 5.0 for location of “pressure test failure”). The pressure test also indicated the west pipe leaked at a single threaded joint coupling near the Hydraulic Oil Area (refer to Section 5.0 for the location of the “joint leak”). A soil sample was

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[5] The sections of Pipeline 8 in the caustic tank area and near the bulkhead had previously been removed; therefore, trenching was not required.

collected under this joint for chemical analysis, but contamination was not detected. The east pipe of the northern section of Pipeline 8 held pressure during the pressure test.

During the drilling of the small holes to conduct the test, water was found in both pipelines. Water was removed as necessary to allow the pressure test to be conducted. A water sample was removed from each pipeline. The water appeared to be highly contaminated based on odor. A sample of the east pipeline water was submitted for analytical testing and the benzene concentration was 390 micrograms per liter (µg/L), and the GRO concentration was 22,000 µg/L. It is possible that this is residual water purposely left in the pipes during their decommissioning.

3.2 INTERIM REMEDIAL ACTIONS

Prior interim remedial actions undertaken at K Ply are summarized in this section. Refer to Figure 3.1 for locations of remedial actions, which are denoted as areas of potential concern.

3.2.1 Hydraulic Oil Recovery System

Ecology issued a remedial action order (No. DE 90-S255) dated May 16, 1990 for ITT Rayonier to recover the spilled hydraulic oil and excavate the PCP soil contamination beneath the Site (discussed below). SEACOR Marine (SEACOR) was subcontracted by ITT Rayonier to install and operate a hydraulic oil recovery system. A hydraulic oil recovery system was installed in March 1992 and consisted of two 6-inch-diameter, 30-foot-deep extraction wells located beneath the mill floor in the approximate center of the plume. The system utilized a two-phase pumping system in which groundwater in each well was recovered to generate a cone of depression at the well, and a separate pneumatic pump was used to skim floating oil from the well [63]. The containment system consisted of individual concrete receptacles located beneath each press, with metal trays to direct leaks from hydraulic lines into the concrete receptacle. The containment system was evaluated by an independent engineer who reported that the system had sufficient volume for containing hydraulic oil leaking directly from the presses, but did not provide for pressurized or fugitive leaks from pumps or piping. Further, no operational procedures were in place to maintain the receptacles and clear them of debris or overflow from wash-down water [64].

No hydraulic oil was recovered in the first 2 years of operation, which was attributed to inconsistent pumping rates, high viscosity oil, and fine-grained soils [65]. Available records up through 2007 indicate that the system was successful in recovering only a limited quantity of hydraulic oil; instead, its primary purpose switched to one of containment—to maintain drawdown to prevent further migration downgradient of the oil. The hydraulic oil recovery system was operated until it was decommissioned in late 2012 as part of mill demolition. Extraction wells were capped and protected during demolition.

3.2.2 Pentachlorophenol Cleanup

Under the 1990 remedial action order (No. DE 90-S255), ITT Rayonier undertook cleanup of the PCP contamination of soils beneath the Site (refer to area of past remedial action #2 in Figure 3.1). ITT Rayonier subcontracted SEACOR to excavate an estimated 150 tons of PCP-contaminated soils in the vicinity of the panel oiler location. The excavation and backfill of contaminated soils was completed by November 1991. Soils were excavated to a cleanup goal concentration of 25 mg/kg for PCP, resulting in an excavation approximately 25 feet wide by 40 feet long by 2 to 6 feet deep (approximately 150 tons of soil). However, to preserve the structural integrity of the building, with authorization from Ecology, the excavation was not completed to the cleanup goal in a narrow section adjacent to the raised concrete pad at the southern edge of the excavation, as well as in a small area of the bottom of the excavation that extended to 2 feet below grade [56]. Composite samples collected from each of the remaining excavation sides and one composite taken from the bottom of the deeper portion of the excavation indicated that the cleanup goal was otherwise achieved. Available records indicate that the soil left in place has concentrations of PCP up to 840 mg/kg, and bis(2-ethylhexyl)phalate of up to 310 mg/kg. Low concentrations (i.e., less than 2 mg/kg) of PAHs (fluoranthene, fluorene, 2-mehtylnapthalene, naphthalene, phenanthrene, and chrysene) were detected in samples of soil left in place on all four walls of the excavation.

Approximately 130 CY of PCP-contaminated soil and construction debris was transferred off-site to Marine Shale Processors Inc., in Saint Rose, Louisiana [56, 66]. The excavation was backfilled with clean imported soil and provided with surface drainage to minimize potential infiltration of water into the surface soils [56, 66].

3.2.3 Resin Cleanup

Available records indicate that in approximately 1985, PenPly excavated a small quantity of soil from the area of the resin tank following a spill of glue (refer to area of past remedial action #5 in Figure 3.1). The excavation was up to approximately 3 feet deep in places. Ecology issued an enforcement order (No. DE 85-753) compelling PenPly to properly characterize the resin-impacted material for off-site disposal. PenPly conducted the required testing, demonstrated that neither phenol nor formaldehyde was detected in the soil, and the order was closed in October 1986 [67].

3.2.4 Interim Action Work Plan Activities

The IAWP activities addressed how site soils would be stabilized and protected from infiltration following the Mill Demolition Project until the Site would be further investigated and fully remediated. Selected elements of IAWP were implemented by the Port during the Mill Demolition Project.

The IA components completed after the Mill Demolition Project was completed included the following:

- Abatement, removal, and disposal of hazardous materials in the mill structures.
- Removal and disposal of hazardous liquids in tanks and vaults, including the caustic storage area and press hydraulic oil vaults.
- Removal of ITT Rayonier remedial action equipment and storage tanks.
- Protection and abandonment of the two hydraulic oil recovery wells maintained by ITT Rayonier.
- Cleanup and removal of clean debris on the surface.
- Removal of electrical transformers.
- Implementation of BMPs for stockpiling of hazardous materials removed during demolition to be disposed of off-site.
- Asbestos wrapping on the vent stack and the fly ash on the inside of the stack.
- Removal of stockpiled fly ash.
- Placement of the plastic sheeting in the two TPH-G contamination areas that are described in the Temporary Erosion Sediment Control (TESC) Plan [28].

3.2.4.1 TESC Plastic Sheeting

Plastic sheeting was placed in accordance with the TESC Plan in the area of subsurface contamination under the mill to minimize stormwater infiltration. Plastic sheeting was placed over the GRO-contaminated area north of the concrete pad and over the hydraulic oil/hot press area. A portion of the GRO-contaminated area is also covered by concrete (Figure 3.2).

Per the work plan, interim action stabilization measures to limit infiltration will continue to be monitored by the Port until superseded by another plan or until cleanup commences. The Port will continue to repair and maintain stabilization measures implemented under the IAWP.

3.2.4.2 Stormwater Sampling

In accordance with conditions of the NDPES CSWGP permit, the Port sampled stormwater as specified in the permit. The list of monitoring requirements (i.e., turbidity, pH, visual oil sheen) in the CSWGP permit does not include quantification of petroleum compounds, which is of most concern at the Site; therefore, to ensure protectiveness, stormwater was also sampled for these additional parameters. Sampling occurred prior to demolition, to document baseline conditions, and quarterly for 1 year following demolition, to monitor any effects of demolition. No effects of demolition were noted after 1 year of monitoring. Per the plan, after the initial year of quarterly monitoring, stormwater sampling was scaled back to a yearly basis as there were no exceedances of water quality parameters or applicable MTCA criteria.

4.0 Remedial Investigation Activities

4.1 SOIL

The soil investigation was completed in September and October 2013. The section below describes general field methods used for surface and subsurface soil sampling and laboratory analytical methods. More details on the RI field activities can be found in the Supplemental Data Collection Technical Memorandum [68] submitted to Ecology in January 2014.

4.1.1 Soil Borings

Soil borings were advanced using direct-push probe sampling technology by Holocene Drilling of Puyallup, Washington, between September 9, 2013 and October 16, 2013, in accordance with the procedures described in the RI/FS Work Plan [69]. Borings were advanced from the ground surface to depths typically between 12 and 20 feet below ground surface (bgs) and were continuously logged according to the United Soil Classification System (USCS). Soil logs are summarized in the Supplemental Data Collection Technical Memorandum in Appendix A. Soil sample locations are shown on Figures 2.2A through D. Concrete cores were cut into pre-designated locations on the loading dock concrete pad area to allow the direct-push probe access to the underlying soil.

All soil samples were field screened for indications of petroleum using a PID. Visual observations of contamination, such as staining and sheen, and olfactory indications of contamination were also recorded. The presence of sheen was screened by placing a small volume of soil in a stainless steel bowl with water. In the Hydraulic Oil Area, blot tests of all borings and ultraviolet (UV) light testing of a small subset of borings were used to document potential contamination. Blot tests were performed by placing a dry paper towel on the soil core and recording the color and type of staining that appeared. UV light testing was completed in a dark room by shining a UV light along the length of the soil core to look for contamination.

Following field screening of soil cores, select intervals from most soil borings were targeted for sample analysis. Other borings were logged for visual evidence of contamination only (i.e., not sampled). Soil for analysis was first removed from the direct-push probe sampling liner from the sample interval of interest (e.g., 2 to 4 feet bgs) and placed into a decontaminated stainless steel bowl for homogenization. Samples were typically collected in the saturated zone (at the water table where there is tidal influence), the vadose zone (shallow soil), or both. Following homogenization, the soil was placed into laboratory-supplied sample containers, labeled, and immediately placed in a cooler maintained at a temperature of approximately 4 ºC using crushed ice.

Samples analyzed for GRO/BTEX were collected directly from the soil core according to USEPA Method 5035. Samples were transported to Freidman & Bruya, Inc. in Seattle, Washington, under standard chain-of-custody procedures.

4.1.2 Hollow-Stem Auger Soil Borings

Hollow-stem auger borings were drilled by Holocene Drilling of Puyallup, Washington, between September 18 and 20, 2013, in accordance with the procedures described in the RI/FS Work Plan [69]. Borings were advanced from the ground surface to a typical depth of 19 feet bgs. Soil was collected for logging purposes using an 18-inch split spoon sampler. The split spoon was driven at 2.5-foot intervals using a 150-pound hammer. The split spoon samplers were decontaminated between sample collection intervals. Soil samples were field screened to identify intervals potentially contaminated with volatile constituents using a PID. PID readings and visual observations of contamination, such as staining and sheen, were documented on the boring logs. The number of hammer blows necessary to drive the split spoon (i.e., the standard penetration test) was also recorded.

Per the RI/FS Work Plan [69], soil samples were not collected for laboratory analysis during well installation unless the field screening indicated that potential contamination was present. In only one instance did this occur and one sample was collected from the PP-23 boring where an elevated PID reading was observed. Soil volume from this interval was first collected directly from the split spoon for GRO/BTEX using USEPA Method 5035A. Soil from the desired depth interval was then scooped directly from the split spoon using a decontaminated stainless steel spoon and homogenized in a stainless steel bowl. Following homogenization, the sample material was placed into laboratory-supplied sample vials and jars, labeled, and immediately placed in a cooler maintained at a temperature of approximately 4 ºC using crushed ice. The sample was transported to Freidman & Bruya, Inc. in Seattle, Washington, under standard chain-of-custody procedures.

4.1.3 Test Pits

Test pits were dug with an excavator using a 2-foot-wide bucket. A toothed bucket was used for the majority of the test pits; however, a flat bottom bucket was used for KT-2 and KT-20, which were excavated to reveal subsurface piping, to ensure that the piping was not ruptured during excavation.

Test pits were excavated in approximately 6-inch-deep increments and the soil was logged continuously by a field technician according to the USCS. Test pit soils were screened for VOCs by inserting a PID monitoring probe into the sidewall of the test pit. Signs of contamination such as odors, sheens, or staining were noted on field forms. Test pits were approximately 3 to 4 feet wide by 6 feet long and ranged in depth between 3 and 11 feet. KT-1, which exposed Pipeline 8, was a trench approximately 3 feet deep and 384 feet long.

Test pit soil samples were collected by scraping material from the desired depth of the sidewall of the excavation into a decontaminated stainless steel bowl, using a stainless steel spoon or trowel. Soil for VOC analysis was collected directly from the excavation sidewalls using USEPA Method 5035 procedures. The sample material was placed into laboratory-supplied sample vials and/or jars, labeled, and immediately placed in a cooler maintained at a temperature of approximately 4 ºC using crushed ice. Samples were transported to Freidman & Bruya, Inc. in Seattle, Washington, under standard chain-of-custody procedures.

4.1.4 Surface Soil

The sampling locations for surface soil samples SS-1 through SS-3 were selected based on lack of pavement and lack of recent ground disturbance, and SS-4 through SS-6 were selected based on the footprint where the former mill stack was demolished. This was done in the field in coordination with Ecology. The sample locations were photographed, and samples were collected beneath any duff layer vegetation to a depth of approximately 3 inches using a decontaminated stainless steel spoon. Soils were homogenized in a decontaminated stainless steel bowl and placed into laboratory-provided jars. Sample jars were labeled and immediately placed in a cooler maintained at a temperature of approximately 4 ºC using crushed ice. Samples were transported to Freidman & Bruya, Inc. in Seattle, Washington, under standard chain-of-custody procedures.

4.1.5 Petrophysical and Ultraviolet Assessment

In addition to sampling for analytical chemistry, a subset of soil borings with observed or suspected non-aqueous phase liquid (NAPL) were selected for petrophysical analysis and UV photography. These nine samples were collected by driving a parallel core adjacent to an existing direct-push boring to target a specific undisturbed and known contaminated interval for sampling using a 4-foot-long stainless steel liner. The liner was cut to isolate the desired depth interval for analysis, then capped and immediately frozen with dry ice to prevent loss of fluid. Samples were transported to PTS Laboratories in Santa Fe Springs, California, under standard chain-of-custody procedures. Once at the laboratory, the nine frozen cores were cut in half lengthwise and then photographed in visible, as well as UV, light. The UV light causes fluorescence in certain types of petroleum that contain sufficient PAH and heterocyclic organic compounds (such as diesel and heavier fuels). The stronger the fluorescence, the greater the relative concentration of petroleum within the core. This technique allows for quick identification of the distribution and relative concentration of petroleum across the core, which aids greatly in the selection of the six specific intervals for follow-up petrophysical testing as described in Section 5.4.2. Those intervals are identified by red box outlines in the UV photographs found in Appendix F of the Supplemental Data Collection Memorandum [68]. Core samples were not collected from three of the nine cores due to low or no fluorescence (i.e., no significant hydrocarbon accumulation).

4.1.6 Cultural Resource Monitoring

The K Ply mill is located near Tumwater Creek and is in close proximity to one of the three documented Klallam villages in the Harbor area. The project area is approximately 1 mile from the Tse-whit-zen village site and another documented Klallam village site at the mouth of Ennis Creek.

Prior to demolition of the mill and associated aboveground structures, in April 2012 the Department of Archaeology and Historic Preservation (DAHP) determined that no archaeological oversight was necessary for the demolition of historic buildings and/or associated structures and made a Determination of Non-Significance (DNS). DAHP recommended that future remediation activities that occur below grade should be monitored by a professional archaeologist [70].

In accordance with the AO for this investigation and prior agreements with Ecology and the Port, cultural resource protocols for monitoring during all ground-disturbing activities were completed in compliance with federal, state, and local laws and regulations in accordance with Section VIII.P. In addition, the Port, the City of Port Angeles, and the Lower Elwha Klallam Tribe (LEKT) have an agreement that all ground-disturbing activities in the area between the bluff to the south and the shoreline behind which the Site is located require monitoring of site work by an archaeologist.

Historical Research Associates, Inc. (HRA) completed archaeological monitoring for the remedial investigation in accordance with the existing Port, City, and LEKT settlement agreement. The HRA archaeologist monitored all ground disturbing activities including direct-push soil borings, test pit excavations, and monitoring well installation. All field observations were recorded in a field notebook, and photographs were taken of each location and the general work area.

Monitoring results and recommendations for further investigation and remedial actions are summarized in the *Archaeological Monitoring Report for K Ply Remediation Project* included in Appendix C.

4.1.7 Analytical Methods

The soil samples collected, described above, were analyzed for some or all of the following constituents using the analytical methods summarized below and in accordance with the RI/FS Work Plan [69]:

- Metals (silver, arsenic, chromium, copper, lead, nickel, and zinc) by USEPA Method 6020
- Mercury by USEPA Method 7471
- DRO and ORO by NWTPH-Dx with silica acid gel cleanup
- GRO by NWTPH-Gx
- VOCs by USEPA Methods 8260 and 8021
- Semivolatile organic compounds (SVOCs) by USEPA Method 8270
- Polychlorinated biphenyls (PCBs) by USEPA Method 8082
- Dioxins/furans (surface soil samples only) by USEPA Method 1613

4.1.8 Data Validation

A Compliance Screening, Tier I data quality review was performed on the soil analytical data with the exception of the dioxin/furan data. A USEPA Stage 2A data validation review was performed by EcoChem, Inc. on the dioxin soil analytical data. The analytical results are determined to be of acceptable quality for use with minor qualifications as detailed in the data validation reports attached in the Data Collection Technical Memorandum in Appendix A.

4.2 GROUNDWATER

The groundwater investigation was completed in September and October 2013. The section below describes field methods used for installation of monitoring wells and analytical laboratory methods. Groundwater quality is summarized in Section 5.5.

4.2.1 Monitoring Well Installation and Development

Ten monitoring wells (PP-4R, PP-6R, PP-15R, PP-20, PP-21, PP-22, PP-23, PP-24, PP-25, and PP-26) were installed on the Site from October 18 to 20, 2013.

Three of these wells were replacement wells as PP-15, PP-4, and PP-6 were destroyed during mill demolition. Well PP-15 was located in the high-concentration area of the GRO and benzene plume and was replaced with PP-15R. Wells PP-6 and PP-4 were located east of the edge of the contamination beneath the mill and serve an important role in monitoring the eastern extent of contamination. PP-6 was replaced with PP-6R, and PP-4 replaced with PP-4R. A fourth unplanned well, PP-26, was initially intended to be a replacement for PP-4 but was installed just east of the location of piezometer PZ-8. The distance between PP-26 and PZ-8 is 5.5 feet. PZ-8 was not damaged during the installation of PP-26. PP-26 replaces the piezometer PZ-8 for monitoring groundwater quality and the decommissioning of PZ-8 is planned. Monitoring well locations are shown in Figures 2.2A through D.

4.2.1.1 Field Methods

Monitoring well installation was completed by Holocene Drilling. The boreholes for the wells were drilled using standard hollow-stem auger technique. Auger boreholes were advanced using a 4-inch inner diameter auger. Split-spoon soil samples were collected every 2 feet during completion of soil boring activities. Soil samples were only collected based on field observations and indications of the presence of petroleum contamination.

The monitoring wells were constructed with 10-foot-long screens set from 8 to 18 feet bgs. Well screen assemblies consist of a 10-foot length of 2-inch-diameter 0.020-inch (20-slot), Schedule 40 polyvinyl chloride (PVC) pipe set in a 10/20 Colorado silica sand filter pack. The sand filter pack was installed by pouring sand into the space between the well casing and auger as the auger was withdrawn. A weighted tape was used to monitor filter pack placement and depth during installation. The sand filter pack extends 2 feet above the top of the screened interval. A 3-foot-thick seal of hydrated bentonite chips was installed in the annular space immediately above the sand filter pack. The remainder of the annular space was sealed with bentonite grout to within 1 foot of the ground surface.

Monitoring Wells PP-23, PP-24, and PP-25 were secured with flush-to-ground locking steel protective monuments with expansion seals on the well casing to minimize the potential for surface water entering the monument. Monitoring Wells PP-4R, PP-6R, PP-15R, PP-20, PP-21, and PP-26 were installed with aboveground protective steel monuments and bollards. PP-22 was installed with an aboveground protective steel monument and Ecology blocks. Well completion details are summarized in the Data Collection Technical Memorandum in Appendix A.

Well development was completed by continuous pumping at a steady rate using a battery-operated Whale pump. Well development equipment was decontaminated by pumping clean water through the pump and washing to the satisfaction of the field technical staff. Well development was terminated when turbidity readings stabilized or were below 50 Nephelometric Turbidity Units (NTU). Installed wells were labeled with a permanent marker on the well casing and on the well covers. A professional survey, including measuring point elevation and ground surface elevation, was completed for all monitoring wells installed.

4.2.2 Monitoring Well Sampling

On October 14 and 15, 2013, groundwater samples were collected from 19 existing and newly installed monitoring wells. The following section describes the field methods used for sampling.

4.2.2.1 Field Methods

All wells were purged and sampled using low-flow procedures to achieve the lowest turbidity practicable with a peristaltic pump and disposable polyethylene tubing. Prior to and during sampling, depth to water was measured to the nearest 0.01 foot using a water level indicator. The monitoring well was purged prior to sampling at a maximum rate of 0.5 liters per minute. During purging, field parameters (i.e., temperature, pH, conductivity, salinity, and turbidity) were recorded at 5-minute intervals using a multi-parameter water quality meter. Once the field measurements for water quality parameters were stable (within 10 percent) for three consecutive readings, the groundwater sample was collected. The last set of field parameters measured during purging will represent field parameters in the groundwater sample. All field measurements were recorded on a groundwater sample collection form, included in the Data Collection Technical Memorandum in Appendix A.

After purging the well and labeling the sample bottles, the groundwater sample was collected by directly filling the laboratory-provided bottles from the pump discharge line at the same flow rate that was used for purging. The sample bottles were labeled and immediately placed in a cooler maintained at a temperature of approximately 4 ºC using crushed ice. Samples were transported on ice to Freidman & Bruya, Inc. in Seattle, Washington, under standard chain-of-custody procedures.

4.2.3 Direct Push Groundwater Screening Sampling

Groundwater screening samples were collected from Boring K-90 in a location with historical petroleum storage, from K-98 and K-99 in the vicinity of the former dry well, and from K-200 through K-203 along the 4-inch sewer line running to the southeast of the former mill. Screening samples were also collected from Borings PF-1 through PF-9 on the Peninsula Fuels property.

4.2.3.1 Field Methods

Groundwater grab samples were collected by inserting temporary 1-inch-diameter PVC casing with 5- or 10-foot slotted PVC screens into the direct-push boring rods once soil sampling was completed. The rods were then removed to allow groundwater to flow into the screen. Screen lengths and depths were determined in the field and set to span across the water table. A static depth to water measurement was also collected after installation and the screen depth was readjusted to span the water table when necessary.

Groundwater was purged from the temporary PVC casing using a peristaltic pump with disposable high-density polyethylene (HDPE) and silicone tubing. Groundwater screening samples were collected by filling laboratory-provided bottles directly from the pump discharge line once the purge water was visually clear. The sample bottles were labeled and immediately placed in a cooler maintained at a temperature of approximately 4ºC using crushed ice. Samples were transported on ice to Freidman & Bruya, Inc. in Seattle, Washington, under standard chain-of-custody procedures.

4.2.4 Analytical Methods

The groundwater samples were analyzed for some or all of the following constituents by the methods indicated below and in accordance with the RI/FS Work Plan [69]:

- DRO by NWTPH-Dx with silica acid gel cleanup
- GRO by NWTPH-Gx
- MTCA metals (arsenic, cadmium, chromium, lead, and mercury) by USEPA Methods 200.8, 245.1/245.5, and 7470A
- BTEX by USEPA Method 8021
- VOCs by USEPA Method 8260
- SVOCs by USEPA Method 8270
- Formaldehyde by USEPA Method 8315A

4.2.5 Data Validation

A Compliance Screening, Tier I data quality review was performed on the groundwater analytical data. The analytical results are determined to be of acceptable quality for use with minor qualifications as detailed in the data validation reports attached in the Data Collection Technical Memorandum in Appendix A.

4.2.6 Water Level Elevations

Water level elevation measurements from representative wells and piezometers were completed on October 14, 2013 during low tide and January 28, 2014 during high tide conditions. All measurements were completed within an approximately 1-hour-long period. Water and/or LNAPL levels and elevations from October 14, 2013 are summarized in the Data Collection Technical Memorandum in Appendix A and results from both events are presented in Section 5.2.

4.3 SEDIMENT

Sediment sampling was conducted in July 2013 and samples were collected for chemical analysis and sediment bioassay testing. Sediment profile imaging (SPI) was also conducted to assess the presence of woodwaste and sediment health. The findings from this sediment sampling event and other recent testing are summarized in Section 5.6.

4.3.1 Surface Sediment Sampling

Sediment investigation activities in front of the Site included the collection and analysis of surface sediment (0 to 10 cm) samples to evaluate if sediments in front of the Site were historically impacted from discharges from the Site, and sediment imaging to evaluate the presence of wood debris waste. The sediment sampling investigation was coordinated to be consistent with the Western Port Angeles Harbor Group (WPAHG) sampling event, and the procedures were performed in accordance with the WPAHG RI/FS Work Plan [71].

Three surface sediment samples were collected (KSS-1, KSS-2, and KSS-3) within the nearshore area of Port Angeles in front of the Site on July 9, 2013. The surface sediment sampling location KSS-1 was located in front of the historical sanitary sewer outfall. Surface sediment sampling location KSS-2 was located directly offshore of the existing outfall (and the historical entrance to the log pond). The surface sediment sampling location KSS-3 was the furthest east of the sediment samples and was located offshore of the log storage yard. Positioning and navigation to the surface sediment sampling locations in the Harbor was accomplished with a differential global positioning system with an accuracy of within 2 meters. Water depths were measured with the vessel depth finder, corrected for tide, and converted to mudline elevations.

The surface sediment sampling was performed from the BioMarine Enterprises' R/V Kittiwake by Integral Consulting field staff. The surface sediment samples were collected from a depth of 0 to 10 cm using a stainless steel Van Veen grab sampler. Multiple grabs were required at each sampling location to obtain the volume of sediment required for the chemical analyses and the biological testing.

Sample processing for the surface sediment samples collected occurred on the boat. Sediment sample characteristics and observations were made in a field notebook and include notes on texture, color, biological organisms or structures, presence of debris, relative size of wood debris, presence of sheen or contamination, and odor. Sediment descriptions were recorded in a field notebook. Samples for total volatile solids (TVS) were collected directly from the grab sampler and placed in the sample containers. Once sufficient sample volume was collected, the samples were homogenized to a uniform appearance in stainless steel bowls (several bowls were required for each location). Following homogenization, the remaining sample containers for chemical analysis and bioassay testing were filled. All sampling containers were tightly capped, labeled, and immediately placed in a cooler maintained at a temperature of approximately 4 ºC using crushed ice.

Samples for conventional and chemical analysis were shipped to ALS Environmental in Kelso, Washington and samples for PCB and dioxins/furans analysis were shipped to Axys Analytical Services in Sidney, British Columbia, Canada, under standard chain-of-custody procedures. Samples for bioassay testing were delivered to Newfields in Port Gamble, Washington, under standard chain-of-custody procedures. Sediment quality is summarized in Section 5.5.

4.3.2 Sediment Profiling Imaging

SPI was completed at the three sediment sample locations to evaluate and delineate the extent of wood debris and to provide information on benthic habitat quality [71]. Images were collected using an Ocean Imaging Systems 3731 camera of the sediment column in profile. Plan view images were also taken to evaluate surface features. Multiple images were obtained at each location and a full analysis of the images was completed by Germano and Associates [72]. Refer to the WPAHG Sampling and Analysis Plan (SAP) for additional details on the qualitative metrics that were determined from the images [73].

4.3.3 Analytical Methods

The surface sediment samples collected were analyzed for the methods indicated below, in accordance with the RI/FS Work Plan [69] and WPAHG RI/FS Work Plan [71]:

- Grain size by Puget Sound Estuary Program (PSEP)
- Total solids by USEPA Method 160.3 Modified
- TVS by USEPA Method 160.3
- Total organic carbon by Plumb 1981
- Metals (arsenic, cadmium, chromium, copper, lead, silver, and zinc) by USEPA Method SW6020A
- Mercury by USEPA 7471B
- SVOCs by USEPA 8270D
- PAHs and PCP by USEPA 8270 SIM
- Butyltins by Krone 1988
- GRO and ORO by NWTPH-Dx with silica gel and acid cleanup
- PCBs (congeners) by USEPA 1668A
- Dioxins/furans by USEPA 1613B

4.3.4 Bioassay Testing

Biological toxicity tests were conducted following review of the analytical data with Ecology. The toxicity tests were conducted consistent with the procedures in the WPAHG RI/FS SAP [71]. Bioassay testing included the following:

- 10-day amphipod test with *Eohaustorius estuarius*
- 20-day polychaete test with *Neanthes arenaceodentata*
- 48-hour benthic larval test with the bivalve *Mytilus galloprovincialis* following the resuspension protocol

4.3.5 Data Validation

The sediment data were validated in accordance with the quality assurance procedures identified in the WPAHG RI/FS Work Plan [71]. This included a Compliance Screening, Tier 1 data quality review on all sediment data with the exception of the dioxin/furan and PCB data. The dioxin/furan data and PCB data were validated with a USEPA Stage 2B review by EcoChem. All other data were validated by Floyd|Snider. Data quality reports can be found in the Data Collection Technical Memorandum in Appendix A.

5.0 Remedial Investigation Findings

In this section, the relevant findings of the remedial investigation concerning the nature and extent of contamination in soil, groundwater, and sediments are summarized.

5.1 SITE GEOLOGY

The primary geologic units at the Site, illustrated in cross sections A-A’, B-B’, and C-C’ (Figures 5.1, 5.2, and 5.3, respectively) generally consist of native beach deposits overlain by dredge fill. This dredged fill material consists of sand and silty sand in some areas with abundant shell fragments and occasional lenses of silt. The thickness of the dredge fill beneath the Site is generally in the range of 12 to 16 feet, and increases in thickness to approximately 20 feet at the shoreline bulkhead [3]. A well-graded gravelly sand structural backfill was encountered beneath the loading dock concrete pad structure in the southern end of the former mill at approximately 5 feet above grade to the ground surface.

Native deposits underlying the dredged fill are visually similar to the overlying dredge fill and 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 geotechnical borings drilled to a depth of approximately 78 feet near the shoreline at the nearby MTA site, the beach deposits appear to be about 30 feet thick, though these deposits likely thin toward the bluff south of the Site [51].

Glacial drift deposits including Vashon till and outwash 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 glaciofluvial 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 [51].

5.2 SITE HYDROGEOLOGY AND GROUNDWATER FLOW

5.2.1 Shallow Groundwater Flow Directions and Horizontal Gradients

A shallow, unconfined aquifer is present beneath the Site that first occurs in the dredged fill and beach deposits. Groundwater is generally encountered at approximately 10 feet bgs in the vicinity of the former K Ply mill building, slightly lower in the area of the log pond and debarker operations, and between 6 and 8 feet bgs on the Peninsula Fuels property to the south (a topographically low area). Groundwater elevation is highly variable along the shoreline due to tidal effects. The aquifer is thought to be recharged by groundwater from transmissive portions of the glacial deposits upgradient of the shoreline area to the south, and infiltrating precipitation. Groundwater discharges to the Harbor through a riprap slope that covers an older permeable wooden bulkhead structure [3].

Potentiometric contours based on groundwater elevation data collected on October 14, 2013 and January 28, 2014, are presented in Table 5.1 and illustrated on Figures 5.4 and 5.5. Based on these measurements, the overall groundwater flow direction is predominately northerly, toward the Harbor, with a horizontal gradient of approximately 0.005 feet per foot (ft/ft) in these directions. This gradient is consistent with the tide-corrected gradient range of 0.002 to 0.006 ft/ft and net gradient of 0.002 ft/ft calculated as part of an earlier tidal study on the adjacent MTA site [74] as discussed in the following section. Water level measurements indicate an area of mounded groundwater in the vicinity of the concrete pad at the southern end of the former mill building, such that the inferred groundwater flow direction beneath the site includes an easterly and a slight southerly component from this area.

5.2.2 Tidal Influence

Tidal influence is strongest on water level elevations near the shoreline and decreases in effect inland. The tidal influence affects the short-term horizontal gradient, but not the overall net horizontal gradient, which drives groundwater flow to the north into the Harbor. During previous investigations on the adjacent MTA site, variability in groundwater flow directions adjacent to the shoreline was observed and attributed partially to tidal variations. Tidal influence on the potentiometric surface in monitoring wells as far as 600 feet inland was also measured at the MTA site [74]. The study 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. At the Site, groundwater elevation measurements during a high tide of approximately +8 feet mean lower low water (MLLW) did not indicate such a groundwater gradient reversal at the shoreline. However, observations of petroleum contamination spread above and below the average water table as a “smear zone” suggest the influence of tidal fluctuation on shallow water levels. A slightly increased smear zone thickness of approximately 5 feet was observed in soil borings close to the shoreline, compared to a 2-to 4-foot-thick smear zone observed in soil borings farther inland. Wells at the Site were sampled at low tide, when gradients are steepest, in order to obtain representative groundwater samples that minimize the mixing of saltwater with shallow groundwater, which is more pronounced during high tides.

5.3 NATURE AND EXTENT OF CONTAMINATION OVERVIEW

The results of the remedial investigation sampling of soil, groundwater, and sediment are summarized in this section and presented in Figures 5.6 through 5.11. Additional details for specific areas of the Site are given in the following subsections.

The primary contaminants detected at the Site are GRO, DRO, ORO, and BTEX, found in both soil and groundwater. Contaminant detections are generally limited to the footprint of the former K Ply mill building with some contaminant migration in groundwater west of the mill footprint into S. Cedar Street. There are also some localized and shallow areas of dioxin/furan and PCP soil contamination within the Site.

An additional limited zone of GRO, DRO, and BTEX contamination also exists within the Peninsula Fuels property. This limited contamination area appears to originate in the southern half of the property near borings PF-7 and PF-8 and extends a limited distance downgradient but not beyond the Peninsula Fuel northern boundary; therefore, it does not appear to be the source of the much more extensive and greater concentation GRO contamination observed downgradinet on the Site.

Within the Site, GRO has been detected in smear zone soils at concentrations up to 14,000 mg/kg. GRO contamination is also extensive and extends continuously from the alley/concrete pad area north in a more narrow zone to the bulkhead area (Figure 5.8). GRO was encountered in vadose zone soils as well, but mostly confined under the loading dock concrete pad. In the concrete pad area, the depth to vadose contamination is approximately 3 feet below surrounding grade (equivalent to 8 feet below the raised concrete pad surface). This depth is also the approximate depth where Pipeline 8 was encountered in this area (refer to Figures 5.1 and 5.3). GRO concentrations in vadose zone soils near Pipeline 8 ranged from 3,400 to 17,000 mg/kg.

GRO contamination in groundwater is most concentrated at the south end of the Site in the vicinity of the loading dock concrete pad, with a maximum detection of 15,000 µg/L in October 2013. Elevated GRO concentrations were also observed in groundwater near the bulkhead at concentrations up to 6,500 µg/L during the same event.

Similar to GRO, benzene concentrations in smear zone soils were generally greatest in the vicinity of Pipeline 8 under the loading dock concrete pad, where concentrations were generally greater than 10 mg/kg and ranged up to 210 mg/kg. Benzene occurs in vadose zone soils as shallow as approximately 3 feet bgs (8 feet under the loading dock concrete pad itself) in the vicinity of Pipeline 8 at concentrations ranging from 4.1 to 21 mg/kg.

According to the laboratory reports, the gasoline in soil appears weathered, which is expected, considering that Pipeline 8 was apparently decommissioned in 1969, leaving sufficient time for any gasoline released from this pipeline to have weathered.

Elevated benzene was detected in groundwater at concentrations greater than 5,000 µg/L in the vicinity of Pipeline 8. Benzene concentrations greater than 500 µg/L generally extend beneath S. Cedar Street and extend to the bulkhead to the north. The distribution of benzene in groundwater is consistent with the observed primary groundwater flow directions to the north.

Hydraulic oil LNAPL was encountered in the area identified by previous investigations near the former presses. RI borings further delinated the extent of ORO contamination at the north edge of this area. Elevated DRO concentrations were detected in the vicinity of Pipeline 8 beneath the loading dock concrete pad and in the alley south of the mill. DRO and ORO were generally not detected or detected at low levels in site groundwater.

Chemistry data indicate that the sediment chemistry, including dioxin/furan and PCB results for these locations, are similar to sample results found in other areas of the Harbor (i.e., there is no obvious “hot spot” in sediment off of the Site). SPI images do not indicate significant wood debris in this area.

5.4 SOIL QUALITY DETAILS

Soil quality was investigated in several targeted areas of current and former operations to fill data gaps from prior investigations and determine whether soil has been impacted by these operations. The specific areas and contaminants that were investigated include: the hydraulic oil LNAPL area below the former plywood presses; the gasoline previously found under the loading dock concrete pad area; PCP at the former panel oiler area; unknown possible contaminants at the former dry well, former wood debris pile, and former log pond; TPH releases at the former AST/UST areas and around the current debarker mechnical operations; dixoins/furans in the area where the stack fell during mill demolition and to the east; and possible TPH releases at the adjacent Peninsula Fuels property to the south.

5.4.1 Hydraulic Oil Area

The Hydraulic Oil Area is an area beneath the northern end of the former mill where hydraulic oil impacts have been previously investigated, and where commingling with gasoline contamination has been documented. Soil borings were advanced primarily to better define the limits of the hydraulic oil contamination, which were not previously well-defined. The extent of the Hydraulic Oil Area, including the zone of hydraulic oil free product and elevated ORO, is shown in map view on Figure 5.6 and in cross-section on Figure 5.2.

ORO concentrations ranged from 24,000 to 32,000 mg/kg in smear zone soils collected from borings K-63, K-64, K-67, and K-73, indicating likely presence of LNAPL in the smear zone. Petrophysical testing of a soil sample collected from adjacent to the LNAPL extraction well EW-2 measured oil fluid saturation of 50.7 percent of the total pore volume of 37.4 percent (i.e., approximately 19 percent NAPL by soil bulk volume). Field blot testing in this boring showed approximately 1 foot of NAPL-soaked soils in the smear zone at this location. This compares to the 2.5 feet of LNAPL measured in the well, indicating that LNAPL thickness in wells are exaggerated compared to the thickness of the LNAPL zone observed in soil.

Oil-range TPH had been detected at concentrations up to >107,000 mg/kg (10 percent by weight) in this area during previous investigations. In the eastern portion of the Hydraulic Oil Area, generally to the east of boring K-63, gasoline odors and GRO detections were commingled with ORO in smear zone soils. This area of commingled GRO and ORO contamination was found to extend to the north to the vicinity of boring K-103, with the eastern and western extents of the area of ORO contamination similar to the extents of the GRO contamination (refer to Figure 5.8).

ORO concentrations greater than 2,000 mg/kg were also detected in vadose zone soils as shallow as 3.5 feet bgs in borings K-50 and K-66 outside the northern edge of the LNAPL area. During a previous investigation, an ORO concentration of 54,000 mg/kg was detected in a sample collected from about 6 feet bgs in the PP-2 boring at the southern edge of the LNAPL. This suggests that some residual ORO is present in vadose zone soils overlying the zone of LNAPL contamination (refer to Figure 5.6).

Step-out borings near well PP-12 were advanced, as shown on Figure 2.2B, to better define the limits of LNAPL in this area. Prior to advancing the step out boring, a boring was advanced adjacent to PP-12. That boring showed an approximately 1-foot-thick zone of fluorescence in soils, which correlated with 1.9 feet of LNAPL observed in the well. The step out boring within 10 feet of PP-12 showed similar fluorescence thickness; however, in the boring 20 feet further away from PP-12 only thin lenses of fluorescence were observed and these lenses were limited to the more coarse-grained soils. This suggests that the viscous hydraulic oil product layer in the smear zone does not thin uniformly across a wide distance (i.e., pancake), but rather it terminates within a short distance of its currently observed extents. Samples collected for analysis outside of the zone of inferred LNAPL, especially downgradient, contained ORO. However, concentrations were much less than those in the LNAPL fluorescence zone and, therefore, are not suggestive of the presence of LNAPL. In summary, the extent of LNAPL is generally consistent with the estimated extent as portrayed in prior investigations. ORO was found to extend downgradient to the north beyond the LNAPL area but at much lower concentrations (refer to Figures 5.6).

The volume of hydraulic oil LNAPL is estimated to be a minimum of 9,000 gallons (refer to Appendix D). This is based on the estimated extent of the plume, the average thickness of LNAPL observed in soil cores, the thickness (adjusted) in wells within the plume, and the results of the petrophysical testing. Refer to Appendix D for calculations and methodology.

5.4.2 Gasoline Area

As a result of the many borings conducted during the RI in formerly inaccessible areas following mill demolition, the extent of the gasoline under the mill is now well documented, as shown in plan view on Figure 5.8 and in cross-section on Figures 5.1, 5.2, and 5.3. The Gasoline Area consists primarily of an approximately 300-foot-wide area beginning under the alleyway and former loading dock concrete pad (which includes a substantial area of vadose zone contamination), and an elongated stretch of chiefly smear zone contamination that extends approximately 500 feet northward of the pad, comingles with the Hydraulic Oil Area, and extends to the bulkhead.

GRO detections and field indications of petroleum contamination, including rainbow sheens, were also encountered in shallow vadose zone soils under the loading dock concrete pad especially in the vicinity of Pipeline 8, where concentrations greater than 7,000 mg/kg were detected in vadose zone samples collected from the K-21 and K-47 borings (refer to Figure 5.8 for the location of the "pressure test failure area" and "joint leak"). The vadose zone contamination generally terminates just north of the concrete pad in the vicinity of well PZ-06A. Field indications of gasoline and GRO detections were also encountered in vadose zone soils from borings K-50 and K-66 to the north of the Hydraulic Oil Area; however, this vadose contamination appears to be localized and separate from much larger releases and the more highly contaminated soil in the vicinity of the loading dock concrete pad.

The greatest concentrations of GRO, DRO, and BTEX in the smear zone were detected in samples from the area under the loading dock concrete pad close to Pipeline 8, in the area of pressure test failure for both 4-inch pipes (refer to Section 3.1.4). The elongated distribution of gasoline in the smear zone downgradient of the loading dock concrete pad is consistent with a mechanism of movement in which petroleum products migrate at the water table surface and are subsequently smeared by water table fluctuations, roughly following the groundwater flow direction shown on Figures 5.4 and 5.5.

As shown in the worksheets in Appendix D, an estimate of the total mass of gasoline-contaminated soil at the Site (based on the total volume of contaminated soil in the vadose and smear zone and the average TPH concentration within those zones) is approximately 218,000 pounds (equivalent to 36,000 gallons of gasoline). This volume is substantially greater than the approximately 350 gallons of static volume contained within each 4–inch-diameter pipe (with an approximately length of 750 feet running from Terminal 1 to Peninsula Fuels) to Terminal 1. This large volume of gasoline contained in site soils likely could have occurred only when the pipeline was in active operation and is not due to leakage of residual fuel in the pipes following its decommissioning in 1968.

As with prior investigations, BTEX soil contamination generally corresponds with the extent of GRO in soil. BTEX was detected in the smear zone soil samples from the loading dock concrete pad to the bulkhead. Of particular concern are the elevated concentrations of benzene that occur at concentrations up to 120 mg/kg in soil. These elevated concentrations are found mostly in the soils under the loading dock, forming a benzene "hot spot" as represented by the 10 mg/kg soil concentration contour in Figure 5.8. This hot spot area appears to be the source area for the benzene observed in downgradient groundwater.

DRO was detected in several vadose zone samples under the loading dock concrete pad near Pipeline 8, with a maximum concentration of 24,000 mg/kg in the sample collected from K-48 located very close to Pipeline 8. DRO was reported at lesser concentrations under the loading dock concrete pad to the east of Pipeline 8, where analytical results in smear and vadose zone soil samples suggest potential chromatographic overlap with GRO. Field indications of DRO, including rainbow sheens, were observed in vadose and smear zone soils in this area. DRO was generally not detected, or reported at low levels where analytical data suggest chromatographic overlap with ORO, in soil samples to the north of the pad (refer to Figure 5.7).

Petrophysical testing for NAPL pore fluid saturation was also conducted for vadose and smear zone soils in the Gasoline Area. The results were presented in the Supplemental Data Collection Memorandum [68] and are discussed here. Adjacent to well PZ-06, where a trace accumulation of NAPL is consistently present, NAPL pore fluid saturation measurements were 9.8 percent of the pore fluids in the vadose zone and 8.7 percent of the pore fluids in the smear zone. Similarly, at boring K-27, immediately adjacent to Pipeline 8 under the loading dock concrete pad, NAPL pore fluid saturation was 9.1 percent in the highly contaminated vadose zone soils. At boring K-15, at the eastern edge of the apparent gasoline source area, pore fluid saturation in the smear zone was less, at 5 percent of pore fluid. Generally, pore fluid saturation of NAPL was greatest in finer-grained materials (silts and very fine sands). This is consistent with field observations of strong gasoline odors and elevated PID readings in the finer-grained soils, as well as stronger UV fluorescence. It is likely that the NAPL is retained at higher concentrations in these materials due to their higher porosity and stronger capillary forces relative to coarser-grained materials. However, overall, these are relatively low pore fluid saturations and do not suggest a risk of LNAPL within the Gasoline Area being able to continue to flow as a separate phase liquid.

Petroleum additives including carcinogenic polycyclic aromatic hydrocarbons (cPAHs), lead, and VOCs were analyzed in a subset of samples with suspected GRO and DRO contamination, in accordance with MTCA Table 830-1. Lead and other metals including arsenic, barium, and chromium were detected in most samples analyzed, at concentrations typical of regional background soil concentrations. Detected metals concentrations did not exceed their respective MTCA CULs. PCBs were not detected in any soil samples. cPAH toxicity equivalency quotients (TEQs) ranged from non-detect to 0.25 mg/kg in most of these samples. One sample collected from K-89 near the bulkhead had a cPAH TEQ of 17 mg/kg; however, this boring was advanced immediately adjacent to a buried, creosoted piling and adjacent samples were not contaminated with cPAHs. This sample also had a naphthalene concentration of 690 mg/kg, which is also commonly associated with the presence of creosote.

5.4.3 Pentachlorophenol Area

In the vicinity of the former panel oiler, where oil containing PCP and PCBs were once used, soil samples were collected within the footprint of the former Panel Oiler Area as well as immediately to the north. Additionally, three direct push borings (K-29, K-39, and K-37) were advanced to the east, west, and south of the panel oiler. SVOCs, PCBs, and PCP were analyzed in shallow and smear zone soil samples. PCP was detected at 230 mg/kg in the 2.5 feet bgs sample (AOPC3-10) in the vicinity of the former panel oiler where soil staining and a possible PCP odor were noted. PCP was not detected in any other samples and PCBs were not detected, suggesting that PCP in soil is confined to the small panel oiler footprint where staining and odors are also present.

5.4.4 Peninsula Fuel Company

The extent of GRO and benzene soil contamination on the Peninsula Fuels property is shown on Figure 5.8. Soil borings PF-1 through PF-9 were advanced near former pumps, fill ports, and ASTs in the center of the property, near pipeline outlets to the north, and to the south, in order to determine whether the soil gasoline contamination from this property is continuous with contamination at the Site and whether a source of GRO contamination at the Peninsula Fuels property is contributing to contamination at the Site. Samples were generally collected from the smear zone soils where indications of petroleum were strongest.

In the middle and south end of the Peninsula Fuels property, in borings located near former fill ports and AST pads, GRO was detected in the smear zone samples from the PF-7 and PF-8 borings, with concentrations of 1,600 and 2,200 mg/kg, respectively. DRO concentration of 12,000 and 3,400 mg/kg were also detected in the PF-8 and PF-7 borings, respectively, indicating a release has occurred in this area. Petrophysical testing of smear zone soil from PF-7 measured a low NAPL pore fluid saturation of 3.3 percent, signifying a limited potential for continued LNAPL mobility. Soil samples collected for petrophysical testing did not exhibit UV fluorescence indicating a lack of hydrocarbon; therefore, pore fluid petrophysical testing was not conducted.

Closer to the alley, GRO was detected at lesser concentrations at PF-2 and, in the alley, at PP-23. Prior investigations in this area [53, 52], indicated the presence of moderate GRO and DRO contamination in smear zone soils in this area. The clearly localized extent of GRO and DRO contamination, lesser overall GRO and DRO concentrations, and lack of groundwater contamination at the northern edge of the Peninsula Fuels property (as discussed below) suggest that contamination in the middle and south end of the Peninsula Fuels property is not migrating across this property to the Site. Instead, groundwater mounding under the loading dock may have contributed to contaminant migration from the Gasoline Area as far south as DP-04, located in the alley.

5.4.5 Dry Well Area

Two soil borings, K-98 and K-99, were advanced to assess soil quality in the former dry well area. Field indications of contamination, including staining, odors and elevated PID measurements, were not observed. Soil samples collected from immediately above the water table in this area were non-detect for GRO, DRO, ORO, BTEX, SVOCs, VOCs, and metals were detected at concentrations consistent with natural background.

5.4.6 Former Hog Fuel Storage Areas and Other TPH Usage Areas

Three soil borings (K-90 through K-92) and three test pits (KT-10, KT-11, and KT-13) were advanced in: the vicinity of former USTs/ASTs, a Hog Fuel Storage Area (where dumping of petroleum products and solvent still bottoms historically occurred), and a second former hog fuel pile on the eastern side of the former K Ply mill. A slightly elevated PID reading and gasoline odor were noted at 8 feet bgs at K-92, near the former UST/AST area. An elevated GRO concentration of 1,500 mg/kg was detected in this sample. A DRO concentration of 2,600 mg/kg was also detected in shallow soils from test pit KT-11 adjacent to one of the hog fuel piles. These detections appear to be isolated, and GRO and DRO were not detected in other samples collected from these areas.

The terminus of the sewer line running to the southeast of the former mill building where gasoline-like odors were previously observed could not be exposed; therefore, contingency soil borings K-200 through K-203 were advanced along the line and sampled for GRO, DRO, ORO, and BTEX. No analytes were detected in these samples suggesting that this segment of the former sewer was not a contributor to the existing gasoline plume found at the Site.

5.4.7 Site-Wide and Stack Area Surface Soil

Six surface soil samples (SS-1 through SS-6) were collected in order to assess whether historical burning of saltwater-saturated wood at the former K Ply mill caused local deposition of dioxins/furans in surface soils. These included three samples in areas where soil appeared to be relatively undisturbed to assess possible deposition of airborne dioxins/furans, and three samples in the area where the former K Ply mill smokestack fell during mill demolition releasing ash deposits. Dioxin/furan TEQ concentrations in the site-wide surface soil samples ranged from 0.2 to 8.1 picograms per gram (pg/g), which is less than the the MTCA Method B unrestricted land use criteria of 12.8 pg/g TEQ (ingestion only) and 11.3 pg/g TEQ (ingestion and dermal contact). Dioxin/furan TEQ concentrations in the area where the stack came to lie ranged from 19.4 to 222 pg/g, suggesting some of the dioxin-containing ash in the stack debris was mixed into nearby surface soils as it fell.[6] These concentrations are less than the MTCA industrial CUL of 590[7] pg/g.[8]

5.4.8 Log Pond Fill Area

Two soil borings (K-100 and K-101) were advanced within the extents of the former log pond in order to access the historical fill quality in this area. Field indications of contamination were not observed in either boring. Samples from immediately above the water table were analyzed for GRO, DRO, ORO, BTEX, cPAHs, and metals. Results were primarily non-detect or cosistent with natural background. One ORO concentration of 2,800 mg/kg was detected in the sample from K-101 from a depth of 12 feet bgs, suggesting the sample was from the material that collected at the base of the former log pond.

5.4.9 Debarker Operations

Four soil borings (K-94 through K-97) were advanced in the area surrounding the current debarker operatons. Field indications of contamination were not observed and GRO, DRO, ORO, and BTEX results from samples collected from immediately above the water table at these locations were all non-detect.

5.5 GROUNDWATER QUALITY

Site-wide groundwater quality was assessed during two monitoring events in October 2013 and January 2014. Prior data collected from direct push borings in the alley south of the Site, in S. Cedar Street to the west, and to the north along the bulkhead are also considered in this discussion. Concentration contours representing the extent of GRO and benzene contamination in site-wide groundwater are shown on Figures 5.9 and 5.10. These figures incorporate older data collected by prior Geoprobe investigations. The description of groundwater quality in the vicinity of the former mill is divided into two sections: the southern portion of the former mill building, and the northern portion of the former mill building including the bulkhead vicinity.

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[6] Following demolition, the Port collected samples of ash residue that either coated some of the bricks or was from the inside of a fiberglass liner from the stack itself. Dioxin-containing compounds between 4.93 and 43,400 TEQ pg/g were found in some of the samples. These results were provided by the Port to Ecology for review. The dioxin-containing stack debris was determined to be a solid waste and transported off-site to a permitted landfill for disposal.

[7] 590 pg/g TEQ is the MTCA Method C industrial land use criteria for direct contact (ingestion) plus dermal contact. This is consistent with Ecology's recent change to use an updated oral cancer potency factor for 2,3,7,8-TCDD based on information from the California Environmental Protection Agency.

[8] To prevent dispersal of dioxins/furans in soil near the former stack, the Port has covered the soils in the Stack Area with sheeting until the final remedial action is undertaken.

5.5.1 Southern Portion of the Former Mill Building

In the southern portion of the former mill building, wells PP-15R, PP-26, PZ-04, and PZ-07 were sampled for GRO, DRO, and BTEX. Additionally, PP-15R was sampled for the petroleum additives specified in MTCA Table 830-1. GRO concentrations in monitoring wells ranged from 2,100 µg/L in samples from PZ-07 to 12,000 µg/L in samples from PP-15R during the October 2013 monitoring event. GRO concentrations measured during the January 2014 event were similarly elevated in this area, ranging from 1,600 to 16,000 µg/L. Detected benzene concentrations were also greatest in samples from PP-15R, with concentrations of 3,700 and 4,400 µg/L during the October and January events, and were also the least in samples from PZ-07. GRO and benzene concentrations in groundwater in the southern portion of the former mill building are generally greatest in wells PP-15R and PP-26 to the north and northeast of Pipeline 8 where it runs under the loading dock concrete pad, and decrease farther to the east and southeast in wells PZ-07 and PZ-04.

DRO was detected at 770 and 1,100 µg/L in samples from PZ-04 during the October and January events, respectively, and was detected at concentrations less than 500 µg/L in samples from the remaining wells in the southern portion of the former mill building. ORO was not detected in groundwater samples from the southern portion of the former mill building.

In addition to GRO and BTEX, naphthalene and 1,2-dichloroethane were detected at 13 and 87 µg/L, respectively, in samples collected from PP-15R during October 2013 monitoring. The naphthalene concentration is less than the MTCA Method A groundwater standard of 160 µg/L. The 1,2-dichloroethane detection was not replicated or found elsewhere at the Site, and is considered a localized issue or possible false positive. Lead and the remaining VOCs and SVOCs specified in MTCA Table 830-1 were not detected.

Previous investigation in the southern portion of the former mill building also included sampling of groundwater from wells and direct-push borings to the west of the Site in S. Cedar Street. A GRO concentration of 5,800 µg/L was detected in well PZ-2, and adjacent grab samples had detected concentrations between 1,000 and 2,000 µg/L. Groundwater benzene concentrations in the Gasoline Area were greatest immediately to the north of the loading dock concrete pad in the vicinity of Pipeline 8, where grab samples had detected concentrations.

5.5.2 Northern Portion of Former Mill Building and Bulkhead Vicinity

In the northern portion of the former mill building and the area north along the bulkhead, hydraulic oil product (LNAPL) was measured in wells PP-2, PP-3, PP-11, and PP-12 during both monitoring events, with the thickness of this layer of product ranging from 0.33 feet at PP-3 to 2.23 feet at PP-2 during the October event. Several wells targeted for hydraulic oil product thickness measurement, including PP-1 and PP-10, were not able to be located and presumed to be destroyed during mill demolition. PP-14 was located but found to be filled with soil and wood fragments.

Wells in the the northern portion of the former mill building and along the bulkhead that were free of NAPL, including PP-13, PP-17, PP-18, PP-19, PP-20, PP-21, PP-22, PZ-12, and PZ-13, were sampled for GRO, DRO, ORO, and BTEX. Additionally, wells along the bulkhead were sampled for VOCs and SVOCs and one bulkhead well, PP-18, was sampled for lead and additional VOCs to fulfill the requirements of MTCA Table 830-1. GRO and BTEX were detected in all of these wells except PP-19 and PZ-13, which are located farthest to the northwest of the former K Ply mill. ORO was not detected in any groundwater samples except for one low-level detection near the reporting limit in PP-13. The highest GRO concentrations measured in the northern portion of the Site of 7,500 and 1,300 µg/L, were detected in the samples collected from PP-18 along the bulkhead during the October 2013 monitoring event; GRO and DRO concentrations were similarly elevated in this well during January 2014 monitoring. GRO concentrations greater than 800 µg/L and DRO concentrations greater than 500 µg/L were also detected in samples from PP-13 and PZ-12 during both events. The most elevated benzene concentrations in this area were detected farther to the west in PP-13, which had detected concentrations of 430 µg/L during October 2013 and 320 µg/L during January 2014. PP-17 and PP-18 also had benzene concentrations greater than 100 µg/L during both events.

The extent of gasoline impacts in groundwater near the bulkhead is also based on groundwater samples from direct-push borings. Previous groundwater grab samples collected from direct push borings along the bulkhead to the north in 2006 were also analyzed for GRO, DRO, and BTEX. GRO was detected at 10,400 µg/L and benzene was detected at 11 µg/L in this sample. GRO concentrations greater than 800 µg/L were also detected in the two grab samples collected from borings between PP-18 and PP-17. Previous grab samples collected in S. Cedar Street to the west of the Site had GRO concentrations ranging from approximately 2,000 to 4,500 µg/L in borings advanced to the south of PP-13 and PZ-12. Benzene concentrations in borings in this area ranged from 1,000 to 3,160 µg/L. Benzene appears to extend to the west in this area to approximately PZ-13 and beneath S. Cedar Street to the eastern side of the adjacent Platypus Marine property.

Several wells in the northern portion of the former mill building were not sampled due to the presence of hydraulic oil product floating on the surface of the groundater. The extent of gasoline impacts to groundwater is evident based on other information. A strong gasoline odor was detected in PP-3 when it was opened for product thickness measurement. Previous investigations in 2007 and 2008 detected GRO and benzene in this well at 5,300 and 1,900 µg/L, respectively. GRO concentrations greater than 800 µg/L were also previously detected in PP-10 and PP-16 and benzene concentrations greater than 100 µg/L were previously detected in PP-10, PP-11, PP-12, PP-14, and PP-16.

Non-BTEX VOCs, SVOCs, and lead were generally non-detect, or detected at concentrations less than screening levels, in samples from the northern portion of the former mill building and bulkhead vicinity. However, at PP-18, localized naphthalene detections were noted at 260 and 230 µg/L during the two monitoring events, which are greater than the MTCA Method A screening level of 160 µg/L. These detections may be attributed to nearby buried creosoted pilings related to the former rail trestle in that area (refer to Figure 5.1).

In the vicinity of the former caustic soda storage vault, at wells PP-13 and PZ-12, purge water was also field screened for elevated pH during groundwater sampling to determine whether leakage of caustic soda occurred. Values for pH in PP-13 ranged from 6.97 to 7.36 and pH values in PP-12 ranged from 7.03 to 7.25, indicating that caustic soda from the vault has not materially affected groundwater pH. These wells were also sampled for formaldehyde to evaluate the potential impacts related to the previous resin release, but formaldehyde was not detected during either event greater than a detection limit 100 µg/L.

5.5.3 Upgradient Areas: Peninsula Fuels Company and Alley South of K-Ply

Figures 5.9 and 5.10 show groundwater quality for GRO and benzene, respectively, based on curent and past data collected during the MTA RI. These figures incorporate older data collected by prior Geoprobe investigations. In the alley south of K Ply, a maximum benzene concentration of 35 µg/L was detected at DP-08 located immediately south of the loading dock concrete pad during a 2009 Landau sampling event. On the Peninsula Fuels property, a maximum groundwater benzene concentration of 200 µg/L and a maximum GRO concentration of 9,500 µg/L were detected in the grab sample collected from the PF-8 and PF-6 direct-push borings respectively. DRO was also detected at concentrations greater than 500 µg/L in PF-2, PF-6, PF-7, and PF-8, with a maximum detection of 2,400 µg/L at PF-8. ORO was not detected in any grab samples from direct-push borings on the Peninsula Fuels property.

The elevated GRO concentrations found in the alley do not appear to increase in concentration southward into the Peninsula Fuels property, as depicted in Figure 5.9, which indicates that GRO concentrations immediately south of the property boundary are slightly less than those detected in the alley. Benzene was only detected immediately south of the loading dock concrete pad and was not detected in the majority of alley groundwater grab samples. Figures 5.9 and 5.10 also show that the GRO/benzene plume found in the south end of the Peninsula Fuels property does not migrate north into the alley. These findings suggest that the groundwater contaminant plume on the Peninsula Fuels property is distinct from the primary K Ply site groundwater contamination, which appears to extend into the alleyway.

Additionally, to the west of Peninsula Fuels, along S. Cedar Street, a localized area where GRO exceeds CULs in groundwater and soil near DP-01 is apparent. This hot spot is fairly close to where former Pipeline 5 tranversed S. Cedar Street.

Groundwater sampling results from wells along the remainder of the upgradient Site boundary (PP-9, PP-24, and PP-25; refer to the Supplemental Data Collection Technical Memorandum in Appendix A) indicate that the adjacent properties evaluated—the former Time Oil, fomer Marine Drive Exxon, former PenPly retail office, and former Port Angeles Truck Stop Chevron—are not sources of contamination to the Site.

5.5.4 Other Areas of Potential Concern

To address specific data objectives, groundwater samples were collected from other selected areas of the former K Ply mill and surrounding property. On the east side of the former mill, samples were collected from direct-push borings K-98 and K-99 in the vicinity of the former dry well, from K-91 and K-92 in the vicinity of former USTs/ASTs, and from K-200 through K-203 along the sewer line to the southeast. GRO, DRO, ORO, and BTEX were not detected in any of these samples. Methylene chloride was detected at 5.4 µg/L in the sample from K-98 but no other VOCs were detected.

Downgradient of the former log pond, along the bulkhead to the northeast of the mill building, groundwater samples were collected from wells PP-20, PP-21, and PP-22 during both the October 2013 and January 2014 monitoring events. Samples were anazlyzed for GRO, DRO, ORO, BTEX, VOCs, and SVOCs. No analytes were detected in PP-20 or PP-21, and PP-22 had scattered low-level GRO, DRO, VOC, and SVOC detections near the reporting limit.

To the southeast of the former K Ply mill along W. Marine Drive, groundwater samples were collected from well PP-24 near the former PenPly retail office and well PP-25 near the W. Marine Drive Exxon during both October 2013 and January 2014 monitoring events. These samples were analyzed for GRO, DRO, ORO, and BTEX, and all results were non-detect.

5.6 SEDIMENT QUALITY

The analytical results were screened against the Sediment Management Standards (SMS) or Puget Sound lowest apparent effects threshold (LAET) criteria for protection of benthic health. Sediment chemistry results are only compared to LAET criteria when total organic carbon (TOC) concentrations are outside the range of 0.5 to 3.5 percent. Of the three sediment samples collected in 2013, there were only three instances where SMS LAET concentrations were exceeded. KSS-1 exceeded the LAET for chrysene and fluoranthene and KSS-2 exceeded the CSL for fluoranthene (Table 5.2 and Figure 5.11). There were no instances of SMS exceedances in the samples collected in 2008 by Ecology [75].

In addition to the individual PAH exceedances of the LAET, there were detections of metals, butyltins, cPAHs, and DRO and ORO. In two of the sediment samples, the DRO and ORO detections were less than the quantitation limit (ranged between 42 and 55 mg/kg for DRO and 170 and 220 mg/kg for ORO), but greater than the method detection limit (ranged between 3.1 and 4 mg/kg for DRO and 6.6 and 8.5 mg/kg for ORO), and are estimated concentrations. There was a poor spectral match to the standards for DRO and ORO in the third sediment sample. The detected concentrations of DRO and ORO in the K Ply samples are similar to TPH results in sediment samples collected across the Harbor. Therefore, there does not appear to be an apparent connection between these DRO and ORO detections in sediment and the K Ply upland contamination. PCBs were detected at levels greater than the reporting limit for all three samples collected in 2013, but the reported concentrations were one to two orders of magnitude lower than the SCO. The summed dioxin/furan TEQ concentration, using half the reporting limit for those analytes that were not detected in the calculation, was 11.9 pg/g for KSS-1, 12.3 pg/g for KSS-2, and 2.2 pg/g for KSS-3. Other SVOCs and individual PAHs were detected, but were at levels less than screening levels.

Only benthic criteria were considered and used to evaluate sediment data. A full evaluation of the sediment data, including consideration of human health and higher trophic levels, will be included in the WPAHG RI/FS.

Because of the fluoranthene and chrysene exceedances in the sediment samples collected in 2013, Ecology requested that the bioassay testing be conducted for the three sediment samples. The bioassay testing was compared to bioassay testing done on the reference sediment collected as part of the WPAHG investigation. The sediments from these locations all met SQS performance standards for each of the bioassay tests.

The sediment profile imaging results for all locations were also included with the evaluation of the WPAHG sediment station imaging in the Sediment Profile Imaging Report prepared by Germano and Associates [68]. The report presents the evaluation of the sediment images taken in the Harbor with regards to physical, chemical, and biological processes. The images indicate that there is between 5 and 20 percent wood debris in KSS-1, less than 5 percent wood debris in KSS-2, and no wood debris in KSS-3. Generally, the image analysis for the Site sediment stations indicated consistency with the sediments observed in other parts of the Harbor.

5.6.1 Consideration of Site Contaminants of Concern and Sediment Quality

The chemistry data, bioassay test results, and SPI images indicate that there are no significant sediment concerns to benthic health in front of the Site. The sediment chemistry for these locations are similar to or of better quality than samples previously collected in the greater Port Angeles Harbor. Dioxin/furan and PCB data indicate that concentrations are lower than at many locations within the Harbor. A full evaluation of these data to consider human health and higher trophic levels, as required by SMS, will be included in the WPAHG RI/FS. These data were provided to the WPAHG consulting team for inclusion in their RI/FS process.

5.7 REMEDIAL INVESTIGATION CONCLUSION

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

6.0 Conceptual Site Model

A conceptual site model (CSM) was developed for the Site to provide a useful summary of site conditions and exposure pathways that are fundamental to the development of CULs. The CSM summarizes 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 6.1.

6.1 ORIGINAL RELEASE MECHANISMS AND PRIMARY CONTAMINATED MEDIA

The original release mechanism for gasoline constituents in the area of the former mill building and alley adjacent to the south consisted of apparent fuel leakage from Pipeline 8 during its active operation. This is based on: (1) lack of any other significant source; (2) the failure of Pipeline 8 during pressure testing; (3) the fact that the area where the pressure test failure occurred lies in an area of highly contaminated vadose zone soils; and (4) the fact that a large volume of gasoline released at the Site is consistent with a release from a pipeline that was in use for many decades. Adjacent upgradient properties are not contributing sources of contamination to the Site.

The original release mechanism for hydraulic oil is spills/leaks from the former hydraulic presses themselves. The original release mechanism for PCP is a release of panel oil near the former panel oiler. These releases contaminated surface and subsurface soil in areas that generally correspond with the former mill building footprint and the alley adjacent to the south, which includes Pipeline 8 and the hydraulic presses. Contaminated vadose zone soils (approximately 2 to 10 feet bgs) are present in three areas: a large area beneath the loading dock concrete pad at the south end of the mill, and two smaller areas beneath the north end of the mill and the bulkhead area.

Release mechanisms vary for the isolated areas of soil contamination identified outside the former mill building footprint and adjacent alley. The original release mechanism for Stack Area soil dioxins was likely deposition from ash released during stack demolition. The original release mechanism for shallow soil contamination near the former hog fuel pile was former mixing of oil with the woody material. The original release mechanism for oil-range hydrocarbons in soil at depth in the Debarker Area was releases to the former log pond bottom.

There is no identified release mechanism from the Site to sediments. The isolated PAHs identified in sediment may be attributable to a variety of possible sources including over-water activities at Terminal 1, historical discharges from the former K Ply sanitary sewer outfall, or weathering of old creosote pilings. It should be noted that there are no detections of cPAHs in RI groundwater data so groundwater discharges from the Site to sediments are not likely a source of the PAHs.

Some cPAHs were found in site soils, however, including in water table soils associated with hydraulic oil or diesel contamination, and in one sample from a boring adjacent to a buried bulkhead creosote piling. Low level cPAH detects were also found to be associated with surface soil form oil/PCP contamination in the PCP Area. All of these soil cPAHs were beneath the mill structure and, therefore, are not likely able to enter the former stormwater drainage for the mill.

6.2 SECONDARY RELEASE MECHANISMS AND POTENTIALLY IMPACTED MEDIA

Gasoline and hydraulic oil, once released to the soil, have been further transported from surface and subsurface soil by secondary mechanisms. Gravity drainage of LNAPLs from the points of release to the water table has occurred, followed by migration downgradient (for the gasoline release) or pooling near the area of release (for the more viscous hydraulic oil). Gasoline product, during and subsequent to its migration downgradient, spread out laterally as a smear zone (approximately 8 to 12 feet bgs) across the water table resulting from seasonal and tidal fluctuations in groundwater levels. Most of the contaminated soil at the Site is within the smear zone. Gasoline that once migrated northward toward the shoreline became commingled with the eastern edge of the hydraulic oil LNAPL accumulation. Some remobilization and transport of the hydraulic oil downgradient may have occurred as a result of comingling. The soil 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.

Contaminated soils are located both in the smear zone (approximately 8 to 12 feet bgs) across a long narrow section and also in the vadose zone, in localized areas. The vadose zone has three areas of contamination (found approximately 2 to 10 feet bgs): a large area beneath the concrete pad at the south end of the mill, and two smaller areas beneath the north end of the mill and the bulkhead area. These smaller areas at the north end of the mill are localized and may represent minor spills.

Soluble constituents of gasoline including benzene have dissolved or are dissolving into groundwater and are migrating by advection toward the Harbor, resulting in large commingled plumes of GRO and benzene. The source area for the large site-wide GRO and benzene plumes appears to be the zone of contaminated vadose and smear zone soil found under the former loading dock concrete pad. The solubility of hydraulic oil constituents is much lower, and no plume of ORO is observed downgradient of the hydraulic oil LNAPL accumulation. Based on similar conditions at the MTA Site, GRO and benzene plumes are expected to be limited to the upper 5 to 10 feet of the saturated zone, which discharges into the Harbor through a riprap-lined shoreline. GRO and benzene in groundwater may be discharging to surface water based on the elevated concentrations in monitoring well groundwater samples located adjacent to the bulkhead.

Contaminant transport from soil by stormwater or erosion is not considered a pathway based on several factors. Surface soil contamination is limited in extent. Site topography[9] and bulkhead construction[10] generally block overland stormwater discharge to the Harbor from areas where surface contamination is present, and stormwater runoff in contact with surface soils generally infiltrates into the subsurface. Stormwater controls including temporary sheeting have been installed to prevent transport of contaminants from the former mill building area. Stormwater monitoring data from the stormwater conveyance ditch indicate no transport of petroleum constituents.

Where volatile constituents such as benzene are present in subsurface soil or groundwater at sufficient concentrations, volatilization has the potential to transport contaminants into future overlying buildings. Currently, only the unoccupied former K Ply office building remains on-site

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[9] The site slopes to the south, away from the Harbor.

[10] The bulkhead is protected by a riprap slope in good condition. The top of the riprap slope is higher in elevation than the rest of the Site, minimizing erosion.

but that building is in an area that is free of soil or groundwater contamination. However, future redevelopment may result in the construction of occupied buildings over areas of contaminated soil or groundwater. Therefore, the vapor intrusion pathway is a pathway of concern because it is likely buildings will be constructed in the future.

There are no indications of further transport of PCP from soil in the area of the former panel oiler, DRO detected in shallow soil near the former hog fuel pile, or DRO detected in soils at the former log pond bottom.

6.3 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 a 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 Site (refer to Appendix E). The evaluation found the Site does not pose a substantial potential risk to terrestrial receptors due to its industrial land use and future redevelopment as proposed in the Port's Central Waterfront Master Plan. No further terrestrial evaluation is necessary.

6.4 CONTAMINANTS OF CONCERN

Site COCs are summarized in Table 6.1 below, based on RI results. Additional discussion of COC determination is provided below. As described in the RI/FS Work Plan [65], the RI was designed to provide information suitable for determining site COCs. Based on the historical review of site operations, COPCs were identified in the IAWP for further investigation, including PCP, SVOCs, metals, and dioxins/furans. Surface soil sampling conducted as part of the IAWP in specific areas where PCBs and VOCs were stored or used has indicated that these chemicals are not of concern in site soil. Surface soil samples analyzed for metals indicate that metals are not COCs. Site COCs are presented below based on exceedances of applicable MTCA Method A criteria. Where COCs are co-located, more prevalent COCs may serve as indicator substances. PCP and dioxins/furans are COCs but limited to specific relatively small areas of the Site.

Table 6.1
Affected Media and Site Contaminants of Concerns

Constituent	Media		
	Soil	**Groundwater**	**Indoor Air (Future Potential Risk)**
GRO	COC	COC	COC[1]
BTEX	COC	COC	COC
DRO	COC	COC	COC[2]
ORO (hydraulic oil)	COC	COC	N/A
PCP	COC[3]	N/A	N/A
Dioxins/furans	COC[3]	N/A	N/A
cPAHs	N/A	N/A	N/A

Notes:
1 Includes volatile petroleum hydrocarbon (VPH) fractions of gasoline and all other potential gasoline constituents (BTEX, n-hexane, 1,2-dibromoethane, 1,2-dichloroethane, MTBE, naphthalene, 1,3,5-trimethylbenzene, 1,2,4-trimethylbenzene).
2 Includes aliphatic petroleum hydrocarbon (APH) fractions of diesel and other potential constituents including naphthalene.
3 Listed as COC because maximum site concentrations exceed MTCA Method B residential criteria but are less than MTCA Method C concentrations.

6.4.1 Petroleum (GRO, DRO, ORO, and BTEX)

The extent and magnitude of GRO, BTEX (associated with releases of gasoline), and ORO (associated with releases of hydraulic oil), are well-established in soil. Releases of diesel also have occurred near Pipeline 8, but are not extensive and diesel is present in soil in several locations where ORO and/or GRO are present. Based on the frequency of detection and concentrations, DRO is considered a COC in soil.

Groundwater COCs include GRO, DRO, ORO, and BTEX compounds. These COCs are based on their presence at elevated concentrations in soil or groundwater, presence as LNAPL, or any combination thereof. DRO was also detected in groundwater samples collected on the Peninsula Fuels property. In the case of DRO groundwater detections on K Ply, they were solely a function of chromatographic overlap from much higher gasoline concentrations.

6.5 OTHER CONSTITUENTS OF CONCERN

In addition to the petroleum constituents that make up the primary contamination issues at the Site, there are localized areas of other non-petroleum contaminants.

6.5.1 Dioxins/Furans

This COC is limited in its extent to the area of surface soils near the former mill stack, based on the results from surface soil samples SS-4, SS-5, and SS-6, which contained up to 222 TEQ pg/g dioxin/furan. These concentrations do not exceed MTCA Method C industrial land use CUL of 590 pg/g TEQ (direct contact and dermal).

6.5.2 Pentachlorophenol

This COC is limited in its extent to the PCP, based on a single detection of 230 mg/kg PCP in shallow soil at location AOPC3-10. The MTCA Method C industrial CUL for PCP is 330 mg/kg.

6.5.3 Carcinogenic Polycyclic Aromatic Hydrocarbons

cPAHs were not detected at significant concentrations in site groundwater or soil following investigation in locations throughout the Site. A single exceedance of the MTCA Method A CUL of 2 mg/kg was detected in soil at K-89, a soil boring that was advanced immediately adjacent to a buried creosote piling. There were several detections of cPAHs in soil at locations where DRO, ORO, or PCP were also detected but not at levels of concerns. Therefore, cPAHs are not considered to be a site COC.

6.6 CURRENT AND FUTURE POTENTIAL EXPOSURE PATHWAYS AND RECEPTORS

Potential exposure pathways, receptors, and exposure scenarios are illustrated on Figure 6.1. Based on current and expected future land use, it is most appropriate to use an industrial exposure scenario and industrial CULs for the upland portion of the Site given that the Site and surrounding land has for decades been zoned and developed for industrial use and will remain so 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 future 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 the 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 the Harbor who may become exposed to contaminated groundwater.

There is currently no inhalation exposure scenario from groundwater contaminant concentrations due to the lack of existing buildings in impacted areas of the Site. Future construction of buildings at the Site over either vadose zone soil contamination, or the groundwater plume, could result in vapor intrusion and this risk should be evaluated prior to construction. A quantitative evaluation of this potential risk is not currently feasible at this time 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 6.4 above) and given the current and future industrial use of the Site and its highly developed setting, there is no terrestrial ecological exposure scenario.

For each affected media, the following potential exposure pathways and receptors are identified:

- *Soil*: The Site is zoned industrial heavy and is surrounded by industrial properties. The future use of the Site will be for industrial purposes. Therefore, future site workers are the primary receptors who could come into direct contact with contaminated site soil in the future. No risk is currently present to the general public because the Site is fenced and considered secure.
- *Groundwater*: Groundwater discharges to the Harbor and is considered the primary potential pathway for contaminants to reach receptors. The potential receptors would include fish/shellfish, and humans who consume fish/shellfish from the Harbor. Groundwater is considered non-potable based on the proximity of the Site to the Harbor.
- *Indoor air*: Currently, there are no structures built on top of areas of GRO-contaminated soil that could pose a risk of vapor intrusion. However, in the future it is possible that structures could be built over GRO-contaminated areas, so this remains a potential future exposure pathway.
- *Sediment*: There is currently no identified pathway for transport of COCs to sediments. COCs in groundwater (e.g., benzene) are primarily volatile and do not have a tendency to partition to sediments. Contaminated groundwater also discharges to the surface waters of the Harbor directly through a riprap slope and not through sediment. Contaminant transport from soil by stormwater is not considered a pathway based on factors including site topography, bulkhead construction, and stormwater controls. A portion of stormwater from the Site discharges to the Harbor via the stormwater conveyance ditch/log pond, though analytical results demonstrate no transport of petroleum constituents. A historical municipal combined sewer outfall (CSO), which was once observed to contain gasoline vapors in 1969, also discharged waste waters to the Harbor, but recent sediment analytical results do not indicate petroleum concentrations at levels of concern. Erosion of contaminated soil to the Harbor sediments in areas other than the stormwater conveyance ditch is not considered a

pathway because of the berm located along the length of the bulkhead that prevents sheet flow and because of the riprap slope that extends along the bulkhead from the Site to the Harbor.

6.7 CLEANUP STANDARDS

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

- The Site is zoned heavy industrial and has been used exclusively for industrial purposes. 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.
- Similar to the MTA Site, the groundwater at the Site is considered 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 the Harbor, and mixes with marine waters in the riprap slope along the Site shoreline. The maximum beneficial use of groundwater is providing discharge to the Harbor for the protection of aquatic life.

6.7.1 Soil

6.7.1.1 Soil Cleanup Levels

Proposed CULs for soil are presented in Table 6.2. CULs were evaluated for COCs found in both soil and groundwater (i.e., BTEX, GRO, DRO, ORO) and for COCs found only in soil (i.e., PCP and dioxin). CULs protective of the applicable exposure pathways were considered, including the direct contact (ingestion) and soil-to-groundwater (discharge to surface water) pathways based on the CSM. Soil CULs to protect against vapor intrusion were not calculated at this time as this pathway does not currently exist. The risk of vapor intrusion from soil is a future risk that will be evaluated and managed at the time of development, as discussed in Section 6.7.3.

Table 6.2
Proposed Soil Cleanup Levels

Contaminant of Concern	Maximum Detected Concentration[1] (mg/kg)	Protection of Groundwater MTCA Method A[2] (mg/kg)	Direct Contact to Soils MTCA Method C Direct Contact (Ingestion) (mg/kg)	Proposed Site Cleanup Level[3] (mg/kg)
DRO	24,000	2,000	Not determined[4]	2,000
GRO	14,000	30[5]	Not determined[4]	30
ORO	32,000[6]	2,000	Not determined[4]	2,000
Benzene	120	0.3[7]	2,400	0.3
Ethylbenzene	170	6	350,000	6
Toluene	180	7	280,000	7
Xylenes	600	9	700,000	9
Pentachlorophenol	230	NA	330	330
Dioxins/furans[8]	0.000222	NA	0.00059	0.00059

Notes:

1 Maximum detected value during the Remedial Investigation.
2 MTCA Method A is applied for these constituents (with the exception of benzene) because it is protective of all pathways including groundwater and surface water. Site use is expected to remain industrial, however.
3 Most conservative value chosen as the CUL.
4 Not determined due to the specialized testing required. For TPH products, this site-specific determination typically results in a concentration that is significantly greater than the MTCA Method A concentration that is protective of groundwater and used as the CUL.
5 Use this value when benzene is present in soil.
6 Greatest concentration detected historically at the Site is 107,000 mg/kg where ORO free product is present.
7 CUL based on three-phase rule calculation using proposed benzene CUL of 51 µg/L.
8 Includes ingestion and dermal contact pathways.

For the protection of groundwater, default MTCA Method A soil CULs for individual BTEX compounds are proposed with the exception of benzene, which was adjusted upward as described below. For DRO, GRO, and ORO, default MTCA Method A values are proposed. MTCA Method A CULs are proposed for the following reasons: (1) the MTCA Method A soil cleanup concentrations are conservative and, therefore, protective of all pathways, and (2) the MTCA Method A values for TPH consider the cumulative risk for all the individual substances such as BTEX and SVOCs present in petroleum. For benzene, the upwards adjustment was made because the default MTCA Method A CUL of 0.03 mg/kg is overly conservative, as it is based upon protection of groundwater to a level of 5 µg/L, which is based upon drinking water use (refer to Footnote C of Table 740-1 in WAC 173-340-900). Instead, the CUL for benzene in soil should be based upon the highest beneficial use of site groundwater, which is protection of marine waters. The MTCA three-phase rule was used to adjust the proposed benzene CUL for soil to 0.3 mg/kg, which is protective of marine waters. Calculations are presented in Appendix B.

For the direct contact (ingestion) worker exposure pathway, BTEX constituents, PCP, and dioxin have established MTCA Method C industrial CULs. However, the highest detected concentrations at the Site for these COCs are less than the MTCA Method C industrial land use value for direct contact CULs. As shown in Table 6.2 above, if CULs for two or more pathways are available, the lower of the two is the proposed Site CUL.

6.7.1.2 Point of Compliance for Soil

The point of compliance (POC) for soil to protect groundwater is throughout the Site. For protection of the soil vapor pathway, the POC is from the surface to the uppermost groundwater table (approximately 8 feet bgs at the Site).

6.7.2 Groundwater

6.7.2.1 Groundwater Cleanup Levels

Proposed groundwater CULs were derived in accordance with WAC 173-340-720, as summarized below. Per WAC 173-340-720(1)(a), groundwater CULs 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 Site is discharge to the surface waters of the 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 6.3), 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). Therefore, groundwater CULs were 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 173-340-708.

Table 6.3
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)
ORO	310[3]	NA	500	500
DRO	2,300[4]	NA	500	500
GRO	16,000[5]	NA	800[5]	800
Benzene	4,400[6]	51	5[7]	51

Notes:

1 Maximum detected value during the Remedial Investigation.

2 Lowest of WAC 173-201A, National Toxics Rule, and National Recommended Water Quality Criteria.

3 310 µg/L was detected in PP-13 on January 18, 2014. The only other detected ORO sample was 290 µg/L in PP-04 on February 5, 2013. The remaining ORO results in groundwater are all non-detect.

4 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.

5 53,000 µg/L was detected in a grab sample from the PZ-06 boring prior to well installation. This result was not used because monitoring well groundwater samples are considered to be more representative of site conditions.

6 11,000 µg/L was detected in a grab sample from the PZ-06 boring prior to well installation. This result was not used because monitoring well groundwater samples are considered to be more representative of site conditions.

7 The MTCA Method A CUL is based on groundwater consumption, which is not applicable to the K Ply Site. The highest beneficial use of site groundwater is discharge to surface water; therefore, the federal or state water quality standards apply.

In accordance with WAC 173-340-720(6)(c)(i), potential groundwater exposure pathways and groundwater uses were considered (refer to Figure 6.1). There is no reasonable scenario under which groundwater would be consumed as drinking water. The potential pathway of concern is discharge of groundwater to the Harbor surface water at the K Ply bulkhead. CULs 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 CULs 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 6.3 for proposed groundwater CULs, which does not include CULs to protect against vapor intrusion from groundwater, as this pathway does not currently exist because there are no occupied structures on-site. The risk of vapor intrusion will be evaluated and managed at the time of development as discussed in Section 6.7.2. For compounds for which the federal criteria are available (e.g., benzene), the standard MTCA 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[11] and protection of aquatic life. This concentration for benzene has been approved for use as a CUL and/or screening level at other MTCA sites being addressed as part of the Puget Sound Initiatives. Federal or state water quality criteria do not exist for TPH-G, TPH-D, or ORO. According to WAC 173-340-730(3)(C), MTCA 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 CUL as listed in Table 6.3.

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

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

(B) The CULs 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.[12] MTCA Method A CULs for GRO, DRO, and ORO are highly conservative relative to a hazard quotient of 1 for all pathways including ingestion of aquatic organisms; therefore, the total hazard index is less than 1.

(C) The CULs 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 CUL for benzene is derived from a 10^{-6} human health cancer risk based on ingestion of aquatic organisms. The sole carcinogenic component of GRO is benzene. MTCA Method A CULs for GRO when benzene is present, DRO, and ORO 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).

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[11] 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.

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

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

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

6.7.2.2 Groundwater Point of Compliance

MTCA states that standard POC for groundwater CULs is throughout the Site to the outer boundary of the plume. However, Ecology may approve a CPOC where it can be demonstrated that it is not practical to meet the CUL within a reasonable restoration time frame. This condition of impracticability holds for the Site given the very large mass of source area soil. The conditional point of compliance (CPOC) 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 Site is discharge to surface water. Therefore, a groundwater CPOC is proposed for the Site within the property boundary along the bulkhead, the closest monitoring location to the point of discharge to surface water.

6.7.3 Indoor Air

6.7.3.1 Indoor Air Cleanup Levels

Currently there are no buildings over or in the vicinity of the contaminated soil and ground water; however, the vapor intrusion pathway is a pathway of concern because it is likely buildings will be constructed on the Site in the future. When building plans are available, an assessment of vapor intrusion risk must occur. To ensure that this assessment is performed, institutional controls in the form of an environmental covenant, which include this requirement, needs to be recorded on the property.

Table 6.4 proposes indoor air CULs taken from Ecology's Cleanup Levels and Risk Calculations (CLARC) website that will be used to evaluate the risk of vapor intrusion in the future. CULs are based on industrial exposure. The COCs listed below are those that are considered volatile and associated with gasoline or diesel.

Table 6.4
Proposed Indoor Air Cleanup Levels

Contaminant of Concern	Proposed MTCA Method C Indoor Air Cleanup Level (µg/m^3)
Benzene	3.2
Toluene	5,000
Ethylbenzene	1,000
Xylenes	100
n-hexane	700
1,2-dichloroethane	0.96

Contaminant of Concern	Proposed MTCA Method C Indoor Air Cleanup Level (µg/m^3)
MTBE	96
Naphthalene	0.74
1,2,4-trimethylbenzene	7
APH [EC5-8 aliphatics] fraction[1]	6000
APH [EC9-12 aliphatics] fraction[1]	300
APH [EC9-10 aromatics fraction][1]	400

Note:

[1] Values not from CLARC but instead are guidance values taken from Table B-1, Ecology Publication no. 09-09-047, Guidance for Evaluating Soil Vapor Intrusion in Washington State: Investigation and Remedial Action, October 2009.

7.0 Remedial Action Objectives and Cleanup Areas

In this section, the remedial action objectives (RAOs) are developed based on the CSM, cleanup standards and other MTCA requirements, and other Site considerations, including future land use.

7.1 REMEDIAL ACTION OBJECTIVES

RAOs are substantive goals for a cleanup action that address the overall MTCA cleanup process. The RAOs described in this section are used to provide a structure for the evaluation of remedial alternatives that address the distinct remedial objectives for different areas of the Site based on site geography, site development; and the applicable cleanup standards.

Human health and the environment can be protected through achievement of the following RAOs:

1. Prevent COCs in groundwater from discharging to surface water at concentrations greater than CULs protective of surface water. This is necessary for protection of human health and the environment.
2. Remove, to the extent practicable, LNAPL accumulations on the water table. This RAO is intended to address specific MTCA requirements. 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.”
3. Prevent inhalation exposure in potential future buildings constructed over soil or groundwater contamination with volatile COCs present at concentrations that may pose a risk for vapor intrusion.

No RAO is needed for the pathway of direct contact exposure to soil by industrial workers because there were no exceedances of industrial soil CULs identified as part of the RI/FS for those COCs with CULs available in Ecology’s CLARC tables (i.e., BTEX, PCP, dioxins/furans). For those COCs without CLARC values to protect against direct contact in industrial settings (i.e., GRO, DRO, ORO), it is possible that some site TPH concentrations are currently at concentrations that would exceed a site-specific determination of a concentration protective of direct contact. These site-specific determinations typically result in concentrations that exceed 10,000 mg/kg. However, soils at these levels are proposed for removal as part of the proposed cleanup action.

In conjunction with these RAOs, the Port has provided several objectives to guide the selection and implementation of the remedial action. In addition to protecting human health and the environment, the cleanup action should:

1. Prepare the Site for industrial use in the marine trades, consistent with the adjacent terminal facilities.
2. Allow for completion of remedial activities in 2015 and 2016 if possible, to return the Site to economic use in 2016.
3. The cleanup should be consistent with management of stormwater by infiltration in unimpacted areas of the Site to the extent possible.

These objectives are in accordance with the RAOs, and in the interest of the Port, the economy of the area, and the protection of the local environment.

7.2 SITE DEFINITION AND CONTAMINANTS OF CONCERN

The approximate Site Boundary was developed based on the extent of COCs as established in this RI at concentrations greater than CULs. The Site Boundary is illustrated on Figure 7.1.

As shown on Figure 7.1, groundwater and soil contamination identified upgradient of the K Ply mill at the Peninsula Fuel Company property, is not included in the Site definition. This contamination is associated with activities on the Peninsula Fuels property and is considered a separate site, as contamination appears to have not migrated beyond its property boundary.

7.3 CLEANUP AREAS

Remedial alternatives in Section 9.0 are organized according to RAOs for the FS evaluation. These RAOs apply to one or more areas, which are illustrated as Cleanup Areas on Figure 7.1. The Cleanup Areas, which correspond to each RAO, are summarized in the following table. Cleanup Areas for which there is no RAO are discussed below.

RAO	**Cleanup Areas**
1. Prevent COCs in groundwater from discharging to surface water at concentrations greater than CULs protective of surface water.	Gasoline Area, Hog Fuel Storage Area
2. Remove, to the extent practicable, LNAPL accumulations on the water table.	Hydraulic Oil Area Gasoline Area (only near PZ-06)
3. Prevent inhalation exposure in potential future buildings with underlying soil contamination to indoor air with volatile COC concentrations greater than CULs.	Gasoline Area

7.3.1 Minor Cleanup Areas

Outside of the main areas for cleanup (i.e., the Gasoline Area and Hydraulic Oil Area) there are several smaller areas in which contaminated soil is located. The RI findings indicate minor exceedances of MTCA Method A or B screening levels in four other specific areas, referred to as the Stack Area, the Hog Fuel Storage Area, the PCP Area, and the Log Pond Fill Area (refer to Figure 7.1). These have all been designated "cleanup areas" even though some are quite small and others do not have concentrations of contaminants greater than industrial standards. This is because the expected cleanup/redevelopment of the Site will involve relocation of significant amounts of soil and all areas of contamination must be appropriately managed.

Three of these areas are located on the east side of the Site, outside the area where the majority of the contamination is located. The Stack Area consists of the area near the former mill stack where dioxins were detected in two surface soil samples but at concentrations less that the applicable MTCA Method C standard. The Hog Fuel Storage Area consists of the area where shallow DRO and GRO soil contamination was observed near the former hog fuel pile. The PCP Area consists of the area beneath the former mill where PCP was detected in soil but at concentrations less than applicable MTCA Method C standard. The Log Pond Fill Area consists of the former log pond bottom where a sample was found with oil-range hydrocarbon concentrations greater than the applicable standard. More importantly, the contamination associated with the Log Pond Fill Area is found in only deeper soils, represented by boring K-101, in which ORO was detected at concentrations greater than applicable criteria in soil at a depth of 12 feet corresponding to the former log pond bottom surface. The potential extent of the Log Pond Fill Area, based on the historical outline of the log pond, is shown on Figure 7.1.

7.4 MODEL TOXICS CONTROL ACT ALTERNATIVE EVALUATION CRITERIA

7.4.1 Model Toxics Control Act Threshold Requirements

The cleanup standards presented in Section 6.0 and RAOs 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. 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 8.0). 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 (DCA) be conducted as part of the alternatives evaluation, as described below and presented in Section 9.0.

7.4.2 Model Toxics Control Act Selection Criteria and Disproportionate Cost Analysis

Technologies that meet the threshold requirements listed above and pass the initial screening presented in Section 8.0 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 DCA, 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.

8.0 Identification and Screening of Remedial Technologies

A preliminary screening of potential technologies, was conducted to eliminate those alternatives that do not meet the threshold requirements (presented in Section 7.0), or are technically infeasible at the Site. 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 for all Cleanup Areas.

8.1 POTENTIALLY APPLICABLE TECHNOLOGIES

The relatively common occurrence of petroleum contamination nationwide has resulted in a range of technological approaches for remediating petroleum contamination in soil and groundwater and/or recovery of separate-phase product. Potentially applicable technologies are briefly described below in general terms.

8.1.1 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, thermal treatment, and 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 on-site treatment by thermal desorption, are considered variations on the excavation/disposal alternative. Less commonly used but potentially applicable in situ technologies considered include chemical oxidation, soil flushing, solidification/stabilization, thermally enhanced SVE, and phytoremediation.

Monitored Natural Attenuation. This involves regular soil and/or groundwater sampling to monitor the results of one or more naturally occurring physical, chemical, or biological process that reduces the mass, toxicity, volume, or concentration of contaminants in soil. These in situ processes include biodegradation and volatilization.

Institutional Controls. Institutional controls are physical, legal, and administrative measures that are implemented to minimize or prevent human exposure to contamination by restricting access to the Site. Institutional controls often involve deed restrictions or covenants, site advisories, use restrictions, or consent decrees, and would be implemented at the Site to limit or prohibit activities that may interfere with the integrity of any cleanup action or result in exposures to hazardous substances at the Site. Institutional controls are typically implemented in addition to other technologies when those technologies leave COCs on-site at concentrations greater than CULs.

Excavation and Landfill Disposal. Excavation of areas of contaminated soil using standard construction equipment and transport to an appropriate landfill is the most commonly employed technology for remediation of petroleum. Excavated areas would be subjected to confirmational soil sampling prior to backfill, compaction, and regrading.

Excavation and On-Site Treatment. Excavation of areas of highly contaminated soil using standard construction equipment and ex situ biological treatment (land farming) or on-site treatment by incineration or thermal or evaporative desorption. Excavated areas would be subjected to confirmational soil sampling prior to backfill, compaction, and regrading. Soil treated on-site could be used for backfill if treated to cleanup standards.

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 groundwater containing dissolved oxygen and nutrients through saturated zone soils only.

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.

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 SVE, 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. This technology is primarily used to remediate jet fuel and diesel-range hydrocarbons.

Chemical Oxidation. Chemical oxidation is also referred to as in situ chemical oxidation (ISCO). It involves injection of oxidizing agents such as ozone, hydrogen peroxide, Fenton's reagent, percarbonate, persulfate, or permanganate to rapidly destroy organic contaminants including TPH in both saturated and unsaturated zones. Applicability of chemical oxidation is dependent on soil types and the homogeneity of the subsurface, as injected solutions tend to follow preferential pathways through heterogeneous soil.

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

Solidification and Stabilization. Solidification or stabilization of soil that contains COCs at concentrations greater than CULs physically and chemically immobilizes the contaminants within the soil matrix, thereby reducing or eliminating contaminant mobility. With solidification, the contaminants are either enclosed or bound within the soil matrix via a binding agent such as modified sulfur cement, polyethylene extrusion, or emulsified asphalt. Stabilization involves adding and mixing a chemical compound with the contaminated soil to make the COC immobile through a chemical reaction that forms a new compound that is less toxic than the parent COC or through adsorption processes. Both of these technologies would be combined with leachability testing and/or long-term groundwater compliance monitoring to ensure that the contaminants are immobile and do not leach to groundwater.

In Situ Thermal Treatment. 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/or creating a barrier with the underlying contaminated soil. Institutional controls are typically required to maintain the cap.

8.1.2 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. If extracted, groundwater may be treated by a variety of ex situ groundwater treatment technologies such as liquid phase carbon adsorption, column air stripping, or discharge to the local publicly-owned treatment works (POTW). 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.

Institutional Controls. Institutional controls are physical, legal, and administrative measures that are implemented to minimize or prevent human exposure to contamination by restricting access to a site. Institutional controls often involve deed restrictions or covenants, site advisories, use restrictions, or consent decrees and would be implemented at a site to limit or prohibit activities that may interfere with the integrity of any cleanup action or result in exposures to hazardous substances at a site. Institutional controls are typically implemented in addition to other technology(s) when that technology leaves COCs on-site at concentrations greater than CULs.

Enhanced Biodegradation. Enhanced biodegradation accelerates 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.

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 groundwater, separate-phase petroleum product, and hydrocarbon vapor from unsaturated soils. Extracted liquids and vapor are treated and/or collected for disposal.

Bioslurping. Bioslurping is a variation on dual-phase extraction that 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 groundwater. 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.

Chemical Oxidation. Also referred to as ISCO, this treatment involves injection of oxidizing agents such as ozone, hydrogen peroxide, Fenton's reagent, percarbonate, persulfate, or permanganate to rapidly destroy hydrocarbons. Effectiveness depends in large part on the mass loading of hydrocarbons in soil and groundwater and natural oxidant demand.

Permeable Reactive Barrier (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 of 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.

8.1.3 Separate-Phase Product

In addition to excavation and off-site disposal or on-site treatment, which offer a direct approach to remediating LNAPL, other 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 and 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 a 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. Bioslurping is unsuitable for deeper LNAPL beyond the reach of vacuum-recovery.

8.2 RETAINED TECHNOLOGIES

The results of the preliminary technology screening evaluation are presented in Table 8.1. The screening process resulted in rejecting or retaining technologies based on whether the technology is capable of attaining RAOs and meeting the MTCA threshold criteria, given the COCs and impacted media, effectiveness and proven success at similar sites, and applicability of the technology within site physical constraints. In addition to the technologies described above, a no-action alternative was evaluated as part of the screening process. The retained technologies are summarized below and then aggregated into remedial alternatives for evaluation in Section 9.0.

8.2.1 Retained Soil Remediation Technologies

Based on the preliminary technology screening, the technologies discussed below were retained for further evaluation to address soil contamination.

8.2.1.1 Institutional Controls

Institutional controls have been retained for further evaluation as a soil remedial technology. As a stand-alone technology, institutional controls would not reduce, destroy, or remove any chemical contamination in addition to what would occur via natural processes, but would instead be implemented in addition to other technologies to meet RAOs, ensure long-term protectiveness of the selected remedy, and prevent exposure to contaminated soil. Institutional controls would be implemented with any technology that leaves contamination in place in excess of applicable CULs. Institutional controls could include current and future safety or soil management requirements for subsurface excavation activities such as utility work, landscaping, or construction that disturbs the ground in areas of soil contamination. When used in combination with other remedial technologies, institutional controls could successfully achieve the Site RAOs, and could be implemented given the Site physical conditions.

8.2.1.2 Surface Capping

Surface capping of contaminated soil has been retained for further evaluation. When implemented with institutional controls, capping addresses all of the soil COCs through management of the exposure pathways. Cap technologies may be designed to consist of either impermeable or semi-permeable paving, or placement of permeable clean, compacted soil or gravel. Cap design details would be developed during the remedial design phase of the project. Capping used in combination with other remedial technologies, such as source removal to address soil to groundwater concerns, could successfully achieve the RAOs and could be implemented given the physical conditions.

8.2.1.3 Excavation and On-Site or Off-Site Treatment or Disposal

Excavation and on-site or off-site treatment or disposal of soil has been retained for further evaluation because it addresses all of the soil COCs. The technology may be implemented to remove all soil contamination to a selected soil concentration or action level, or be implemented to a limited extent to remove and/or treat soil hot-spot areas. Soil excavation may be implemented in combination with other technologies depending on the extent of contamination left in place following a focused hot-spot removal. If excavation were conducted as a hot-spot removal, additional actions would be required to manage exposure for the contaminants remaining on the Site, and allow for future Site operations and redevelopment. Excavation can also be implemented given the physical conditions of the Site, which is relatively free of obstructions.

8.2.1.4 Chemical Oxidation

Chemical oxidation has been retained for further evaluation as a soil remedial technology. Chemical oxidation has the potential to effectively reduce, destroy, or remove COCs in a relatively fast timeframe. Chemical oxidation could successfully achieve the RAOs, and could be implemented given the Site physical conditions.

8.2.2 Retained Groundwater Remediation Technologies

Based on the preliminary technology screening, the technologies discussed below were retained to address groundwater contamination.

8.2.2.1 Bioremediation

Bioremediation has been retained for further evaluation as a groundwater remedial technology. As a stand-alone technology, without soil source control, bioremediation would not effectively reduce, destroy, or remove any chemical contamination in a reasonable timeframe due to the large mass of source material. However, bioremediation could be implemented in conjunction with a source removal technology as a biopolish to address lower concentration smear zone areas and areas where contamination is only present in groundwater. In combination with other technologies, bioremediation could successfully achieve the RAOs, and could be implemented given the Site physical conditions.

8.2.2.2 Chemical Oxidation

Chemical oxidation has been retained for further evaluation as a groundwater remedial technology. Chemical oxidation has the potential to reduce, destroy, or remove COCs in a reasonable timeframe. Chemical oxidation could successfully achieve the RAOs, and could be implemented given the Site physical conditions.

8.2.2.3 *Monitored Natural Attenuation*

Monitored natural attenuation has been retained for further evaluation as a groundwater remedial technology. As a stand-alone technology, monitored natural attenuation would not reduce, destroy, or remove any chemical contamination other than what would occur via natural processes. Monitored natural attenuation is being retained as a technology to be used in conjunction with a source removal technology. In combination with other technologies, monitored natural attenuation could successfully achieve the RAOs, and could be implemented given the Site physical conditions.

8.2.2.4 *Air Sparging*

Air sparging has been retained for further evaluation as a groundwater remedial technology. Air sparging is being retained as a POC technology to be used in conjunction with other remedial approaches. In combination with other technologies, air sparging could successfully achieve the RAOs, and could be implemented given the Site physical conditions.

8.2.3 Retained Light Non-Aqueous Phase Liquid Technologies

8.2.3.1 *Excavation and On-Site or Off-Site Treatment or Disposal*

Excavation and on-site or off-site treatment or disposal of LNAPL-impacted soil has been retained for further evaluation as a remedial technology for hydraulic oil LNAPL. Active product recovery has been tried and shown not to be sufficiently effective in recovering the viscous hydraulic oil LNAPL under site conditions. Excavation and on-site treatment or off-site disposal is capable of successfully meeting the RAOs.

8.2.3.2 *Passive Product Recovery*

Passive product recovery methods, including well bailing and product recovery inserts, are retained for further evaluation as a remediation technology for the trace accumulation of gasoline LNAPL near PZ-6 only. This technology is capable of successfully meeting the RAO for LNAPL removal.

9.0 Alternatives Evaluation and Disproportionate Cost Analysis

In this section, the retained technologies are assembled into four alternatives that each address all the Site RAOs and meet the MTCA threshold criteria. Alternatives are then subjected to a detailed analysis relative to the MTCA evaluation criteria and disproportionate cost criteria.

9.1 DESCRIPTION OF REMEDIAL ALTERNATIVES

Descriptions of the remedial action components that constitute the four representative remedial alternatives are presented below. For each alternative, remedial actions are organized according to the RAO that each would address. The remedial approach for each RAO is summarized in Table 9.1. Estimated excavation volumes are presented in Table 9.2. Conceptual illustrations of the remedial alternatives are provided in Figures 9.1 through 9.4. Estimated costs and underlying assumptions for each are provided in Appendix F.

All four alternatives include excavation to address hydraulic oil LNAPL, and three of four alternatives include excavation to address gasoline contamination. For all remedial alternatives that involve excavation of soil, off-site disposal at a Subtitle D landfill is assumed; however, use of on-site thermal (a.k.a. evaporative) desorption for soil treatment and re-use of the treated soil as backfill may be a more sustainable alternative approach as discussed in Section 10.0.

Each of the alternatives discussed below will address the minor cleanup areas as well, including the PCP Area, the Stack Area, the Hog Fuel Storage Area, and the Log Pond Fill Area. For Alternatives 1 and 2, the low-level contamination in the PCP Area would be addressed with institutional controls in the form of limited use/notification restrictions and for Alternatives 3 and 4, the contamination in the PCP Area would be addressed with excavation with the soil either relocated on-site or sent off off-site for disposal. For Alternatives 1 through 4, the soil from the Hog Fuel Storage Area would be excavated and the soil would be sent off-site for disposal or treated on-site and reused. The dioxin-containing soil in the Stack Area would be scraped off with each of the four Alternatives, consolidated, and eventually used as backfill in excavated areas.

The remedial action under all four alternatives for the Log Pond Fill Area is limited use/notification restrictions, based on the impracticality of excavation at that depth and across that extent. Sampling would be conducted in the Log Pond Fill Area during remedial design to better delineate the boundary of the contamination and need for limited use/notification restrictions.

Limited use/notification restrictions may be necessary in areas where soil or groundwater exceeds applicable Method A or B Cleanup levels (e.g., for petroleum related contaminants) and in areas where Method C is the applicable cleanup level (e.g., dioxins and PCP).

9.1.1 Alternative 1: Light Non-Aqueous Phase Liquid/Bulkhead Excavation, Air Sparge Curtain, and Institutional Controls

Alternative 1 is illustrated conceptually in Figure 9.1. This alternative consists of limited excavation to remove hydraulic oil LNAPL and soil contamination near the bulkhead, installation of an air sparge curtain to attain CULs at the bulkhead CPOC, institutional controls to address the potential future vapor inhalation pathway, and groundwater compliance monitoring.

An air sparge treatment zone at the point of discharge to surface water was selected as the preferred alternative for the MTA Site. Site conditions at the MTA Site include a large volume of contaminated soil that will remain permanently beneath buildings upgradient of the treatment zone, and, therefore, contribute to a relatively long restoration time frame.

At the K Ply Site, the mill demolition allows for the potential for other more permanent alternatives to be considered that were not applicable to the MTA Site (refer to Alternatives 3 and 4).

9.1.1.1 Remove Light Non-Aqueous Phase Liquid to the Extent Possible

This alternative includes the excavation and disposal of LNAPL-contaminated soil within the Hydraulic Oil Area. It also includes product recovery inserts in PZ-6 and other wells with measureable gasoline LNAPL.

Excavation of the LNAPL would involve removal and stockpiling of the upper 4 feet of surface soil followed by removal of the approximately 6 to 8 feet of underlying NAPL-containing soil (based on field observations). Approximately 3,800 cubic yards of contaminated soil would be disposed of. The upper 4 feet of clean soil would be used as backfill if suitable. Excavation would be conducted using standard construction equipment. Free product, if visible at the water table, would be removed using a vacuum recovery truck. Contaminated soil and free product would be transported off-site for disposal or recycling.

9.1.1.2 Prevent Discharge of Contaminants of Concern to Surface Water Greater than Cleanup Levels

This alternative would use air sparging to treat petroleum hydrocarbons in groundwater prior to its discharge into the Harbor. The effectiveness of air sparging in meeting the groundwater CULs at the CPOC would be enhanced with a focused excavation of soil with concentrations greater than 30 mg/kg GRO and 2,000 mg/kg ORO to remove contaminated smear zone and vadose zone soil from the area near the bulkhead.

Assuming a 4-foot thickness of contamination (based on field observations), approximately 540 cubic yards of contaminated soil from the smear zone and 60 cubic yards of contaminated soil from the vadose zone will be removed and disposed of off-site. Eight feet of clean overburden soil in the area of smear zone contamination and four feet in the area of vadose zone contamination would be excavated and likely be used as backfill. 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 for transport to a recycling or disposal facility. Shoring may be used to provide excavation stability; nevertheless, setbacks from structures, including the bulkhead, are expected to be necessary.

Based on available information, the air sparge 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, and extending far enough to the west to stop potential migration of the plume lobe located to the northwest near the Port office. 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. It is expected that the air sparge curtain would be located upgradient of the former railway trestle located adjacent to the bulkhead. Some integration of the sparge system with the one being designed for the MTA Site would be expected. For example, similar to the MTA Site sparge curtain, 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. 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.

The geology of the area where an air sparge curtain would be located is consistent with the requirements of 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 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. 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. Tidal variation, including the chemical effects of shallow saline mixing from the Harbor into fresh groundwater, is not expected to be a significant factor in the engineering of the air sparge curtain.

The air sparge curtain alternative may require collection of additional design data prior to implementation for system optimization. Once installed, compliance monitoring of groundwater inside and downgradient from the treatment area would be maintained.

9.1.1.3 Prevent Inhalation Exposure in Potential Future Buildings

Under this alternative, large portions of the Gasoline Area will have soil/groundwater contamination left untreated. This soil and groundwater presents potential future indoor air risk, so institutional controls will be put in place that require that deed restrictions (Environmental Covenants) be placed on the parcels that contain residual contaminated soil or groundwater and that the indoor air pathway must be evaluated and mitigated during redevelopment as part of the institutional controls.

9.1.2 Alternative 2: Chemical Oxidation, Capping, and Institutional Controls

Alternative 2 is illustrated conceptually in Figure 9.2. Alternative 2 consists primarily of in situ chemical oxidation (ISCO) to treat soil and groundwater contaminated with GRO, DRO, ORO, and BTEX, followed by enhanced bioremediation as needed to attain the groundwater CULs at the CPOC. Compliance monitoring of groundwater would be conducted. Hydraulic oil LNAPL would be excavated and disposed of off-site. Areas where vadose zone soils would be left in place would be capped, and institutional controls would address the potential future vapor inhalation pathway.

No treatment at the point of discharge to surface water, such as an air sparge curtain, would be necessary with this alternative, because this alternative would chemically oxidize the source material and provide for enhanced bioremediation of groundwater prior to discharge.

9.1.2.1 Remove Light Non-Aqueous Phase Liquid to the Extent Possible

This alternative includes the excavation and disposal of LNAPL-contaminated soil within the Hydraulic Oil Area. It also includes product recovery inserts in PZ-6 and other wells with measureable gasoline LNAPL.

Excavation of the LNAPL would involve removal and stockpiling of the upper 4 feet of surface soil followed by removal of the approximately 6 to 8 feet of underlying LNAPL-containing soil (based on field observations). Approximately 3,800 cubic yards of contaminated soil would be disposed of. The upper 4 feet of clean soil would be used as backfill if suitable. Excavation would be conducted using standard construction equipment. Free product, if visible at the water table, would be removed using a vacuum recovery truck. Contaminated soil and free product would be transported off-site for disposal or recycling.

9.1.2.2 Prevent Discharge of Contaminants of Concern to Surface Water Greater than Cleanup Levels

This alternative would involve chemical oxidation of soil in the Gasoline Area smear zone to attain applicable CULs (30 mg/kg GRO, 0.3 mg/kg benzene, and 2,000 mg/kg ORO). Injection of an oxidizing agent would be used to destroy COCs in saturated zone soil and shallow groundwater throughout the Gasoline Area. It is assumed that a readily available commercial oxidant, such as RegenOx, would be applied using direct-injection techniques or wells over a treatment period of approximately 1 to 3 years.

RegenOx uses a solid alkaline oxidant that employs a sodium percarbonate complex with a multi-part catalytic formula. It directly oxidizes contaminants while its catalytic component generates a range of highly oxidizing free radicals that destroy organic compounds including petroleum hydrocarbons. The treatment relies on physical contact of the oxidant with the organic contaminant to be oxidized, and so it is expected to require over a thousand closely spaced injections and multiple treatment rounds to address the widespread area of soil and groundwater contamination. The approximate minimum mass of oxidant required can be estimated based on the estimated mass of TPH-G in smear zone soil of 210,700 pounds. For petroleum hydrocarbon treatment, RegenOx also produces oxygen as a result of its reactions providing transition from in situ chemical oxidation to enhanced aerobic bioremediation.

This alternative would also include a contingency option to couple the chemical oxidation technology with a subsequent application of a controlled-release bioremediation substrate (such as Oxygen Release Compound) to treat the remaining low-level contaminant concentration biologically over time.

The chemical oxidation alternative would require collection of additional design data prior to implementation. The alternative includes compliance monitoring of groundwater at the POC and reapplication of ISCO, should rebound occur.

9.1.2.3 Prevent Inhalation Exposure in Potential Future Buildings

As noted above, this alternative would employ ISCO to treat smear zone soil in the Gasoline Area to applicable CULs (30 mg/kg GRO, 0.3 mg/kg benzene, and 2,000 mg/kg ORO), and would include follow-on enhanced bioremediation measures as needed to meet the groundwater CULs. Attainment of these CULs would address the inhalation potential future pathway in the majority of the Gasoline Area; ISCO treatment would not remediate vadose zone contamination.

Under this alternative, portions of the Gasoline Area will have soil/groundwater contamination left that presents a potential future indoor air risk, so Institutional Controls will be put in place that require that deed restrictions (Environmental Covenants) be placed on the parcels that contain residual contaminated soil or groundwater and that the indoor air pathway must be evaluated and mitigated during redevelopment as part of the institutional controls.

9.1.3 Alternative 3: Focused Source Control Excavation, Bioremediation, and Institutional Controls

Alternative 3 is illustrated conceptually in Figure 9.3. This alternative consists of source control excavation within the Hydraulic Oil and Gasoline Areas, excavation in the PCP Area, excavation of hydraulic oil LNAPL and gasoline LNAPL with follow up treatment of groundwater using enhanced bioremediation agents, compliance monitoring of groundwater, and institutional controls that require an evaluation of vapor intrusion risk. Although this alternative would remove a sufficient mass of source material that would provide benefit to groundwater quality, post-excavation groundwater treatment may be needed (refer to Section 9.1.3.2). Treatment with enhanced bioremediation agents may be used following excavation to shorten the restoration time frame for residual soil left unexcavated and groundwater.

9.1.3.1 Remove Light Non-Aqueous Phase Liquid to the Extent Possible

This alternative includes the excavation and disposal of LNAPL and LNAPL-contaminated soil within both the Hydraulic Oil Area and near PZ-6 in the Gasoline Area.

Excavation of the LNAPL would involve removal and stockpiling of the upper 4 feet of surface soil followed by removal of the approximately 6 to 8 feet of underlying LNAPL-containing soil (based on field observations). Approximately 3,800 cubic yards of contaminated soil would be disposed of. The upper 4 feet of clean soil would be used as backfill if suitable. Excavation would be conducted using standard construction equipment. Free product, if visible at the water table, would be removed using a vacuum recovery truck. Contaminated soil and free product would be transported off-site for disposal or recycling.

9.1.3.2 Prevent Discharge of Contaminants of Concern to Surface Water Greater than Cleanup Levels

This alternative would attain CULs at the conditional POC through a combination of removal of TPH source mass by targeted excavation in two areas, and enhanced bioremediation deployed within the excavation, as well as in downgradient plume areas.

This alternative would involve excavation of downgradient gasoline-contaminated soil beginning at the bulkhead and extending into the Hydraulic Oil Area. This would create a zone of clean soil for upgradient groundwater to flow through and undergo bioremediation prior to discharge to the Harbor. Soil with concentrations greater than 2,000 mg/kg ORO, 30 mg/kg GRO, and 0.3 mg/kg benzene would be removed from both the vadose and smear zones throughout this area. Assuming a 4-foot thickness of contamination, approximately 3,500 cubic yards of contaminated soil from the smear zone and 300 cubic yards of contaminated soil from the vadose zone would be excavated from the northern portion of the former mill building and bulkhead vicinity. The upper 8 feet of clean soil would be excavated and is expected to be used as clean backfill.

This alternative also includes upgradient excavation of the large source area under and downgradient of the former loading dock concrete pad near Pipeline 8 that also includes the PCP Area. The volume of contaminated soil to be excavated in this area is estimated to be approximately 4,820 cubic yards in the smear zone and 3,100 cubic yards in the vadose zone. Excavation would continue in the vadose zone until site CULs are achieved for the soil COCs. Excavation in the underlying smear zone would continue until remaining smear zone soils contain benzene and GRO concentrations less than 10 mg/kg and 3,000 mg/kg, respectively. This action will remove approximately 90 percent of the contaminant mass in the smear zone. The smear zone hot spot area targeted for excavation is shown on Figure 5.8 and generally lies within the area of vadose zone contamination with a narrow downgradient extension. Residual smear zone soil with GRO concentrations less than 3,000 mg/kg may act as a source of groundwater contamination but any impacts to groundwater will be addressed through bioremediation and/or monitored natural attenuation.

The PCP-contaminated soil that is located above the gasoline-contaminated soil in this area will need to be excavated to allow removal of Pipeline 8, which crosses through the PCP Area. The excavated PCP-containing soil may be re-used on-site as backfill (if compliance sampling concentrations are less than the CUL) or hauled off-site for disposal (if compliance sampling concentrations exceed the CUL). The former concrete pad would need to be removed to grade to allow access to this soil. The upper 8 feet of clean soil in the area of smear zone-only contamination and the upper 4 feet of soil overlying the vadose zone contamination would be considered overburden and used as clean backfill (assuming it meets CULs prior to backfilling).

Excavation would be conducted using standard construction equipment to remove contaminated soils from the subsurface. Soil would be stockpiled on-site for treatment on-site or loaded directly into trucks for transport to a recycling or disposal facility. Shoring may be used to provide excavation stability; nevertheless, setbacks from structures, including the bulkhead, are expected to be necessary. If in some area smear zone contamination is found to extend deep into the water table, such as is thought to exist near the bulkhead, application of chemical oxidants will be considered in an attempt to treat the deeper smear zone. The oxidants will be blended into deeper soils using standard construction equipment equipped with specialty soil mixing attachments.

Alternative 3 would also include post-excavation groundwater treatment. Prior to backfilling, enhanced bioremediation will be utilized within the footprint of the excavation areas to address residual groundwater contamination that is not removed as part of the source removal excavation and to potentially reduce the restoration time frame for groundwater at the Site. The addition of an aerobic bioremediation enhancement product (such as oxygen-releasing compound [ORC], ORC Advanced) to smear zone soil and shallow groundwater would allow for acceleration of the natural biodegradation process by providing nutrients for microorganisms and oxygen as the key electron acceptor needed in to the biologically-mediated decomposition of organic contaminants in groundwater. After the soil has been excavated, the ORC would be directly applied to the open pit and then covered with backfill. Infiltration galleries would be installed in the open excavation areas prior to backfilling and would allow for future addition of ORC or similar product in liquid form, as necessary, as a contingent delivery system to treat both residual smear zone soils left unexcavated and groundwater, as described below.

Following the completion of the source area excavation and backfilling, an assessment of groundwater conditions would be performed to determine the need for additional in situ bio treatment of groundwater site-wide, including the relatively elevated levels of benzene that have migrated beneath Cedar Street. The post-excavation groundwater treatment would be adaptive and based on lessons learned from the excavation and initial response of the system to the ORC application. The treatment could include application of biological amendments via the delivery system that is installed following the excavation or via in situ injections using a Geoprobe. Figure 9.3 indicates the general site areas where bio treatment would occur. In particular, the core of the downgradient benzene plume under Cedar Street will be targeted, as well as groundwater near the conditional point of compliance near the bulkhead.

The alternative includes compliance monitoring of groundwater at the POC as well as upgradient areas. This may involve the replacement of certain wells that were abandoned as part of the excavation activities and addition of new wells along the bulkhead and along Cedar Street.

9.1.3.3 Prevent Inhalation Exposure in Potential Future Buildings

As noted above, this alternative would involve excavation of a substantial portion of gasoline-contaminated soil to applicable CULs, which would eliminate some of the potential future inhalation exposure pathway risk in buildings constructed over excavated areas. However, the indoor air pathway must be evaluated prior to any building development. The evaluation will be performed in accordance with current Ecology Vapor Intrusion regulation or guidance. Mitigation will be necessary if the assessment indicates an unacceptable risk of vapor intrusion.

9.1.4 Alternative 4: Excavation, Bioremediation, and Institutional Controls

Alternative 4 is illustrated conceptually in Figure 9.4. This alternative consists of excavation of the entire area of contaminated soil within the Gasoline Area (including into the alleyway) to applicable CULs, excavation of the PCP Area, excavation of the Hydraulic Oil and Gasoline Areas, and excavation of the Hog Fuel Storage Area. Treatment of groundwater with enhanced bioremediation agents, compliance monitoring of groundwater, and institutional controls in areas where soil remains on-site at levels greater than CULs, including the small area of TPH-contaminated soil at depth in the former log pond near the current debarker area.

Although this alternative would remove a sufficient mass of source material that would provide additional benefit to groundwater quality, post excavation groundwater treatment may be needed especially for the benzene plume that has migrated under Cedar Street. Treatment of groundwater with enhanced bioremediation agents, chemical oxidation, air sparging, or monitored natural attenuation may be used following excavation to shorten the restoration time frame for groundwater. The general areas for bio treatment of groundwater are shown on Figure 9.4.

9.1.4.1 Remove Light Non-Aqueous Phase Liquid to the Extent Possible

This alternative includes the excavation and disposal of LNAPL and LNAPL-contaminated soil within the Hydraulic Oil Area and the Gasoline Area.

Excavation of the LNAPL would involve removal and stockpiling of the upper 4 feet of surface soil followed by removal of the approximately 6 to 8 feet of underlying NAPL-containing soil (based on field observations). Approximately 3,800 cubic yards of contaminated soil would be disposed of. The upper 4 feet of clean soil would be used as backfill if suitable. Excavation would be conducted using standard construction equipment. Free product, if visible at the water table, would be removed using a vacuum recovery truck. Contaminated soil and free product would be transported off-site for disposal or recycling.

9.1.4.2 Prevent Discharge of Contaminants of Concern to Surface Water Greater than Cleanup Levels

This alternative would attain CULs at the conditional POC through a combination of wholesale removal of the TPH source mass by excavation, and enhanced bioremediation within the excavation to biologically treat any residual contamination in soil and/or groundwater.

This alternative would involve removal of contaminated soil from the Gasoline and Hydraulic Oil Areas. Smear zone and vadose zone soil with concentrations above 30 mg/kg GRO, 0.3 mg/kg benzene, and 2,000 mg/kg ORO would be removed. Assuming a 4-foot thickness of contamination, approximately 15,600 cubic yards of contaminated soil from the smear zone and 2,800 cubic yards of contaminated soil from the vadose zone will be disposed of off-site. The upper 8 feet of clean soil in the area of smear zone contamination and upper 4 feet in the area of vadose zone contamination would be excavated and is expected to be used as clean backfill.

Excavation would be conducted using standard construction equipment to remove contaminated soils from the subsurface. Soil would be stockpiled on-site, and loaded directly into trucks for transport to a recycling or disposal facility. Shoring may be used to provide excavation stability; nevertheless, setbacks from structures, including the bulkhead, are expected to be necessary.

Alternative 4 would also include post excavation groundwater treatment. Prior to backfilling enhanced bioremediation would be utilized within the excavation area to address residual groundwater contamination that is not removed as part of the source removal excavation. The addition of an aerobic bioremediation enhancement product (such as ORC, ORC Advanced) to smear zone soil and shallow groundwater would allow for acceleration of the natural biodegradation process by providing nutrients for microorganisms and oxygen as the key electron acceptor needed in the biologically-mediated decomposition of organic contaminants in groundwater. After the soil has been excavated, the ORC would be directly applied to the open pit and then covered with backfill. Infiltration galleries would be installed in the open excavation areas prior to backfilling and would allow for future addition of ORC as necessary as a contingent delivery system.

Following the completion of the source area excavation and backfilling, an assessment of groundwater conditions would be performed to determine the need for additional in-situ bio treatment of groundwater site wide, including the relatively elevated levels of benzene that have migrated beneath Cedar Street. The post excavation groundwater treatment would be adaptive and based on lessons learned from the excavation and initial response of the system to the ORC application. The treatment could include application of biological amendments via the delivery system that is installed following the excavation or via in-situ injections using a Geoprobe. Figure 9.4 indicates the general site areas where bio treatment would occur, in particular, the core of the downgradient benzene plume under Cedar Street will be targeted as well as groundwater near the CPOC near the bulkhead.

The alternative includes compliance monitoring of groundwater at the POC as well as upgradient areas. This may involve the replacement of certain wells that were abandoned as part of the excavation activities and addition of new wells along the bulkhead and Cedar Street.

9.1.4.3 Prevent Inhalation Exposure in Potential Future Buildings

As noted above, this alternative would involve excavation of a substantial portion of gasoline-contaminated soil to applicable CULs, which would eliminate most of the potential future inhalation exposure pathway risk in buildings constructed over excavated areas. However, the indoor air pathway must be evaluated prior to any building development. The evaluation will be performed in accordance with current Ecology Vapor Intrusion Guidance. Mitigation will be necessary if the assessment indicates an unacceptable risk of vapor intrusion.

9.2 EVALUATION AND DISPROPORTIONATE COST ANALYSIS

In this section, alternatives for each Cleanup Area are evaluated relative to each other using the MTCA evaluation and disproportionate cost analysis (DCA) criteria. The detailed comparison for each alternative is presented in Table 9.3, and a summary of the overall evaluation is presented in Table 9.4. The results of the evaluation are presented below using the procedures for DCA provided in WAC 173-340-360(3)(e).

Based on the comparative evaluation, the alternatives ranked in order from most to least permanent are: Alternative 4 ($7.5 million), Alternative 2 ($7.0 million), Alternative 3 ($5.2 million), Alternative 1 ($2.4 million). Alternative 4 is the most permanent solution identified and serves as the baseline DCA cleanup alternative against which other, less permanent alternatives are compared.

As explained in Section 9.1.2.2 above, the effectiveness and implementability of chemical oxidation under Alternative 2 is problematic at this Site given the volume and extent of source mass. Although chemical oxidation as a technology is theoretically capable of destroying sufficient contaminant mass to attain CULs, feasibility is governed by site-specific factors that suggest critical implementability and effectiveness problems, especially in comparison to the baseline DCA alternative. Based on the large contaminant mass load in the soil and groundwater, the estimated minimum mass of oxidant that would be required to be introduced is 1.1 million pounds. This volume of oxidant is expected to require substantial time to deliver to the subsurface, and the reliance of the treatment on physical contact is expected to necessitate over a thousand closely spaced borings, with a multi-year period of repeat injections and monitoring projected.

The actual mass of oxidant that is likely to be required is expected to be several times the minimum mass calculated based on stoichiometry, because of the known difficulty delivering in situ treatment reagents into the subsurface. As initial high contaminant mass is reduced, the effectiveness of the repeat treatments typically decreases dramatically, so that low concentrations needed for compliance are difficult to achieve. In particular, contaminant mass bound in interstitial pore spaces of the aquifer soils is likely to persist as a recalcitrant source of contamination for many years. In addition, Alternative 2 would leave in place several areas of vadose zone-contaminated soil that would not be treatable with ISCO. In short, there is too much source mass at the Site for ISCO to be an effective solution site-wide.

This DCA also compares Alternative 3 to Alternative 4. Because the benefits of Alternative 3 in terms of overall risk reduction are similar to those of the most permanent option, Alternative 4, the incremental cost of implementing more soil removal and bioremediation under Alternative 4 over Alternative 3 is are disproportionate to the benefits based on this evaluation.

Alternative 3 would include removal of LNAPL and the most highly contaminated soil, including all vadose zone contaminated soil and smear zone soil with the greatest benzene and GRO concentrations, as well as smear zone soil close to the bulkhead, and would augment such removal with bioremediation of groundwater in excavated areas and in downgradient plume areas. These areas are considered the highest priority for removal to protect human health and the environment and address the RAOs for soil, groundwater, and indoor air. The northern portion of the excavation, in conjunction with the excavation to remove hydraulic oil LNAPL, would remove source area contamination within a large enough distance (approximately 250 feet) from the bulkhead that enhanced bioremediation is expected to be effective in achieving the groundwater CULs at the CPOC permanently.

The southern portion of the excavation is aimed at removing the main gasoline source area for the benzene (and GRO) groundwater plume that extends northwest of the mill footprint beneath Cedar Street, and to allow for introduction of sufficient bioremediation reagents to enhance bioremediation of the less contaminated downgradient smear zone soil that would be left in place but expected to attenuate slowly over time. Site data for the downgradient edge of the Cedar Street Benzene Plume, which has remained stable or shrinking in the nearly decade-long period it has been monitored, demonstrate the attenuation of GRO and benzene in groundwater already occurring downgradient of the source area. However, this plume will be bio-treated to accelerate the restoration time frame and further protect the Harbor.

Alternative 4 adds to Alternative 3 by removing contaminated smear zone soil (about 8,400 additional cubic yards, plus substantially more overburden soil) from the center and southern edges of the former mill footprint, augmented with bioremediation of groundwater in this area (refer to Table 9.2 for a comparison of estimated soil excavation volumes).

Alternative 4 would not achieve RAOs any faster than Alternative 3, or have a shorter overall restoration timeframe. Alternative 4 is estimated to cost about $2.3 million more than Alternative 3.

While the Alternative 4 approach is technically the most permanent, the remedial components of Alternative 3 are intended to result in commensurate risk reduction as under Alternative 4. Both Alternatives 3 and 4 include a post-excavation groundwater treatment component that provides for continued remediation of the entire area of contaminated groundwater; both rely on source removal and enhanced aerobic biodegradation of contaminants. It is expected that CULs will be permanently attained at the groundwater CPOC within 5 to 10 years under both Alternatives. Alternative 3 includes excavation of a substantial area and volume that is approximately $^{2}/_{3}$ of the tonnage of contaminated soil that would be excavated in Alternative 4 (approximately 24,000 tons versus 35,000 tons; refer to Table 9.2). The smear zone soil that is not being excavated under Alternative 3 will continue to undergo natural attenuation until the soil achieves site CULs; however, this is not expected to occur for approximately 30 years. Infiltration galleries will be positioned over these areas to allow enhancement of the natural attenuation process if monitoring indicates slower than expected natural attenuation.

Viewed in this context, the removal under Alternative 4 of the less contaminated upgradient smear zone soils (i.e., soil with TPH concentrations less than 3,000 mg/kg) is the primary difference between the two alternatives (compare Figures 9.3 and 9.4); however, this additional excavation of smear zone increases contaminated soil volume substantially and also requires removal/replacement of a large volume of clean overburden. Alternative 4 provides a relatively small incremental benefit that is disproportionate to the added costs. The alternative that provides the best combination of protectiveness, long-term effectiveness, and cost, therefore, is Alternative 3: Focused Excavation, Bioremediation, and Institutional Controls.

10.0 Preferred Cleanup Action

In this section, the Preferred Cleanup Action is described for the Site (including a description of how it complies with the requirements of MTCA), and describes the ARARs, the estimated cost, and implementation time frame.

10.1 DESCRIPTION OF THE PREFERRED CLEANUP ACTION

The Preferred Cleanup Action for the Site is Alternative 3, which involves focused excavation of soil that contains LNAPL or is contributing to groundwater contamination, followed by bioremediation within as well as outside the excavation areas for treatment of groundwater. Several minor areas of concern will also be addressed through either excavation or relocation on-site. This is illustrated conceptually in Figure 9.3. The Preferred Cleanup Action also includes compliance monitoring of groundwater and institutional controls. The following paragraphs describe the preferred cleanup action.

The cleanup will involve removal of TPH source mass by targeted excavation in two cleanup areas followed by enhanced bioremediation within the excavation areas. This first is the Hydraulic Oil Area-contaminated soil that extends from the area of the former plywood presses downgradient to near the bulkhead. The second is the Gasoline Area contaminated soil that extends from under the loading dock to the bulkhead.

Removal of contamination from the vadose and smear zone in the Hydraulic Oil Area (and the comingled downgradient portion of the Gasoline Area) would create a zone of clean soil for any future contaminated groundwater to flow through prior to discharge to the Harbor. It is expected that this clean zone, with subsequent bio-amendments, will create optimum conditions for bioremediation to treat contaminated groundwater such that by the time it discharges into the Harbor, concentrations would be at CULs.

Soils lying upgradient of the Hydraulic Oil Area would be excavated as well. This would achieve source control for the elevated concentrations of benzene and GRO found in groundwater downgradient of this area. It would also lessen the risk of vapor intrusion if buildings are constructed in this area.

Excavation in both areas would continue until CULs are achieved for all site COCs located in the vadose soil (soils generally above 8 feet bgs). Smear zone soils (soils generally between 8 and 12 feet bgs) would be excavated to CULs in the Hydraulic Oil Excavation Area and to remediation levels in the Gasoline Excavation Area. The objective of using a remediation level in the Gasoline Excavation Area is to remove the greatest concentration soils to achieve source control to reduce the potential for future groundwater contamination. These soils are shown in Figure 5.8 as the core contamination area defined by benzene concentrations greater than 10 mg/kg and GRO greater than 3,000 mg/kg. This action would remove approximately 90 percent of gasoline in the smear zone soils. Remaining smear zone contamination concentrations greater than CULs but less than remediation levels will be addressed through bioremediation with a focus on treatment of groundwater to prevent plume migration to the bulkhead.

The volume of contaminated soil to be excavated is estimated to be approximately 10,250 cubic yards in the smear zone and 5,250 cubic yards in the vadose zone. The former concrete pad would need to be removed to grade to allow access to this soil.

An estimated 19,100 cubic yards of clean overburden will need to be excavated from this area. Excavated overburden, including the structural fill under the current pad, will be used as backfill if it can be demonstrated that such soil meets CULs prior to backfilling.

Excavation would be conducted using standard construction equipment to remove contaminated soils from the subsurface. Up to 10 existing monitoring wells may lie in areas to be excavated and will need to be abandoned beforehand. A more limited number of replacement wells will be installed following excavation activities. Soil would be stockpiled on-site, loaded directly into trucks for transport to a disposal facility or, alternatively, treated on-site to CULs and then used as backfill (refer to Section 10.2). In addition, the piles of concrete that remain on-site will be crushed and used as backfill. Shoring may be used to provide excavation stability; nevertheless, setbacks from structures, including the bulkhead, are expected to be necessary.

When excavating the smear zone, part of which lies below the groundwater surface, it may be not be possible to dig more than several feet into the water table without soil caving. If this occurs, dewatering may be necessary, which poses significant implementability challenges. Instead, the use of chemical oxidants is proposed as an alternative to dewatering. The oxidants would be applied in liquid or powder form and then mixed with the soil using standard excavation equipment with specialized mixing attachments.

The Preferred Cleanup Action would also include post-excavation groundwater treatment. Prior to backfilling, enhanced bioremediation will be utilized within the footprint of the excavation areas to address residual groundwater contamination that is not removed as part of the source removal excavation. The addition of an aerobic bioremediation enhancement product (such as ORC in powder form) to smear zone soil and shallow groundwater in these areas would allow for acceleration of the natural biodegradation process by providing nutrients for microorganisms and oxygen as the key electron acceptor needed in the biologically-mediated decomposition of organic contaminants in groundwater. Infiltration galleries would be installed in the open excavation areas prior to backfilling and would allow for future addition of ORC as necessary as a contingent delivery system to treat both residually contaminated groundwater and residual smear zone soils that are contributing to contamination.

Following the completion of the source area excavation and backfilling, selected monitoring wells that were abandoned prior to construction would be replaced (and new wells added if needed). Groundwater monitoring of these new wells would be conducted to determine current conditions both within the K Ply property boundary as well as along Cedar Street. If the results of that monitoring indicate the CULs will not be attained within a reasonable timeframe at the CPOC along the bulkhead, the need for additional groundwater treatment will be evaluated.

As shown in Figure 10.1, the core area of the gasoline and benzene plume in groundwater contamination under the former mill is anticipated to be adequately addressed with the source area excavation, but the groundwater contamination plume under Cedar Street may require additional treatment. The post-excavation groundwater treatment would be adaptive and use any lessons learned from the excavation ORC applications. Additional data may also be needed to fill data gaps (e.g., current dissolved oxygen levels, soil pH, soil oxygen demand, bacteriological census count) prior to the formulation of a specific treatment plan. Alternatively, a pilot test may be prudent to inform the treatment selection. The treatment could include application of biological amendments via the delivery system that is installed following the excavation (i.e., via infiltration galleries) or instead may rely on injection of liquid amendments using a Geoprobe (e.g., in Cedar Street).

As discussed above, the selection and design of post-excavation groundwater treatment would be developed following completion of the source area excavation and groundwater compliance monitoring. The approach would be presented to Ecology in a Supplemental Engineering Design Report.

10.1.1 Minor Cleanup Areas

The minor Cleanup Areas include the PCP Area, the Stack Area, the Hog Fuel Storage Area, and the Log Pond Fill Area. The contamination present at the PCP Area and the Hog Fuel Storage Area are very limited in extent. The soil from the PCP Area will be incidentally excavated as "overburden," as the soil will either be reused on-site for backfill or sent for disposal off-site. The soil from the Hog Fuel Storage Area will be excavated and the soil will be sent off-site for disposal or treated to meet CULs and reused. The dioxin-containing soil in the currently unpaved Stack Area will be scraped off, consolidated, and eventually used to backfill and be covered with clean soil.

Institutional controls in the form of limited use/notification restrictions will be necessary in areas where soil or groundwater exceeds applicable MTCA Method A or B CULs (e.g., for petroleum-related contaminants) and in areas where MTCA Method C is the applicable CUL (e.g., dioxins and PCP). Additional sampling would be conducted in the Log Pond Fill Area during remedial design to better delineate the boundary of the contamination in that area.

10.1.2 Prevent Inhalation Exposure in Potential Future Buildings

As noted above, the Preferred Cleanup Action would involve excavation of all gasoline-contaminated vadose zone soils with concentrations greater than CULs and a substantial portion of gasoline-contaminated smear zone soil to either CULs or remediation levels. Removal of these soils will substantially lessen, but not eliminate, the risk of a future vapor intrusion pathway. Therefore, the risk of vapor intrusion for any future building constructed on-site will still need to be addressed.

Institutional controls will be necessary to require that this evaluation be done. This evaluation will occur for any building constructed on the property and, depending on subsurface conditions under the building, may involve additional testing and analysis in accordance with current Ecology regulation or guidance to evaluate the actual risk of vapor intrusion into future buildings. If an unacceptable risk is anticipated as a result of this assessment, remedial measures may be necessary during construction, such as a vapor barrier). Institutional controls are expected to include an environmental covenant that describes the location of the known remaining contamination, requires evaluation and mitigation of the vapor intrusion risk when new construction is proposed, and meets other requirements under state law.

10.2 ON-SITE TREATMENT OPTION

An option instead of disposing of the contaminated soil off-site at a landfill is to treat the soil on-site and then reuse the treated soil as backfill. A more detailed description of this option followed by its advantages and disadvantages (including cost) is discussed in the following paragraphs. Final decision as to how excavated soil at the Site will be addressed (i.e., on-site treatment and re-use or off-site disposal) will be determined during remedial design.

10.2.1 Technology Description

In the past few years, the technology to effectively treat and destroy petroleum-related contaminants on-site with mobile treatment units has advanced such that the limitations posed by the earlier “pug mill” type mobile on-site treatment units (which primarily were related to high mobilization cost, low effectiveness in certain soil types, and inability to meet air permit requirements) are now solved. The primary change in technology was a shift to an “evaporative desorption” technique. In this technology, a large metal bin is filled with contaminated soil. Two bins at a time are placed inside a mobile treatment unit. The treatment unit is lined with ceramic heaters and has doors shut and seal to allow the soil to be placed under a vacuum. The treatment unit uses electricity to heat the soil to the desired temperature where the contaminants are rapidly evaporated (desorbed) into the air stream. The air stream is directed to a catalytic oxidization unit to destroy the contaminants prior to discharge to the atmosphere. The contaminant loading to the oxidizer is continually monitored, as is the temperature inside the treatment unit. When the off-gassing declines to a minimal value, the electricity is cut off and the treatment unit opened and the soil bin taken out for cooling (and confirmation testing as required). The next set of bins are then placed inside and the process restarted. The time required to treat each batch of soil depends upon the contaminant being treated and the cleanup goals, but typically 4 to 6 hours are required for each batch. Up to 250 to 300 tons per day can be processed in this fashion per treatment unit. After cooling, the treated soil is then wetted (to allow compaction), placed back into the excavation, and compacted. A three-man crew works 24 hours a day in this fashion.

10.2.2 Advantages

The advantages of this technology are that the contaminants are permanently destroyed instead of being transferred to another location, so it ranks higher as a MTCA selection criterion. It also ranks significantly high in sustainability (not a MTCA criterion, however). This is because the soil that is treated is re-used on-site. This saves considerable truck traffic miles and fossil fuel use related to both the transport of soil to the landfill as well as the import of clean backfill from a quarry (itself a limited resource). In addition, this is a far more cost effective solution than landfilling, should a portion of the soils with the greatest benzene concentrations turn out to be classified as a dangerous waste based on TCLP testing for waste characterization purposes.

10.2.3 Disadvantages

Given that this technology is relatively new and patented, there is only one national vendor (Reterro Inc.) with a limited portfolio of large projects (however, all were successful). The technology also has a smaller daily treatment maximum as opposed to mass excavation and disposal so, therefore, would take longer (up to 3 to 4 months assuming 500 tons/day using two treatment units) compared to dig and haul, which can be done in as little as 6 weeks (assuming excavation and transport of 1,000 tons per day = 30 truckloads per day).

10.2.4 Cost

The unit cost for this technology is approximately $110 per ton, which makes it uncompetitive in urban areas where the hauling distance to a rail transfer station serving a Subtitle D landfill is small and there are nearby sources of inexpensive fill. However, in Port Angeles, given the long haul distance to the nearest transfer station (Olympia) and lack of nearby gravel quarries, the unit cost is comparable to dig and haul (refer to cost summaries in Appendix F).

10.3 COMPLIANCE WITH THE MODEL TOXICS CONTROL ACT

The Preferred Cleanup Action meets the following minimum requirement for selection of a cleanup action under MTCA WAC 173-340-360(2)(a):

(i) **Protect Human Health and the Environment.** The Preferred Cleanup Action will protect human health and the environment in both the short-term and long-term. The Preferred Cleanup Action will permanently reduce the identified risks presently posed to human health and the environment through a combination of excavation followed by bioremediation, and monitoring of groundwater to confirm that surface waters of the Harbor are protected.

(ii) **Comply with Cleanup Standards.** The Preferred Cleanup Action is expected to comply with the CULs for groundwater and soil. A CPOC at the bulkhead is proposed for groundwater.

(iii) **Comply with Applicable State and Federal Laws.** The Preferred Cleanup Action is expected to comply with all state and federal laws and regulations as discussed in Section 10.5, below.

(iv) **Provide Compliance Monitoring.** The Preferred Cleanup Action will include compliance monitoring for soil and groundwater. Post-excavation groundwater monitoring is expected to last up to 10 years and be conducted semi-annually. A groundwater monitoring plan will be prepared following completion of the excavation activities.

The Preferred Cleanup Action also meets the other requirements for selection under MTCA WAC 173-340-360(2)(b), which includes the following:

(i) **Using Permanent Solutions to the Maximum Extent Practicable.** The Preferred Cleanup Action utilizes permanent solutions to the degree practical.

(ii) **Providing for Reasonable Restoration Time Frame.** The excavation portion of the Preferred Cleanup Action will require approximately 3 to 4 months to implement (average of 500 tons per day excavated). The time frame for post-excavation bio-treatment to achieve groundwater CULs at the CPOC is anticipated to be approximately 5 to 10 years depending on the levels of contamination that persist following excavation. The timeframe for all site soil to achieve CULs (primarily the smear zone soil left unexcavated in the Gasoline Area at concentrations less than the Site remediation levels but greater than the Site CULs) is expected to require up to 30 years, as a result of natural attenuation processes that will be monitored. However, infiltration galleries will be positioned to delivery bio-amendments to accelerate this process if it appears to require longer than 30 years.

(iii) **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 or if Ecology believes there is sufficient public interest in the Site.

Finally, because this remedy relies on a CPOC due to the impracticality of attaining CULs throughout the entire Site, this cleanup action is not considered fully permanent under WAC 173-340-360(2). The Preferred Cleanup Action complies with the following requirements for non-permanent groundwater cleanup actions under MTCA WAC 173-340-360(2)(c)(ii):

A. **Treatment or Removal of the LNAPL.** This will be permanent as all known areas of LNAPL will be excavated and removed.

B. **Groundwater Containment, Including Barriers, to Avoid Spreading of the Groundwater Plume.** This will be done by the use of ORC to create an aerobic biologically-active zone that will treat residual COCs in groundwater to the CULs prior to discharge into the Harbor.

10.4 INSTITUTIONAL CONTROLS

Following cleanup, institutional controls will need to be placed on the property deed that describe where areas of soil that remain greater than site CULs, as well as a requirement for vapor intrusion assessment for buildings built over areas of remaining contaminated soil. The environmental covenant must include the following requirements:

- A vapor intrusion assessment must be performed on any part of the property consistent with current Ecology guidance or regulation prior to the construction of buildings on-site. If the assessment indicates no soil or groundwater contamination in or near future building areas, then no further action is necessary. However, if building will occur over areas of residual groundwater or soil contamination, then a more detailed assessment of the potential vapor intrusion must be performed, which may lead to the need for mitigation.
- In areas of vapor intrusion risk, only slab-on-grade buildings without basements shall be allowed to be constructed. Prior to construction, Ecology shall review and approve any proposed engineering plans for engineered controls and/or mitigation systems (such as vapor barriers and sub-slab depressurization systems).
- Land use shall remain industrial.

10.5 SCHEDULE AND SUMMARY OF THE ESTIMATED REMEDY COSTS

A summary of the estimated cost and anticipated estimated schedule for the Preferred Cleanup Action is presented in the table below. Appendix F contains details of the cost estimate.

Activity	Cost	Schedule	Notes
1) Planning and Engineering, Engineering Design Report	$75,000	Late 2014 to mid-2015	Assumes CAP/AO for cleanup finalized by February 2015
2) Soil Excavation and Disposal	$2,800,000	Mid- to late 2015 (estimated 3 months)	Assumes removal and disposal or treatment of 24,100 tons of contaminated soil at 500 tons per day average and excavation and reuse of 20,400 tons of clean overburden

Activity	Cost	Schedule	Notes
3) Bioremediation Amendments	$423,000	2015 (main application in excavation) 2016 to 2018 (yearly applications via infiltration galleries) 2016 to 2018 (three on-site injections in downgradient benzene plume)	Assumes addition of 28,000 pounds of ORC following excavation Assumes addition of 2,000 pounds per injection event, and a total of three annual events Assumes 3x treatment of benzene plume beneath Cedar Street
4) Construction Management, Confirmation Sampling, and Reporting	$198,000	2015 (estimated 3 months)	
5) Groundwater Compliance Monitoring (assumes 10 years)	$190,000	2015 to 2025	Assumes quarterly sampling of eight wells and annual reporting for 5 years and semiannual monitoring of eight wells and annual reporting for 5 years
Construction Sub Total (Items 2–5)	$3,600,000		
Plus Taxes and 30% Contingency	$5,200,000		8.4% tax and 10% contractor markup applied to Items 2–5

10.6 APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

The Preferred Cleanup Action 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 Site.

10.6.1 Chemical-Specific Applicable or Relevant and Appropriate Requirements

The Preferred Cleanup Action is predicted to attain concentration-based CULs developed under MTCA for the COCs in applicable media at the Site. Please refer to Section 7.0 for a detailed discussion of how CULs were identified.

10.6.1.1 Sediment Management Standards (WAC 173-204)

SMS may be applicable at the Site and will be a decision made in the future as part of the Harbor-wide sediment investigation and cleanup action that is being performed by the WPAHG and Ecology.

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

The Preferred Cleanup Action will comply with Washington State Surface Water Standards that apply to stormwater discharges during remedial construction. Standards that control discharge of other pollutants to stormwater generated during construction would be applicable.

10.6.1.3 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 CULs. 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.

10.6.1.4 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.

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

Pursuant to Chapter 70.94 of the Revised Code of Washington (RCW), Washington Clean Air Act, the purpose of this regulation is to establish controls for new or modified sources emitting toxic air pollutants 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 on-site thermal desorption unit to treat soils as part of the Preferred Cleanup Action 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.

10.6.2 Location-Specific Applicable or Relevant and Appropriate Requirements

The following location-specific ARARs would apply to the Preferred Cleanup Action.

10.6.2.1 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.

10.6.2.2 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.

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

The Washington state 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 Cleanup Action will comply with the applicable substantive requirements under the City of Port Angeles' Shoreline Management Act Program.

10.6.3 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 with or are specific to the technologies that are used during the implementation of cleanup actions. The Preferred Cleanup Action will comply with the following requirements.

10.6.3.1 Washington Dangerous Waste Regulations (WAC 173-303)

These requirements potentially apply to the identification, generation, accumulation, and transport of hazardous/dangerous wastes at the Site during remediation. These standards are applicable to any soil wastes that are taken off-site for disposal with concentrations that exceed Washington Dangerous Waste criteria. Of primary concern would be benzene, which is present in some soils at relatively elevated concentrations. According to this ARAR, if benzene is present in soil at leachable concentrations that exceed 0.5 mg/L it would be classified with a D018 waste code and would need to first be either treated to levels less than this concentration or disposed of at a Subtitle C hazardous waste landfill. This ARAR will not be applicable for soils that would be thermally treated on-site.

10.6.3.2 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 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.

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

The Preferred Cleanup Action 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 1 acre, and so will require a

NPDES Stormwater Construction Permit, administered by Ecology to control discharge of pollutants from the construction activities.

10.6.3.4 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 Act (NEPA) compliance.

10.6.3.5 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 CFR 1901.120
- Occupational Safety and Health Act (OSHA)
- Washington Industrial Safety and Health Act (WISHA), WAC 296-62, WAC 296-155, and 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.

10.6.3.6 Underground Injection Well Registration

The Underground Injection Control (UIC) Program protects groundwater quality by regulating discharges to UIC wells. UIC wells are manmade structures used to discharge fluids into the subsurface. Introducing ORC may require registration with the UIC Program, especially if done using infiltration galleries. 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 ORC would meet this standard.

10.7 CONCLUSION

This FS fully complies with requirements under the 2012 AO and provides sufficient information on cleanup action alternatives to enable a cleanup action to be selected for the Site in accordance with WAC 173-340-350.

11.0 References

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K Ply Site

Remedial Investigation/ Feasibility Study

Tables

Table 2.1
Areas of Potential Concern for Reference on Figure 2.5[1,2]

Figure 2.5 Reference #	**Area of Potential Concern**
1	Historical Solvent Use and Distillation Areas
2	Green End Building
3	Panel Oiler
4	Caustic Tank Area
5	Resin Tank Area
6	Hydraulic Oil/Hot Press Area
7	Electrical Shop
8	Machine Shop
9	Room 14
10	Green Veneer Chipper Room and the East Exterior of the Green Veneer Chipper Room
11	Paper Station
12	Glue Loft
13	Forklift Shop
14	Bamford/8-foot Lathe Building
15	Equipment/Storage Building #10
16	Pipeline 8
17	Historical On-Site Underground Storage Tanks and Aboveground Storage Tanks
18	Abandoned Storm Sewer
19	Hog Fuel Pile
20	Former Log Pond
21	Port Angeles Harbor
22	Stack
23	Wood Debris Pile
24	4-foot Lathe
25	10-foot Lathe

Notes:

1. Sources for identifying the areas of potential concern include Landau Associate's 1988 *Environmental Evaluation: Peninsula Plywood Property, Port Angeles Washington* and Argus Pacific's 2012 *PenPly Mill Demolition and Abatement Project Hazardous Material Survey*.
2. Areas of Potential Concern were only identified for areas within the tentative site boundary.

Table 5.1
Water Level Elevation and Tidal Information

Monitoring Well	Elevation of TOC (ft NAVD 88)	Date	Time of Sampling (24-hour)	Depth to Water (ft)	Depth to Product (ft)	Product Thickness (ft)	Water Table Elevation (ft NAVD 88)	Approximate Tidal Elevation at Time of Sampling[1] (ft NAVD 88)	Approximate Height of Water Table above/below Tidal Level at Time of Sampling (ft)
MW-23	16.62	10/14/2013	1846	10.85	--	--	5.77	2.17	3.60
	16.62	1/28/2014	1031	10.61	--	--	6.01	7.22	-1.21
MW-8	17.89	10/14/2013	1853	12.08	--	--	5.81	2.2	3.61
	17.89	1/28/2014	1027	11.91	--	--	5.98	7.21	-1.23
PP-11[2]	15.21	10/14/2013	1833	11.26	10.22	1.04	4.85	2.12	2.73
	15.21	1/28/2014	1027	10.91	9.91	1.00	5.17	7.21	-2.04
PP-12[2]	15.21	10/14/2013	1831	11.9	10.02	1.88	4.95	2.12	2.83
	15.21	1/28/2014	1022	11.34	9.75	1.59	5.25	7.19	-1.94
PP-13	16.64	10/14/2013	1817	11.5	--	--	5.14	2.06	3.08
	16.64	1/28/2014	1123	11.27	--	--	5.37	7.26	-1.89
PP-15R	17.74	10/14/2013	1820	12.01	--	--	5.73	2.06	3.67
	17.74	1/28/2014	1120	10.91	--	--	6.83	7.23	-0.40
PP-17	16.32	10/14/2013	1829	11.69	--	--	4.63	2.12	2.51
	16.32	1/28/2014	1100	11.23	--	--	5.09	7.26	-2.17
PP-18	16.41	10/14/2013	1823	11.91	--	--	4.5	2.09	2.41
	16.41	1/28/2014	1104	11.20	--	--	5.21	7.26	-2.05
PP-19	15.64	10/14/2013	1833	11.53	--	--	4.11	2.12	1.99
	15.64	1/28/2014	1051	10.23	--	--	5.41	7.28	-1.87
PP-2[2]	15.78	10/14/2013	1822	12.49	10.26	2.23	5.23	2.09	3.14
	15.78	1/28/2014	1038	12.18	9.98	2.20	5.51	7.27	-1.76
PP-20	20.09	10/14/2013	1820	15.81	--	--	4.28	2.06	2.22
	20.09	1/28/2014	1108	14.32	--	--	5.77	7.26	-1.49
PP-21	17.62	10/14/2013	1817	13.42	--	--	4.2	2.06	2.14
	17.62	1/28/2014	1110	12.26	--	--	5.36	7.26	-1.90
PP-22	17.53	10/14/2013	1813	12.71	--	--	4.82	2.08	2.74
	17.53	1/28/2014	1116	12.31	--	--	5.22	7.23	-2.01
PP-23	16.58	10/14/2013	1830	10.31	--	--	6.27	2.12	4.15
	16.58	1/28/2014	1037	10.02	--	--	6.56	7.27	-0.71
PP-24	17.84	10/14/2013	1817	11.65	--	--	6.19	2.06	4.13
	17.84	1/28/2014	1057	11.48	--	--	6.36	7.25	-0.89
PP-25	19.86	10/14/2013	1813	13.51	--	--	6.35	2.08	4.27
	19.86	1/28/2014	1101	13.36	--	--	6.5	7.26	-0.76
PP-26	17.96	10/14/2013	1823	12.02	--	--	5.94	2.09	3.85
	17.96	1/28/2014	1117	11.52	--	--	6.44	7.23	-0.79
PP-3[2]	16.22	10/14/2013	1826	11.08	10.75	0.33	5.43	2.09	3.34
	16.22	1/28/2014	1035	11	10.5	0.50	5.66	7.27	-1.62
PP-4R	17.85	10/14/2013	1838	12.02	--	--	5.83	2.11	3.72
	17.85	1/28/2014	1114	11.33	--	--	6.52	7.26	-0.74
PP-6R	18.01	10/14/2013	1841	12.32	--	--	5.69	2.11	3.58
	18.01	1/28/2014	1110	12	--	--	6.01	7.26	-1.25
PP-7	16.36	10/14/2013	1813	10.62	--	--	5.74	2.08	3.66
	16.36	1/28/2014	1200	10.3	--	--	6.06	7.02	-0.96
PP-9	17.09	10/14/2013	1832	11.23	--	--	5.86	2.12	3.74
	17.09	1/28/2014	1042	10.96	--	--	6.13	7.24	-1.11
PZ-1	16.52	10/14/2013	1822	10.65	--	--	5.87	2.09	3.78
	16.52	1/28/2014	1051	10.15	--	--	6.37	7.28	-0.91
PZ-12	15.69	10/14/2013	1813	10.37	--	--	5.32	2.08	3.24
	15.69	1/28/2014	1021	10.26	--	--	5.43	7.19	-1.76
PZ-4	20.88	10/14/2013	1833	14.88	--	--	6	2.12	3.88
PZ-6[2]	15.45	10/14/2013	1818	9.94	9.42	0.52	5.89	2.06	3.83
	15.45	1/28/2014	1045	9.25	8.58	0.67	6.70	7.24	-0.54
PZ-7	16.11	10/14/2013	1829	10.15	--	--	5.96	2.12	3.84
	16.11	1/28/2014	1116	9.76	--	--	6.35	7.23	-0.88

Notes:

-- Not measured/not applicable.

1 Information is sourced from the National Oceanic and Atmostpheric Administration (NOAA 2012). The NAVD 88 datum is 0.42 ft above MLLW at Station 9444090 NOAA/NO8/CO-OP3.

2 The water table elevation has been corrected due to the presence of LNAPL product assuming a specific gravity of 0.87 for hydraulic oil product and a specific gravity of 0.74 for gasoline-range organics product.

Abbreviations:

ft	Feet
LNAPL	Light non-aqueous phase liquid
MLLW	Mean Lower Low Water
NAVD 88	North American Vertical Datum of 1988
TOC	Top of casing

Table 5.2
Sediment Analytical Results

		Floyd|Snider 2013 Sample Results			Ecology & Enivronment 2008 Sample Results			Sediment Management Standards (SMS)			
	Location	KSS-1	KSS-2	KSS-3	KP01	KP02	KP03	Benthic Sediment Cleanup Objective (SCO)[1]	Benthic Cleanup Screening Level (CSL)	SMS LAET	SMS 2LAET
	Sample ID	SD0001K	SD0002K	SD0003K	KP01	KP02	KP03				
	Sample Date	07/09/2013	07/09/2013	07/09/2013	6/17/2008	6/17/2008	6/17/2008				
	Sample Depth	0–10 cm	0–10 cm	0–10 cm	0–10 cm	0–10 cm	0–10 cm				
Analyte	**Units**										
Grain Size											
Gravel	%	0.59	3.45	0.15	NA	NA	NA	NA	NA	NA	NA
GS <0.98 µm	%	7.36	5.86	3.95	NA	NA	NA	NA	NA	NA	NA
GS 0.98–1.95 µm	%	3.75	2.66	1.83	NA	NA	NA	NA	NA	NA	NA
GS 1.95–3.9 µm	%	3.79	2.75	1.86	NA	NA	NA	NA	NA	NA	NA
GS 1000–2000 µm	%	1.61	3.86	0.78	NA	NA	NA	NA	NA	NA	NA
GS 125–250 µm	%	6.67	10.97	23.32	NA	NA	NA	NA	NA	NA	NA
GS 15.6–31.3 µm	%	18.4	8.69	4.9	NA	NA	NA	NA	NA	NA	NA
GS 250–500 µm	%	2.2	5.51	3.7	NA	NA	NA	NA	NA	NA	NA
GS 3.9–7.8 µm	%	5.5	3.65	2.36	NA	NA	NA	NA	NA	NA	NA
GS 31.3–62.5 µm	%	17.47	9.47	11.68	NA	NA	NA	NA	NA	NA	NA
GS 500–1000 µm	%	1.42	4.24	1.19	NA	NA	NA	NA	NA	NA	NA
GS 62.5–125 µm	%	19.51	22.71	35.97	NA	NA	NA	NA	NA	NA	NA
GS 7.8–15.6 µm	%	9.11	4.75	3.04	NA	NA	NA	NA	NA	NA	NA
Conventionals											
Ammonia (total as nitrogen)	mg/kg	20.2	8.9	12.1	NA	NA	NA	NA	NA	NA	NA
Moisture	%	51.9	53.1	38.4	NA	NA	NA	NA	NA	NA	NA
Sulfide	mg/kg	650	940	1290	725	758	125	NA	NA	NA	NA
Total Organic Carbon	%	4.39	7.64	1.98	4.21	5.31	1.8	NA	NA	NA	NA
Total Solids	%	45.8	46.8	59.1	44.8	NA	62.3	NA	NA	NA	NA
Total Volatile Solids	%	11.3	16.6	6.73	NA	NA	NA	NA	NA	NA	NA
Metals											
Arsenic	mg/kg	9.1	8.47	4.8	8.6	9.9	3.9	57	93	57	93
Cadmium	mg/kg	1.41	0.801	0.332	1.1	1.3	0.22	5.1	6.7	5.1	6.7
Chromium	mg/kg	32.5	27.4	28.2	26	0	0	260	270	260	270
Copper	mg/kg	39.7	35.5	31.7	32	34	24	390	390	390	390
Lead	mg/kg	12.9	9.43	7.54	12	0	0	450	530	450	530
Mercury	mg/kg	0.102	0.071	0.041	0.16	0.11	0.036	0.41	0.59	0.41	0.59
Silver	mg/kg	0.169	0.095	0.07	0.12	0	0.075	6.1	6.1	6.1	6.1
Zinc	mg/kg	88 J	65.7 J	57.9 J	80	77	58	410	960	410	960
Butyltins											
Di-n-butyltin Cation	µg/kg	6.5	5 J	0.59 JQ	3.1	3.1	NA	NA	NA	NA	NA
n-Butyltin Cation	µg/kg	2.9	2.5 J	0.52 JQ	3.9	NA	NA	NA	NA	NA	NA
Tetra-n-butyltin	µg/kg	2.2 U	2.1 UJ	1.7 U	NA	NA	NA	NA	NA	NA	NA
Tri-n-butyltin Cation	µg/kg	24	13 J	1.3 JQ	40	9.3	NA	NA	NA	NA	NA
Petroleum Hydrocarbons											
Diesel-range Organics	mg/kg	47 JQ	94 JM	16 JQ	NA	NA	NA	NA	NA	NA	NA
Residual-range Organics	mg/kg	210 JQ	330 JM	120 JQ	NA	NA	NA	NA	NA	NA	NA
Total Petroleum Hydrocarbons	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Dioxins/Furans											
1,2,3,4,6,7,8-HpCDD	pg/g	417	253	40.2	350	190	29.7	NA	NA	NA	NA
1,2,3,4,6,7,8-HpCDF	pg/g	28.3	23.9	7.08	52.1	30.6	4.65	NA	NA	NA	NA
1,2,3,4,7,8,9-HpCDF	pg/g	1.77 J	1.78 J	0.343 J	2.57	1.88	0.31 U	NA	NA	NA	NA
1,2,3,4,7,8-HxCDD	pg/g	2.27 J	2.2 J	0.475 J	3.32	2.61	0.59 U	NA	NA	NA	NA
1,2,3,4,7,8-HxCDF	pg/g	2.58 J	2.88 J	0.587 J	4.42	2.57	0.59 U	NA	NA	NA	NA
1,2,3,6,7,8-HxCDD	pg/g	11.1	8.21	1.85 J	17.4	10.90	2.28	NA	NA	NA	NA
1,2,3,6,7,8-HxCDF	pg/g	1.89 J	2.18 J	0.402 J	2.71	1.99	0.49 U	NA	NA	NA	NA
1,2,3,7,8,9-HxCDD	pg/g	9.53	7.58	1.3 J	11.4	8.09	1.67	NA	NA	NA	NA
1,2,3,7,8,9-HxCDF	pg/g	0.223 J	0.234 J	0.094 U	0.271 U	0.26 U	0.05 U	NA	NA	NA	NA

Table 5.2
Sediment Analytical Results

		Floyd|Snider 2013 Sample Results			Ecology & Enivronment 2008 Sample Results			Sediment Management Standards (SMS)			
	Location	**KSS-1**	**KSS-2**	**KSS-3**	**KP01**	**KP02**	**KP03**	**Benthic Sediment Cleanup Objective (SCO)[1]**	**Benthic Cleanup Screening Level (CSL)**	**SMS LAET**	**SMS 2LAET**
	Sample ID	**SD0001K**	**SD0002K**	**SD0003K**	**KP01**	**KP02**	**KP03**				
	Sample Date	**07/09/2013**	**07/09/2013**	**07/09/2013**	**6/17/2008**	**6/17/2008**	**6/17/2008**				
	Sample Depth	**0–10 cm**	**0–10 cm**	**0–10 cm**	**0–10 cm**	**0–10 cm**	**0–10 cm**				
Analyte	**Units**										
Dioxins/Furans (cont.)											
1,2,3,7,8-PeCDD	pg/g	1.86 J	2.85 J	0.54 J	3.48	2.88	0.71	NA	NA	NA	NA
1,2,3,7,8-PeCDF	pg/g	1.58 J	3.13 J	0.393 U	2.27	2.00	0.50	NA	NA	NA	NA
2,3,4,6,7,8-HxCDF	pg/g	1.75 J	2.16 J	0.343 J	2.69	2.20	0.54	NA	NA	NA	NA
2,3,4,7,8-PeCDF	pg/g	2.42 J	5.12	0.591 J	3.63	3.18	0.82	NA	NA	NA	NA
2,3,7,8-TCDD	pg/g	0.67 J	1.15	0.341 J	1.28	1.02	0.43	NA	NA	NA	NA
2,3,7,8-TCDF	pg/g	2.36	6.16	0.598 J	4.04	3.60	0.86	NA	NA	NA	NA
Total HpCDD	pg/g	2650	1440	146	1410	726	93.4	NA	NA	NA	NA
Total HpCDF	pg/g	108	105	27.7	166	116	14.0	NA	NA	NA	NA
Total HxCDD	pg/g	225	164	23.8	229	131	24.8	NA	NA	NA	NA
Total HxCDF	pg/g	53	46.4	12.2	82.1	49.5	11.1	NA	NA	NA	NA
Total OCDD	pg/g	3020	2110	340	2,700	2500	226	NA	NA	NA	NA
Total OCDF	pg/g	67.2	153	32.4	123	204	11.4	NA	NA	NA	NA
Total PCDD	pg/g	48.3	68.4	11	103	63.7	15.0	NA	NA	NA	NA
Total PCDF	pg/g	43.9	74.6	10.6	63.8	49.4	12.7	NA	NA	NA	NA
Total TCDD	pg/g	50.4	72.3	15.2	114	72.5	16.5	NA	NA	NA	NA
Total TCDF	pg/g	59.5	153	18.7	86	89.5	19.4	NA	NA	NA	NA
Summed Dioxin/Furan TEQ[2,3]	pg/g	11.9 J	12.3 J	2.21 J	15.4	11.1	2.34	NA	NA	NA	NA
Summed Dioxin/Furan TEQ with One-half of the Detection Limit[2,4]	pg/g	11.9 J	12.3 J	2.2 J	15.4	11.2	2.43	NA	NA	NA	NA
Polychlorinated Biphenyls (PCBs)											
Dichlorobiphenyls	pg/g	333	467	85.4	NA	NA	NA	NA	NA	NA	NA
Heptachlorobiphenyls	pg/g	2360	2950	669	NA	NA	NA	NA	NA	NA	NA
Hexachlorobiphenyls	pg/g	4610	4980	1240	NA	NA	NA	NA	NA	NA	NA
Monochlorobiphenyls	pg/g	102	357	26.5	NA	NA	NA	NA	NA	NA	NA
Nonachlorobiphenyls	pg/g	123	135	35.7	NA	NA	NA	NA	NA	NA	NA
Octachlorobiphenyls	pg/g	722	947	216	NA	NA	NA	NA	NA	NA	NA
Pentachlorobiphenyls	pg/g	4500	4070	1080	NA	NA	NA	NA	NA	NA	NA
Tetrachlorobiphenyls	pg/g	2690	3280	540	NA	NA	NA	NA	NA	NA	NA
Trichlorobiphenyls	pg/g	1240	2520	273	NA	NA	NA	NA	NA	NA	NA
PCB-001	pg/g	26.2	59.9	4.91 J	NA	NA	NA	NA	NA	NA	NA
PCB-002	pg/g	36.2	164	14.2 J	NA	NA	NA	NA	NA	NA	NA
PCB-003	pg/g	39.7	133	7.35	NA	NA	NA	NA	NA	NA	NA
PCB-004	pg/g	28	60.5	6.75 J	NA	NA	NA	NA	NA	NA	NA
PCB-005	pg/g	3.33 J	7.29 J	0.944 U	NA	NA	NA	NA	NA	NA	NA
PCB-006	pg/g	28.9	35.3	4.26 J	NA	NA	NA	NA	NA	NA	NA
PCB-007	pg/g	8.26 J	9.83 J	0.884 J	NA	NA	NA	NA	NA	NA	NA
PCB-008	pg/g	99.8	134	20.1	NA	NA	NA	NA	NA	NA	NA
PCB-009	pg/g	9.85 J	12.1	1.11 J	NA	NA	NA	NA	NA	NA	NA
PCB-010	pg/g	1.84 J	2.91 J	0.8 U	NA	NA	NA	NA	NA	NA	NA
PCB-011	pg/g	52.5	63	31.7	NA	NA	NA	NA	NA	NA	NA
PCB-012/013	pg/g	30.1	61.2	4.63 J	NA	NA	NA	NA	NA	NA	NA
PCB-014	pg/g	2.21 U	6.06 J	0.854 U	NA	NA	NA	NA	NA	NA	NA
PCB-015	pg/g	70.3	74.7	16	NA	NA	NA	NA	NA	NA	NA
PCB-016	pg/g	51.7	143	10.5	NA	NA	NA	NA	NA	NA	NA
PCB-017	pg/g	68.7	174	13	NA	NA	NA	NA	NA	NA	NA
PCB-018/030	pg/g	134	325	29.7	NA	NA	NA	NA	NA	NA	NA
PCB-019	pg/g	10.9 J	41.7	2.82	NA	NA	NA	NA	NA	NA	NA

Table 5.2
Sediment Analytical Results

		Floyd|Snider 2013 Sample Results			Ecology & Enivronment 2008 Sample Results			Sediment Management Standards (SMS)			
Location		**KSS-1**	**KSS-2**	**KSS-3**	**KP01**	**KP02**	**KP03**	**Benthic Sediment Cleanup Objective (SCO)[1]**	**Benthic Cleanup Screening Level (CSL)**	**SMS LAET**	**SMS 2LAET**
Sample ID		**SD0001K**	**SD0002K**	**SD0003K**	**KP01**	**KP02**	**KP03**				
Sample Date		**07/09/2013**	**07/09/2013**	**07/09/2013**	**6/17/2008**	**6/17/2008**	**6/17/2008**				
Sample Depth		**0–10 cm**	**0–10 cm**	**0–10 cm**	**0–10 cm**	**0–10 cm**	**0–10 cm**				
Analyte	**Units**										
Polychlorinated Biphenyls (PCBs) (cont.)											
PCB-020/028	pg/g	288	546	67.2	NA	NA	NA	NA	NA	NA	NA
PCB-021/033	pg/g	131	283	28.5	NA	NA	NA	NA	NA	NA	NA
PCB-022	pg/g	87.6	180	21	NA	NA	NA	NA	NA	NA	NA
PCB-023	pg/g	0.501 U	4.72 U	0.101 U	NA	NA	NA	NA	NA	NA	NA
PCB-024	pg/g	2.08 J	7.35 J	0.309 J	NA	NA	NA	NA	NA	NA	NA
PCB-025	pg/g	25	36.3	4.63	NA	NA	NA	NA	NA	NA	NA
PCB-026/029	pg/g	56.1	92.3	10.1	NA	NA	NA	NA	NA	NA	NA
PCB-027	pg/g	11.5 J	30.9	2.15	NA	NA	NA	NA	NA	NA	NA
PCB-031	pg/g	231	407	48.9	NA	NA	NA	NA	NA	NA	NA
PCB-032	pg/g	46.8	115	9.09	NA	NA	NA	NA	NA	NA	NA
PCB-034	pg/g	1.68 J	4.66 U	0.262 J	NA	NA	NA	NA	NA	NA	NA
PCB-035	pg/g	13.2 J	18.4	2.96	NA	NA	NA	NA	NA	NA	NA
PCB-036	pg/g	2.46 U	4.71 U	0.794 J	NA	NA	NA	NA	NA	NA	NA
PCB-037	pg/g	78.7	121	19.4	NA	NA	NA	NA	NA	NA	NA
PCB-038	pg/g	1 U	4.81 U	0.554 J	NA	NA	NA	NA	NA	NA	NA
PCB-039	pg/g	2.92 J	4.72 U	0.683 J	NA	NA	NA	NA	NA	NA	NA
PCB-040/041/071	pg/g	126	199	25.2	NA	NA	NA	NA	NA	NA	NA
PCB-042	pg/g	69.7	95.3	12.4	NA	NA	NA	NA	NA	NA	NA
PCB-043	pg/g	14.2 J	26.5	1.98	NA	NA	NA	NA	NA	NA	NA
PCB-044/047/065	pg/g	301	354	56.5	NA	NA	NA	NA	NA	NA	NA
PCB-045/051	pg/g	38.9	72.1	6.92	NA	NA	NA	NA	NA	NA	NA
PCB-046	pg/g	14.1 J	25.9	2.46	NA	NA	NA	NA	NA	NA	NA
PCB-048	pg/g	55	87.9	9.7	NA	NA	NA	NA	NA	NA	NA
PCB-049/069	pg/g	222	245	37	NA	NA	NA	NA	NA	NA	NA
PCB-050/053	pg/g	34.9	55	6.05	NA	NA	NA	NA	NA	NA	NA
PCB-052	pg/g	444	509	83.5	NA	NA	NA	NA	NA	NA	NA
PCB-054	pg/g	0.681 J	0.991 J	0.128 J	NA	NA	NA	NA	NA	NA	NA
PCB-055	pg/g	11.6 J	29.8	1.54 J	NA	NA	NA	NA	NA	NA	NA
PCB-056	pg/g	133	157	29.3	NA	NA	NA	NA	NA	NA	NA
PCB-057	pg/g	1.45 J	2.52 J	0.374 J	NA	NA	NA	NA	NA	NA	NA
PCB-058	pg/g	1.26 U	1.72 U	0.194 U	NA	NA	NA	NA	NA	NA	NA
PCB-059/062/075	pg/g	26.6	39.3	4.65	NA	NA	NA	NA	NA	NA	NA
PCB-060	pg/g	77.3	110	17.9	NA	NA	NA	NA	NA	NA	NA
PCB-061/070/074/076	pg/g	623	701	140	NA	NA	NA	NA	NA	NA	NA
PCB-063	pg/g	12.5 J	14.1	2.58	NA	NA	NA	NA	NA	NA	NA
PCB-064	pg/g	121	160	21.3	NA	NA	NA	NA	NA	NA	NA
PCB-066	pg/g	303	328	66.5	NA	NA	NA	NA	NA	NA	NA
PCB-067	pg/g	9.56 J	13	2.03	NA	NA	NA	NA	NA	NA	NA
PCB-068	pg/g	2.25 J	2.01 J	0.637 J	NA	NA	NA	NA	NA	NA	NA
PCB-072	pg/g	4.32 J	3.1 J	0.716 J	NA	NA	NA	NA	NA	NA	NA
PCB-073	pg/g	0.186 U	0.338 U	0.0463 U	NA	NA	NA	NA	NA	NA	NA
PCB-077	pg/g	34.8	38.6	8.67	NA	NA	NA	NA	NA	NA	NA
PCB-078	pg/g	1.37 U	1.77 U	0.205 U	NA	NA	NA	NA	NA	NA	NA
PCB-079	pg/g	8.19 J	8.04 J	1.87	NA	NA	NA	NA	NA	NA	NA
PCB-080	pg/g	1.19 U	1.55 U	0.179 U	NA	NA	NA	NA	NA	NA	NA
PCB-081	pg/g	1.64 U	2.2 U	0.392 U	NA	NA	NA	NA	NA	NA	NA
PCB-082	pg/g	76.7	81.9	20.3	NA	NA	NA	NA	NA	NA	NA
PCB-083/099	pg/g	414	347	92.8	NA	NA	NA	NA	NA	NA	NA

Table 5.2
Sediment Analytical Results

		Floyd|Snider 2013 Sample Results			Ecology & Enivronment 2008 Sample Results			Sediment Management Standards (SMS)			
	Location	**KSS-1**	**KSS-2**	**KSS-3**	**KP01**	**KP02**	**KP03**	**Benthic Sediment Cleanup Objective (SCO)[1]**	**Benthic Cleanup Screening Level (CSL)**	**SMS LAET**	**SMS 2LAET**
	Sample ID	**SD0001K**	**SD0002K**	**SD0003K**	**KP01**	**KP02**	**KP03**				
	Sample Date	**07/09/2013**	**07/09/2013**	**07/09/2013**	**6/17/2008**	**6/17/2008**	**6/17/2008**				
	Sample Depth	**0–10 cm**	**0–10 cm**	**0–10 cm**	**0–10 cm**	**0–10 cm**	**0–10 cm**				
Analyte	**Units**										
Polychlorinated Biphenyls (PCBs) (cont.)											
PCB-084	pg/g	152	144	36	NA	NA	NA	NA	NA	NA	NA
PCB-085/116/117	pg/g	112	102	28.4	NA	NA	NA	NA	NA	NA	NA
PCB-086/087/097/108/119/125	pg/g	439	408	105	NA	NA	NA	NA	NA	NA	NA
PCB-088/091	pg/g	77.1	72.7	18	NA	NA	NA	NA	NA	NA	NA
PCB-089	pg/g	5.51 J	6.97 J	1.31 J	NA	NA	NA	NA	NA	NA	NA
PCB-090/101/113	pg/g	746	662	175	NA	NA	NA	NA	NA	NA	NA
PCB-092	pg/g	130	115	29.3	NA	NA	NA	NA	NA	NA	NA
PCB-093/095/098/100/102	pg/g	542	501	123	NA	NA	NA	NA	NA	NA	NA
PCB-094	pg/g	2.79 J	2.27 J	0.479 J	NA	NA	NA	NA	NA	NA	NA
PCB-096	pg/g	3.6 J	3.52 J	0.627 J	NA	NA	NA	NA	NA	NA	NA
PCB-103	pg/g	7.52 J	4.91 J	1.26 J	NA	NA	NA	NA	NA	NA	NA
PCB-104	pg/g	0.139 U	0.295 U	0.0463 U	NA	NA	NA	NA	NA	NA	NA
PCB-105	pg/g	258	241	66.3	NA	NA	NA	NA	NA	NA	NA
PCB-106	pg/g	0.832 U	1.05 U	0.951 U	NA	NA	NA	NA	NA	NA	NA
PCB-107/124	pg/g	25.8	24.7	6.67	NA	NA	NA	NA	NA	NA	NA
PCB-109	pg/g	46.4	40	13	NA	NA	NA	NA	NA	NA	NA
PCB-110/115	pg/g	756	676	191	NA	NA	NA	NA	NA	NA	NA
PCB-111	pg/g	1.06 U	0.551 U	0.147 U	NA	NA	NA	NA	NA	NA	NA
PCB-112	pg/g	1.03 U	0.405 U	0.143 U	NA	NA	NA	NA	NA	NA	NA
PCB-114	pg/g	10.5 J	12	3.1	NA	NA	NA	NA	NA	NA	NA
PCB-118	pg/g	668	607	167	NA	NA	NA	NA	NA	NA	NA
PCB-120	pg/g	1.72 J	0.772 J	0.533 J	NA	NA	NA	NA	NA	NA	NA
PCB-121	pg/g	1.04 U	0.447 J	0.142 U	NA	NA	NA	NA	NA	NA	NA
PCB-122	pg/g	7.48 J	7.01 J	2.15	NA	NA	NA	NA	NA	NA	NA
PCB-123	pg/g	11.3 J	10.5	2.89	NA	NA	NA	NA	NA	NA	NA
PCB-126	pg/g	2.09 J	1.89 J	1.08 U	NA	NA	NA	NA	NA	NA	NA
PCB-127	pg/g	0.967 U	1.21 U	1.04 U	NA	NA	NA	NA	NA	NA	NA
PCB-128/166	pg/g	158	211	41.7	NA	NA	NA	NA	NA	NA	NA
PCB-129/138/160/163	pg/g	1020	1100	298	NA	NA	NA	NA	NA	NA	NA
PCB-130	pg/g	61.5	66.8	16.1	NA	NA	NA	NA	NA	NA	NA
PCB-131	pg/g	12 J	14.6	2.97	NA	NA	NA	NA	NA	NA	NA
PCB-132	pg/g	316	344	84.1	NA	NA	NA	NA	NA	NA	NA
PCB-133	pg/g	14.9 J	14.9	3.5	NA	NA	NA	NA	NA	NA	NA
PCB-134/143	pg/g	53.1	56.1	11.7	NA	NA	NA	NA	NA	NA	NA
PCB-135/151/154	pg/g	344	337	82	NA	NA	NA	NA	NA	NA	NA
PCB-136	pg/g	110	111	25.6	NA	NA	NA	NA	NA	NA	NA
PCB-137	pg/g	40.5	51.5	10.7	NA	NA	NA	NA	NA	NA	NA
PCB-139/140	pg/g	15.4 J	17	3.65	NA	NA	NA	NA	NA	NA	NA
PCB-141	pg/g	185	245	51.5	NA	NA	NA	NA	NA	NA	NA
PCB-142	pg/g	1.35 U	2.13 U	1.66 U	NA	NA	NA	NA	NA	NA	NA
PCB-144	pg/g	50	52.9	12.4	NA	NA	NA	NA	NA	NA	NA
PCB-145	pg/g	0.576 J	0.091 U	0.097 U	NA	NA	NA	NA	NA	NA	NA
PCB-146	pg/g	150	168	39.4	NA	NA	NA	NA	NA	NA	NA
PCB-147/149	pg/g	818	794	207	NA	NA	NA	NA	NA	NA	NA
PCB-148	pg/g	1.27 J	1.08 J	0.238 J	NA	NA	NA	NA	NA	NA	NA
PCB-150	pg/g	1.33 J	1.37 J	0.318 J	NA	NA	NA	NA	NA	NA	NA
PCB-152	pg/g	0.678 J	0.89 U	0.151 U	NA	NA	NA	NA	NA	NA	NA
PCB-153/168	pg/g	923	1010	252	NA	NA	NA	NA	NA	NA	NA

Table 5.2
Sediment Analytical Results

		Floyd|Snider 2013 Sample Results			Ecology & Enivronment 2008 Sample Results			Sediment Management Standards (SMS)			
Location		KSS-1	KSS-2	KSS-3	KP01	KP02	KP03	Benthic Sediment Cleanup Objective (SCO)[1]	Benthic Cleanup Screening Level (CSL)	SMS LAET	SMS 2LAET
Sample ID		SD0001K	SD0002K	SD0003K	KP01	KP02	KP03				
Sample Date		07/09/2013	07/09/2013	07/09/2013	6/17/2008	6/17/2008	6/17/2008				
Sample Depth		0–10 cm	0–10 cm	0–10 cm	0–10 cm	0–10 cm	0–10 cm				
Analyte	**Units**										
Polychlorinated Biphenyls (PCBs) (cont.)											
PCB-155	pg/g	0.194 J	0.246 J	0.07 J	NA	NA	NA	NA	NA	NA	NA
PCB-156/157	pg/g	104	134	31.4	NA	NA	NA	NA	NA	NA	NA
PCB-158	pg/g	105	117	28.7	NA	NA	NA	NA	NA	NA	NA
PCB-159	pg/g	14.6 J	15.5	3.96	NA	NA	NA	NA	NA	NA	NA
PCB-161	pg/g	0.986 U	1.54 U	1.22 U	NA	NA	NA	NA	NA	NA	NA
PCB-162	pg/g	3.68 J	2.95 J	1.31 U	NA	NA	NA	NA	NA	NA	NA
PCB-164	pg/g	67.2	74.8	19.9	NA	NA	NA	NA	NA	NA	NA
PCB-165	pg/g	1.11 U	1.77 U	1.36 U	NA	NA	NA	NA	NA	NA	NA
PCB-167	pg/g	37.3	44.1	11.1	NA	NA	NA	NA	NA	NA	NA
PCB-169	pg/g	1.34 U	1.97 U	1.48 U	NA	NA	NA	NA	NA	NA	NA
PCB-170	pg/g	282	309	83.5	NA	NA	NA	NA	NA	NA	NA
PCB-171/173	pg/g	91.5	107	24.9	NA	NA	NA	NA	NA	NA	NA
PCB-172	pg/g	49.7	63.1	14.7	NA	NA	NA	NA	NA	NA	NA
PCB-174	pg/g	267	332	76.9	NA	NA	NA	NA	NA	NA	NA
PCB-175	pg/g	12.9 J	17.6	4.03	NA	NA	NA	NA	NA	NA	NA
PCB-176	pg/g	38.4	48.2	10.1	NA	NA	NA	NA	NA	NA	NA
PCB-177	pg/g	171	188	47.7	NA	NA	NA	NA	NA	NA	NA
PCB-178	pg/g	60.3	70.8	17.2	NA	NA	NA	NA	NA	NA	NA
PCB-179	pg/g	121	148	31.6	NA	NA	NA	NA	NA	NA	NA
PCB-180/193	pg/g	603	763	182	NA	NA	NA	NA	NA	NA	NA
PCB-181	pg/g	1.87 J	3.4 J	0.705 J	NA	NA	NA	NA	NA	NA	NA
PCB-182	pg/g	2.55 J	0.163 U	0.575 J	NA	NA	NA	NA	NA	NA	NA
PCB-183/185	pg/g	212	269	58	NA	NA	NA	NA	NA	NA	NA
PCB-184	pg/g	0.423 U	0.545 U	0.088 J	NA	NA	NA	NA	NA	NA	NA
PCB-186	pg/g	0.223 U	0.132 U	0.0463 U	NA	NA	NA	NA	NA	NA	NA
PCB-187	pg/g	370	530	94.5	NA	NA	NA	NA	NA	NA	NA
PCB-188	pg/g	0.723 U	0.42 J	0.188 J	NA	NA	NA	NA	NA	NA	NA
PCB-189	pg/g	10.2 J	12.4	3.1	NA	NA	NA	NA	NA	NA	NA
PCB-190	pg/g	55.9	68.1	15.8	NA	NA	NA	NA	NA	NA	NA
PCB-191	pg/g	14.1 J	19	3.71	NA	NA	NA	NA	NA	NA	NA
PCB-192	pg/g	0.273 J	0.164 U	0.0479 U	NA	NA	NA	NA	NA	NA	NA
PCB-194	pg/g	166	199	49	NA	NA	NA	NA	NA	NA	NA
PCB-195	pg/g	62.3	83.3	20.4	NA	NA	NA	NA	NA	NA	NA
PCB-196	pg/g	89.4	120	25	NA	NA	NA	NA	NA	NA	NA
PCB-197/200	pg/g	27.2	41.8	10.9 J	NA	NA	NA	NA	NA	NA	NA
PCB-198/199	pg/g	189	252	53.8	NA	NA	NA	NA	NA	NA	NA
PCB-201	pg/g	24.1	34.4	8.23 J	NA	NA	NA	NA	NA	NA	NA
PCB-202	pg/g	36.5	49.9	11.7	NA	NA	NA	NA	NA	NA	NA
PCB-203	pg/g	120	155	34.5	NA	NA	NA	NA	NA	NA	NA
PCB-204	pg/g	0.154 U	0.227 U	0.0463 U	NA	NA	NA	NA	NA	NA	NA
PCB-205	pg/g	7.21 J	12	2.19	NA	NA	NA	NA	NA	NA	NA
PCB-206	pg/g	86.2 J	93.4 J	23.4	NA	NA	NA	NA	NA	NA	NA
PCB-207	pg/g	9.89 J	14.7 J	3.39	NA	NA	NA	NA	NA	NA	NA
PCB-208	pg/g	26.7	26.6	8.95	NA	NA	NA	NA	NA	NA	NA
PCB-209	pg/g	57.7	28	17.6	NA	NA	NA	NA	NA	NA	NA
PCBs (Total, All Forms)	pg/g	16,700	19,700	4,180	NA	NA	NA	NA	NA	NA	NA

Table 5.2
Sediment Analytical Results

		Floyd|Snider 2013 Sample Results			Ecology & Enivronment 2008 Sample Results			Sediment Management Standards (SMS)			
	Location	KSS-1	KSS-2	KSS-3	KP01	KP02	KP03	Benthic Sediment Cleanup Objective (SCO)[1]	Benthic Cleanup Screening Level (CSL)	SMS LAET	SMS 2LAET
	Sample ID	SD0001K	SD0002K	SD0003K	KP01	KP02	KP03				
	Sample Date	07/09/2013	07/09/2013	07/09/2013	6/17/2008	6/17/2008	6/17/2008				
	Sample Depth	0–10 cm	0–10 cm	0–10 cm	0–10 cm	0–10 cm	0–10 cm				
Analyte	**Units**										
Polychlorinated Biphenyls (PCBs) (cont.)											
PCBs (Total, All Forms) - Organic Carbon (OC) Normalized	mg/kg-OC	--[5]	--[5]	0.211	NA	NA	NA	12	65	NA	NA
Summed PCB Congener TEQ One-half of the Detection Limit	pg/g	0.266 J	0.255 J	0.087	NA	NA	NA	NA	NA	NA	NA
Semivolatile Organic Compounds (SVOCs)											
1,2,4-Trichlorobenzene	µg/kg	11 U	11 U	8.5 U	9 U	9 U	9 U	NA	NA	31	5
1,2-Dichlorobenzene	µg/kg	11 U	11 U	8.5 U	7.8 U	7.8 U	7.8 U	NA	NA	35	50
1,3-Dichlorobenzene	µg/kg	11 U	11 U	8.5 U	7.4 U	7.4 U	7.4 U	NA	NA	170	NA
1,4-Dichlorobenzene	µg/kg	11 U	11 U	8.5 U	7.3 U	7.3 U	7.3 U	NA	NA	NA	NA
2,4,5-Trichlorophenol	µg/kg	11 U	11 U	8.5 U	44 U	45 U	44 U	NA	NA	NA	NA
2,4,6-Trichlorophenol	µg/kg	11 U	11 U	8.5 U	46 U	46 U	46 U	NA	NA	NA	NA
2,4-Dichlorophenol	µg/kg	11 U	11 U	8.5 U	NA	NA	NA	NA	NA	29	29
2,4-Dimethylphenol	µg/kg	55 U	15 JQ	43 U	15 U	15 U	15 U	29	29	NA	NA
2,4-Dinitrophenol	µg/kg	220 U	220 U	200 U	110 U	110 U	110 U	NA	NA	NA	NA
2,4-Dinitrotoluene	µg/kg	11 U	11 U	8.5 U	38 U	38 U	38 U	NA	NA	NA	NA
2,6-Dinitrotoluene	µg/kg	11 U	11 U	8.5 U	53 U	54 U	53 U	NA	NA	NA	NA
2-Chloronaphthalene	µg/kg	11 U	11 U	8.5 U	NA	NA	NA	NA	NA	NA	NA
2-Chlorophenol	µg/kg	11 U	5 JQ	8.5 U	7.4 U	7.4 U	7.4 U	NA	NA	NA	NA
2-Methylphenol	µg/kg	11 U	61	8.5 U	NA	NA	NA	63	63	63	63
2-Nitroaniline	µg/kg	22 U	22 U	17 U	41 U	42 U	41 U	NA	NA	NA	NA
2-Nitrophenol	µg/kg	11 U	11 U	8.5 U	39 U	40 U	39 U	NA	NA	NA	NA
3,3'-Dichlorobenzidine	µg/kg	110 U	110 U	85 U	48 U	49 U	48 U	NA	NA	NA	NA
3-Nitroaniline	µg/kg	22 U	22 U	17 U	41 U	42 U	41 U	NA	NA	NA	NA
4,6-Dinitro-o-cresol	µg/kg	110 U	110 U	85 U	83 U	84 U	83 U	NA	NA	NA	NA
4-Bromophenyl phenyl ether	µg/kg	11 U	11 U	8.5 U	9.5 U	9.6 U	9.5 U	NA	NA	NA	NA
4-Chloro-3-methylphenol	µg/kg	11 U	11 U	8.5 U	8.3 U	8.4 U	8.3 U	NA	NA	NA	NA
4-Chloroaniline	µg/kg	11 U	11 U	10 U	99 U	100 U	34 U	NA	NA	NA	NA
4-Chlorophenyl phenyl ether	µg/kg	11 U	11 U	8.5 U	8.3 U	8.4 U	8.3 U	NA	NA	NA	NA
4-Methylphenol	µg/kg	30	120	5.1 JQ	NA	NA	NA	670	670	670	670
4-Nitroaniline	µg/kg	22 U	22 U	17 U	51 U	51 U	51 U	NA	NA	NA	NA
4-Nitrophenol	µg/kg	110 U	110 U	85 U	65 U	66 U	65 U	NA	NA	NA	NA
Benzoic acid	µg/kg	220 U	150 JQ	200 U	110 U	110 U	110 U	650	650	650	650
Benzyl alcohol	µg/kg	22 U	22 U	17 U	14 U	14 U	14 U	57	73	57	73
bis(2-chloroethoxy)methane	µg/kg	11 U	11 U	8.5 U	8.8 U	8.8 U	8.8 U	NA	NA	NA	NA
bis(2-chloroethyl)ether	µg/kg	11 U	11 U	8.5 U	7.4 U	7.4 U	7.4 U	NA	NA	NA	NA
bis(2-chloroisopropyl)ether	µg/kg	11 U	11 U	8.5 U	NA	NA	NA	NA	NA	NA	NA
bis(2-ethylhexyl)phthalate	µg/kg	37 JQ	44 JQ	17 JQ	48	45	33	NA	NA	1,300	3,100
Butyl benzyl phthalate	µg/kg	11 U	11 U	8.5 U	11 U	11 U	11 U	NA	NA	63	900
Diethylphthalate	µg/kg	11 U	11 U	8.5 U	19 U	16 U	16 U	NA	NA	200	1,200
Dimethyl phthalate	µg/kg	11 U	19	19	7.7 U	7.7 U	7.7 U	NA	NA	71	160
Di-n-butyl phthalate	µg/kg	22 U	7.2 JQ	17 U	NA	NA	NA	NA	NA	1,400	5,100
Di-n-octyl phthalate	µg/kg	11 U	11 U	8.5 U	8.2 U	8.3 U	8.2 U	NA	NA	6,200	6,200
Hexachlorobenzene	µg/kg	11 U	11 U	8.5 U	7.9 U	8 U	7.9 U	NA	NA	22	70
Hexachlorobutadiene	µg/kg	11 U	11 U	8.5 U	8 U	8.1 U	8 U	NA	NA	11	120
Hexachlorocyclopentadiene	µg/kg	55 U	54 U	50 U	43 U	44 U	44 U	NA	NA	NA	NA
Hexachloroethane	µg/kg	11 U	11 U	8.5 U	7.1 U	7.2 U	7.2 U	NA	NA	NA	NA
Isophorone	µg/kg	11 U	11 U	8.5 U	8.2 U	8.2 U	8.2 U	NA	NA	NA	NA
Nitrobenzene	µg/kg	11 U	11 U	8.5 U	8.7 U	8.8 U	8.7 U	NA	NA	NA	NA

Table 5.2
Sediment Analytical Results

		Floyd|Snider 2013 Sample Results			Ecology & Enivronment 2008 Sample Results			Sediment Management Standards (SMS)			
Location		KSS-1	KSS-2	KSS-3	KP01	KP02	KP03	Benthic Sediment Cleanup Objective (SCO)[1]	Benthic Cleanup Screening Level (CSL)	SMS LAET	SMS 2LAET
Sample ID		SD0001K	SD0002K	SD0003K	KP01	KP02	KP03				
Sample Date		07/09/2013	07/09/2013	07/09/2013	6/17/2008	6/17/2008	6/17/2008				
Sample Depth		0–10 cm	0–10 cm	0–10 cm	0–10 cm	0–10 cm	0–10 cm				
Analyte	**Units**										
Semivolatile Organic Compounds (SVOCs) (cont.)											
N-Nitroso-di-n-propylamine	µg/kg	11 U	11 U	8.5 U	35 U	36 U	35 U	NA	NA	NA	NA
N-Nitrosodiphenylamine	µg/kg	11 U	11 U	8.5 U	8.6 U	8.6 U	8.6 U	NA	NA	28	40
Pentachlorophenol	µg/kg	110 U	110 U	85 U	47 U	47 U	47 U	360	690	360	690
Phenol	µg/kg	28 JQ	340	12 JQ	44	20	14 U	420	1,200	420	1,200
SVOCs - OC Normalized											
1,2,4-Trichlorobenzene	mg/kg-OC	--[5]	--[5]	0.43	0.21	0.17	0.50	0.81	1.8	NA	NA
1,2-Dichlorobenzene	mg/kg-OC	--[5]	--[5]	0.43	0.19	0.15	0.43	2.3	2.3	NA	NA
1,3-Dichlorobenzene	mg/kg-OC	--[5]	--[5]	0.43	0.18	0.14	0.41	NA	NA	110	110
1,4-Dichlorobenzene	mg/kg-OC	--[5]	--[5]	0.43	0.17	0.14	0.41	3.1	9.0	NA	NA
bis(2-ethylhexyl)phthalate	mg/kg-OC	--[5]	--[5]	0.86 JQ	1.14	0.85	1.83	47	78	NA	NA
Butyl benzyl phthalate	mg/kg-OC	--[5]	--[5]	0.43 U	0.26 U	0.21 U	0.61 U	4.9	64	NA	NA
Diethylphthalate	mg/kg-OC	--[5]	--[5]	0.43 U	0.45 U	0.30 U	0.89 U	61	110	NA	NA
Dimethyl phthalate	mg/kg-OC	--[5]	--[5]	0.96	0.18 U	0.15 U	0.43 U	53	53	NA	NA
Di-n-butyl phthalate	mg/kg-OC	--[5]	--[5]	0.86 U	NA	NA	NA	220	1,700	NA	NA
Di-n-octyl phthalate	mg/kg-OC	--[5]	--[5]	0.43 U	0.19 U	0.16 U	0.46 U	58	4,500	NA	NA
Hexachlorobenzene	mg/kg-OC	--[5]	--[5]	0.43 U	0.19 U	0.15 U	0.44 U	0.38	2.3	NA	NA
Hexachlorobutadiene	mg/kg-OC	--[5]	--[5]	0.43 U	0.19 U	0.15 U	0.44 U	3.9	6.2	NA	NA
N-Nitrosodiphenylamine	mg/kg-OC	--[5]	--[5]	0.43	0.20 U	0.16 U	0.48 U	11	11	NA	NA
Carcinogenic Polycyclic Aromatic Hydrocarbons (cPAHs)											
Benzo(a)anthracene	µg/kg	500	440	110	110	100	45	NA	NA	1,300	1,600
Benzo(a)pyrene	µg/kg	390	400	97	160	98	46	NA	NA	1,600	1,600
Benzo(b)fluoranthene	µg/kg	820	740	140	220	130	54	NA	NA	NA	NA
Benzo(k)fluoranthene	µg/kg	310	270	53	180	100	43	NA	NA	NA	NA
Total Benzofluoranthenes	µg/kg	1,130	1,010	190	400	230	97	NA	NA	NA	NA
Chrysene	µg/kg	**1,400**	930	160	330	180	60	NA	NA	1,400	2,800
Dibenzo(a,h)anthracene	µg/kg	49	47	11	25	11	8.5	NA	NA	230	230
Indeno(1,2,3-cd)pyrene	µg/kg	260	240	59	82	56	14	NA	NA	600	690
Total cPAHs	µg/kg	3,700	3,100	630	1,100	680	270	NA	NA	NA	NA
Summed cPAH TEQ with One-half of the Detection Limit[6]	µg/kg	600	580	140	230	140	63	NA	NA	NA	NA
Carcinogenic Polycyclic Aromatic Hydrocarbons (cPAHs) – OC Normalized											
Benzo(a)anthracene	mg/kg-OC	--[5]	--[5]	5.6	2.6	1.9	2.5	110	270	NA	NA
Benzo(a)pyrene	mg/kg-OC	--[5]	--[5]	4.9	3.8	1.8	2.6	99	210	NA	NA
Benzo(b)fluoranthene	mg/kg-OC	--[5]	--[5]	7.1	5.2	2.4	3.0	NA	NA	NA	NA
Benzo(k)fluoranthene	mg/kg-OC	--[5]	--[5]	2.7	4.3	1.9	2.4	NA	NA	NA	NA
Total Benzofluoranthenes	mg/kg-OC	--[5]	--[5]	9.6	9.5	4.3	5.4	230	450	NA	NA
Chrysene	mg/kg-OC	--[5]	--[5]	8.1	7.8	3.4	3.3	110	460	NA	NA
Dibenzo(a,h)anthracene	mg/kg-OC	--[5]	--[5]	0.56	0.6	0.2	0.5	12	33	NA	NA
Indeno(1,2,3-cd)pyrene	mg/kg-OC	--[5]	--[5]	3.0	1.9	1.1	0.8	34	88	NA	NA
Other Polycyclic Aromatic Hydrocarbons (PAHs)											
2-Methylnaphthalene	µg/kg	26	68	4.8	NA	NA	NA	NA	NA	670	670
Acenaphthene	µg/kg	38	75	8.3	10	8.2	8.1	NA	NA	500	500
Acenaphthylene	µg/kg	59	430	6.8	27	17	8.6	NA	NA	1,300	1,300
Anthracene	µg/kg	190	300	51	88	45	24	NA	NA	960	960
Benzo(g,h,i)perylene	µg/kg	210	210	56	79	64	15	NA	NA	670	720
Dibenzofuran	µg/kg	50	180	5.1	7.5	7.5	7.5	NA	NA	540	540
Fluoranthene	µg/kg	**1,900**	**2,600**	310	340	240	120	NA	NA	1,700	2,500

Table 5.2
Sediment Analytical Results

		Floyd|Snider 2013 Sample Results			Ecology & Enivronment 2008 Sample Results			Sediment Management Standards (SMS)			
Location		KSS-1	KSS-2	KSS-3	KP01	KP02	KP03	Benthic Sediment Cleanup Objective (SCO)[1]	Benthic Cleanup Screening Level (CSL)	SMS LAET	SMS 2LAET
Sample ID		SD0001K	SD0002K	SD0003K	KP01	KP02	KP03				
Sample Date		07/09/2013	07/09/2013	07/09/2013	6/17/2008	6/17/2008	6/17/2008				
Sample Depth		0–10 cm	0–10 cm	0–10 cm	0–10 cm	0–10 cm	0–10 cm				
Analyte	**Units**										
Other Polycyclic Aromatic Hydrocarbons (PAHs) (cont.)											
Fluorene	µg/kg	72	140	14	18	11	12	NA	NA	540	540
Naphthalene	µg/kg	100	1,100	10	10	8.6	12	NA	NA	2,100	2,100
Phenanthrene	µg/kg	540	1,200	150	120	84	90	NA	NA	1,500	1,500
Pyrene	µg/kg	1,600	2,100	300	370	220	120	NA	NA	2,600	3,300
Total LPAH	µg/kg	1,000	3,200	240	260	170	140	NA	NA	5,200	5,200
Total HPAH	µg/kg	7,400	8,000	1,300	1,900	1,200	530	NA	NA	12,000	17,000
Other Polycyclic Aromatic Hydrocarbons (PAHs) – OC Normalized											
2-Methylnaphthalene	mg/kg-OC	--[5]	--[5]	0.24	NA	NA	NA	38	64	NA	NA
Acenaphthene	mg/kg-OC	--[5]	--[5]	0.42	0.24	0.15	0.45	16	57	NA	NA
Acenaphthylene	mg/kg-OC	--[5]	--[5]	0.34	0.64	0.32	0.48	66	66	NA	NA
Anthracene	mg/kg-OC	--[5]	--[5]	2.6	2.1	0.8	1.3	220	1,200	NA	NA
Benzo(g,h,i)perylene	mg/kg-OC	--[5]	--[5]	2.83	1.88	1.21	0.83	31	78	NA	NA
Dibenzofuran	mg/kg-OC	--[5]	--[5]	0.26	0.18	0.14	0.42	15	58	NA	NA
Fluoranthene	mg/kg-OC	--[5]	--[5]	16	8	5	7	160	1,200	NA	NA
Fluorene	mg/kg-OC	--[5]	--[5]	0.71	0.43	0.21	0.67	23	79	NA	NA
Naphthalene	mg/kg-OC	--[5]	--[5]	0.51	0.24	0.16	0.67	99	170	NA	NA
Phenanthrene	mg/kg-OC	--[5]	--[5]	7.6	2.9	1.6	5.0	100	480	NA	NA
Pyrene	mg/kg-OC	--[5]	--[5]	15	9	4	7	1,000	1,400	NA	NA
Total LPAH	mg/kg-OC	--[5]	--[5]	12	6.2	3.1	7.9	370	780	NA	NA
Total HPAH	mg/kg-OC	--[5]	--[5]	66	45	23	29	960	5,300	NA	NA

Notes:

Bold The detected concentration exceeds the LAET and 2LAET.

1 Analytical results compared againist benthic CSL and SCO only. A data comparison for the Preliminary Human Health CSLs and SCOs is included in the Western Port Angeles Harbor RI/FS.

2 World Health Organization 2005 Toxic Equivalency Factors used for calculation of dioxin/furan TEQ (Van den Berg et al. 2006).

3 Calculated using detected dioxin/furan concentrations.

4 Calculated using detected dioxin/furan concentrations plus one-half the detection limit for dioxins/furans that were not detected.

5 Total organic carbon was outside of the recommended range for OC-normalization (0.5–4%) in this sample.

6 Calculated using detected cPAH concentrations plus one-half the detection limit for cPAHs that were not detected.

Abbreviations:

2LAET	Second lowest apparent effects threshold
cm	Centimeter
cPAH	Carcinogenic polycyclic aromatic hydrocarbon
Ecology	Washington State Department of Ecology
GS	Grain size
HpCDD	Heptachlorodibenzo-p-dioxin
HpCDF	Heptachlorodibenzofuran
HxCDD	Hexachlorodibenzo-p-dioxin
HxCDF	Hexachlorodibenzofuran
LAET	Lowest apparent effects threshold
MDL	Method detection limit
µg/kg	Micrograms per kilogram
µm	Micrometer
mg/kg	Milligrams per kilogram
NA	Not available
OC	Organic carbon
OCDD	Octachlorodibenzo-p-dioxin
OCDF	Octachlorodibenzofuran
PeCDD	Pentachlorodibenzo-p-dioxin
PeCDF	Pentachlorodibenzofuran
pg/g	Picograms per gram
RI/FS	Remedial Investigation/Feasibility Study
TCDD	Tetrachlorodibenzo-p-dioxin
TCDF	Tetrachlorodibenzofuran
TEQ	Total equivalancy quotient

Qualifiers:

J	Concentration is estimated.
JM	Concentration is estimated due to poor match to standard.
JQ	Concentration is an estimated value reported below the associated quantitation limit but greater than the MDL.
U	Analyte is not detected at the associated reporting limit.
UJ	Analyte is not detected at the associated reporting limit, which is an estimate.

Table 8.1
Preliminary Screening of Technologies for Soil and Groundwater

Remedial Technology	Applicable Media	COCs Addressed	General Technology Benefits	General Technology Limitations	Consideration of Site Physical Conditions and RAOs[1]	Technology Retained for or Rejected from Further Evaluation
No Action	• Soil • Groundwater	• None; there is no treatment or removal of COCs associated with this technology. This is included in the technology screening for comparative purposes.	• No cost to implement. • No long-term monitoring cost. • Does not cause substantial impacts to site operations.	• Does not reduce or remove chemical concentrations. • Does not protect human health and the environment. • Does not meet cleanup goals in a reasonable restoration time frame. • Technology does not have proven success at sites with similar conditions.	• Not impacted by physical conditions at the Site. • Does not contribute to achievement of RAOs. • Does not address source control or long-term monitoring goals as a standalone technology.	The no action technology does not address any of the Site COCs or achieve RAOs. ○ **Rejected** for remediation of soil. ○ **Rejected** for remediation of groundwater.
Institutional Controls	• Soil • Groundwater	• Applicable to all site soil and groundwater COCs.	• Low cost to implement. • Protective of direct contact pathway through controls or long-term property restrictions.	• Does not reduce or remove chemical concentrations. • Limits future site operations through restrictive covenants or administrative measures. • As a standalone technology, it is not protective of any exposure pathways.	• Can be implemented in combination with other technologies to address site maintenance and redevelopment activities. • Contributes to achievement of RAOs when used in combination with other technologies. • Can be implemented to ensure that future buildings will be constructed to protect from vapor intrusion. • Not limited by site physical conditions. • Can be implemented and maintained in an active facility with minimal disturbances. • Does not address source control or long-term monitoring goals as a standalone technology.	ICs are applicable to all COCs and all media, achieve RAOs when used in combination with other technologies, and can be implemented given site conditions. ○ **Retained** for soil and groundwater in conjunction with other technologies.
Surface Capping	• Soil	• Applicable to all site soil COCs.	• Contains contaminated soil below the ground surface with surface controls or barrier caps. • Provides barrier from contact pathways. • Technology has proven successful at sites with similar conditions.	• Contaminants remain in place and are not removed or destroyed. • Surface cap or barrier maintenance required in perpetuity.	• Not limited by site physical conditions. • Contributes to achievement of RAOs. • Could be designed to address source control.	Surface capping is applicable to all COCs in soil, achieves RAOs when used in combination with other technologies, and can be implemented given site conditions. ○ **Retained** for vadose soil in conjunction with other technologies.
Solidification and Stabilization	• Soil	• Not applicable for remediation of LNAPL or high concentration TPH-impacted soils.	• Technology reduces the mobility of soil contamination through physical or chemical immobilization. • Controls contaminant migration and/or leaching to groundwater.	• Requires long-term groundwater compliance monitoring to ensure the immobilization of contaminants. • Feasibility of implementation decreases with depth below ground surface. • Contaminants remain in place and are immobilized, but not removed (solidification).	• Contributes to achievement of RAOs when used in combination with other technologies. • Does not adequately address source control or long-term monitoring goals as a standalone technology. • Residual LNAPL in soil contamination is an obstacle to effectiveness.	Solidification and stabilization is not applicable to all COCs in soil and is difficult to implement in deeper soils. ○ **Rejected** for remediation of soil.

Table 8.1
Preliminary Screening of Technologies for Soil and Groundwater

Remedial Technology	Applicable Media	COCs Addressed	General Technology Benefits	General Technology Limitations	Consideration of Site Physical Conditions and RAOs[1]	Technology Retained for or Rejected from Further Evaluation
Bioventing/ Bioremediation	• Soil (bioventing and bioremediation) • Groundwater (bioremediation)	• Applicable to remediation of TPH.	• Accelerates the natural biodegradation process. • Can use microorganisms already present in the subsurface.	• May require several rounds of injections of microorganisms, nutrients, or oxygen. • Does not treat inorganics. • Bioventing is limited to dry soil. • May be limited in breaking down the heavier TPH components. • The restoration time frame is unknown and can be long.	• May contribute to the achievement of RAOs when used in combination with other technologies. • Does not address source control or long-term monitoring goals as a standalone technology.	Although demonstrated effective for petroleum hydrocarbons, bioventing is limited to dry soils and can result in increased benzene vapor accumulation. Bioremediation is a presumptive, versatile remediation approach for TPH in groundwater and can be combined with other technologies to achieve RAOs. ○ **Rejected** for remediation of soil. ○ **Retained** for remediation of groundwater in conjunction with other technologies.
Source Removal by Excavation and Landfill Disposal	• Soil • LNAPL • Groundwater (indirectly)	• Applicable to all site soil and groundwater COCs.	• Results in immediate, permanent removal of COCs from the Site, reducing mass in a short time frame. • Effectively removes all soil COCs in excavation area. • Removal of soil contamination in areas of impacted groundwater removes the ongoing source of contaminants to groundwater. • Reduces long-term monitoring and maintenance. • Technology has proven successful at sites with similar conditions.	• Remediation of groundwater is an indirect byproduct of mass removal only. • Can be expensive to implement because of landfill disposal costs. • May require shoring for stability if open cuts cannot be made. • Dewatering may be required for excavations extending below the groundwater table, which generates liquid waste streams that would require treatment and disposal.	• Contributes to achievement of RAOs when used in combination with other technologies. • Site location would require substantial trucking or barging to landfill, with cost and greenhouse gas considerations.	Source removal addresses all COCs, is implementable given site conditions, and achieves RAOs when combined with other remedial technologies. ○ **Retained** for remediation of soil. ○ **Retained** for remediation of groundwater in conjunction with other technologies.

Table 8.1
Preliminary Screening of Technologies for Soil and Groundwater

Remedial Technology	Applicable Media	COCs Addressed	General Technology Benefits	General Technology Limitations	Consideration of Site Physical Conditions and RAOs[1]	Technology Retained for or Rejected from Further Evaluation
Source Removal by Excavation and On-Site Treatment by Biopiles	• Soil • LNAPL • Groundwater (indirectly)	• Applicable to all site soil and groundwater COCs.	• Results in immediate, permanent removal of COCs from the Site, reducing mass in a short time frame. • Effectively removes all soil COCs in excavation area. • Removal of soil contamination in areas of impacted groundwater removes the ongoing source of contaminants to groundwater. • Reduces long-term monitoring and maintenance.	• Long (multi-year) time frame required. • May require shoring for stability if open cuts cannot be made. • Dewatering may be required for excavations extending below the groundwater table, which generates liquid waste streams that would require treatment and disposal. • Requires a large amount of open space.	• Contributes to achievement of RAOs when used in combination with other technologies. • Space and time limitations are large obstacles. • Redundant backfill needed during treatment period.	Source removal addresses all COCs and is implementable given site conditions; however, the lack of space and the long time frame needed for remediation make on-site treatment by biopiles impractical. ○ **Rejected** for remediation of soil. ○ **Rejected** for remediation of groundwater.
Source Removal by Excavation and On-Site Treatment by Incineration or Thermal Desorption	• Soil • LNAPL • Groundwater (indirectly)	• Applicable to all site soil and groundwater COCs.	• Results in immediate, permanent removal of COCs from the Site, reducing mass in a short time frame. • Effectively removes all soil COCs in excavation area. • Removal of soil contamination in areas of impacted groundwater removes the ongoing source of contaminants to groundwater. • Reduces long-term monitoring and maintenance. • Technology has proven successful at sites with similar conditions.	• Can be expensive and/or slow to implement. • Requires large loads of on-site power. • Requires substantial surface infrastructure for operation.	• Contributes to achievement of RAOs when used in combination with other technologies. • No transportation to landfill necessary and may eliminate need for imported backfill, both of which lower greenhouse gas emissions.	Source removal addresses all COCs, is implementable given site conditions, and achieves RAOs when combined with other remedial technologies. ○ **Retained** for remediation of soil. ○ **Retained** for remediation of groundwater in conjunction with other technologies.
Soil Vapor Extraction	• Vadose soil • Groundwater (in conjunction with air sparging)	• Applicable to the volatile fraction of TPH contamination. • Not applicable to the heavier fraction of TPH contamination.	• Can be implemented with limited disturbance to surface activities. • Effective for groundwater. • System can be easily turned on and off to optimize performance and cost.	• Limited to treatment of vadose zone soil and volatile contaminants. • Relatively expensive to install and maintain. • Does not address groundwater contamination for site COCs.	• Does not address contamination in the saturated zone. • Does not contribute to achievement of RAOs when used in combination with other remedial technologies. • Does not address source control or long-term monitoring goals as a standalone technology.	Soil vapor extraction is limited in applicability to vadose zone volatile contamination. ○ **Retained** for remediation of groundwater in conjunction with air sparging. ○ **Rejected** for remediation of soil.

Table 8.1
Preliminary Screening of Technologies for Soil and Groundwater

Remedial Technology	Applicable Media	COCs Addressed	General Technology Benefits	General Technology Limitations	Consideration of Site Physical Conditions and RAOs[1]	Technology Retained for or Rejected from Further Evaluation
Chemical Oxidation	• Soil • Groundwater	• Applicable to TPH contamination.	• Technology reduces contaminant concentrations and mass in place. • Potentially lower cost associated with implementation than landfill disposal.	• Effectiveness limited by subsurface conditions and site heterogeneity as injected solutions can follow preferential pathways. • Requires multiple rounds of injection. • Contaminant rebound may be observed when source concentrations and volume are elevated and insufficient source treatment has occurred. • Success depends on matching the oxidant and in situ delivery system to contaminant concentrations and site conditions. • Oxidants used in technology can be corrosive and explosive.	• May contribute to achievement of RAOs when used in combination with other remedial technologies.	Proven technology for benzene and other TPH COCs has demonstrated high treatment efficiencies. Success depends on matching the oxidant and in situ delivery system to COC loading, soil oxidant demand, and the Site conditions. ○ **Retained** for remediation of soil. ○ **Retained** for remediation of groundwater.
Soil Flushing	• Soil	• Applicable to TPH contamination.	• Can be implemented with minimal disturbance to surface activities.	• Requires injection of large volumes of water and surfactant to release soil contamination into groundwater. • High risk associated with capturing all downgradient groundwater/surfactant to insure contaminants are not mobilized, then transported downgradient. • Technology is expensive to implement due to requirement for groundwater capture and treatment of water.	• High risk associated with the ability to capture groundwater downgradient near the shoreline. • Contributes to achievement of RAOs when used in combination with other technologies.	The soil flushing technology has not been proven effective at sites with similar conditions, and has high risk associated with implementation. ○ **Rejected** for remediation of soil.
Thermal Treatment	• Soil • LNAPL • Groundwater	• Applicable to TPH contamination.	• Can be implemented in a short time frame. • Treats both soil and groundwater contamination simultaneously. • No long-term maintenance required.	• High cost associated with implementation. • Requires large loads of on-site power. • Requires substantial infrastructure for operation.	• Technology not limited by site physical conditions, and can be implemented in coordination with future use conditions. • Contributes to achievement of RAOs when used in combination with other technologies.	Thermal treatment would address all COCs and meet RAOs in conjunction with other technologies; however, it is primarily cost effective for deeper and more recalcitrant contamination. ○ **Rejected** for remediation of soil. ○ **Rejected** for remediation of groundwater.
Monitored Natural Attenuation	• Groundwater	• Applicable to TPH contamination.	• Technology has proven successful at sites with similar conditions.	• Long-term monitoring and reporting required. • Does not control chemical migration.	• Is limited by site physical conditions, and the short distance between contamination and the shoreline. • Would contribute to achievement of RAOs when used in combination with other remedial technologies. • Does not address source control as a standalone technology.	Monitored natural attenuation is applicable to all groundwater COCs and would contribute to the achievement of RAOs when used in combination with other technologies. ○ **Retained** for remediation of groundwater in conjunction with other technologies.

Table 8.1
Preliminary Screening of Technologies for Soil and Groundwater

Remedial Technology	Applicable Media	COCs Addressed	General Technology Benefits	General Technology Limitations	Consideration of Site Physical Conditions and RAOs[1]	Technology Retained for or Rejected from Further Evaluation
Permeable Reactive Barrier Wall	• Groundwater	• Not demonstrated to be applicable for TPH contamination.	• Passively treats contaminated groundwater as it passes through the reactive barrier area. • Can be straightforward to implement, except at significant depths. • Is relatively feasible to implement at shallow depths and does not cause significant disruption to site operations.	• A PRB wall can become "clogged" by migration of fines in groundwater and can be costly to maintain. • Depending on the concentrations in groundwater, the PRB wall may require replacement once the reaction capacity of the material in the wall is reached or the wall pores become clogged.	• There is limited space between the shoreline and TPH contamination for installation. • The PRB would be installed in a tidally influenced area, and may be affected by saltwater chemistry.	PRB does not have proven success with TPH-contaminated sites with similar conditions, and has limited applicability given physical conditions. ○ **Rejected** for remediation of groundwater.
Low Permeability Barrier Wall	• Groundwater	• Applicable to all site COCs.	• Contains soil and groundwater contaminants and restricts continued migration of contaminated groundwater.	• May impact future site operations. • Requires hydraulic control (pumping) inside the barrier wall to maintain an inward gradient of groundwater in perpetuity. • Does not address contamination that has already migrated past the contained area.	• May contribute to achievement of RAOs when used in combination with other remedial technologies. • Lack of confining layer would necessitate large volume of groundwater recovery for hydraulic control. • Widespread nature of groundwater contamination makes containment impractical.	Due to the widespread nature of contamination and lack of confining layer, containment is impractical. Continued dissolution from remaining source areas also makes partial containment ineffective. ○ **Rejected** for remediation of groundwater.
Pump and Treat	• Groundwater	• Applicable to all site COCs.	• Removes dissolved-phase contaminants from groundwater. • Typically causes minimal impact to site operations.	• Unlikely to fully restore groundwater quality. • Does not treat soil source contamination and groundwater is subject to rebound from residual source. • High groundwater pumping rates may be required resulting in high volumes of groundwater for treatment and disposal. • Significant cost associated with treatment and discharge of treated waste stream. • Long-term operation and maintenance required for extraction system in perpetuity.	• Pumping wells would have to be installed along the shoreline, in a tidally influenced area that would result in excessive water volumes requiring treatment and disposal in perpetuity. • May contribute to achievement of RAOs when used in combination with other remedial technologies.	Pump and treat has historically been shown to be ineffective at treating similar sites. Given the Site conditions, concentrations of COCs, and long restoration time frame, pump and treat is impractical. ○ **Rejected** for remediation of groundwater.

Table 8.1
Preliminary Screening of Technologies for Soil and Groundwater

Remedial Technology	Applicable Media	COCs Addressed	General Technology Benefits	General Technology Limitations	Consideration of Site Physical Conditions and RAOs[1]	Technology Retained for or Rejected from Further Evaluation
Air Sparging	• Groundwater	• Applicable to TPH contamination.	• Flushed volatiles rise to the surface for extraction. • Air sparging is a proven technology for GRO and BTEX.	• Although air sparging is a proven technology for BTEX and GRO, the effectiveness for DRO treatment is not well documented. • Would likely require soil vapor extraction system to capture stripped volatiles.	• Success depends on soil heterogeneity and other site-specific factors. • Contributes to achievement of RAOs when used in combination with other remedial technologies. • Does not address source control or long-term monitoring goals as a standalone technology.	Air sparging would not be effective on a site-wide basis; however, it could be used as a point of compliance treatment. ○ **Retained** for remediation of groundwater as point of compliance treatment.
Dual-Phase Extraction	• Soil • Groundwater • LNAPL	• Applicable to all site COCs.	• Removes contamination from vadose zone soil and shallow groundwater. • Technology is moderate in cost to implement. • Technology is capable of treating source soils together with groundwater at shallow depth.	• Implementation results in extraction of contaminated groundwater that requires treatment prior to disposal. • Cost of treatment and disposal of extracted water can be significant. • Technology typically has high maintenance costs. • Depresses groundwater table and introduces oxygen.	• Primarily used for free product areas. • Not practical due to large size of TPH plume. • Does not address source control or long-term monitoring goals as a standalone technology.	Dual-phase extraction is not practical for a large plume, depresses the groundwater table while introducing oxygen, and is primarily used in free product areas. ○ **Rejected** for remediation of soil. ○ **Rejected** for remediation of groundwater. ○ Rejected for remediation of LNAPL.
Passive Product Recovery	• LNAPL	• Applicable to hydraulic oil and gasoline LNAPL.	• Efficient method of recovering product. • Does not alter existing groundwater gradient.	• Product recovery rate is slow because it relies on existing gradients. • Capture area can be limited depending on method.	• Limited recovery rate and area would be consistent with trace accumulations of gasoline LNAPL.	Passive recovery methods, including use of bailers and product recovery inserts, would be effective in meeting the RAO in a limited area of the Site. ○ **Retained** for the gasoline LNAPL area at PZ-6. ○ **Rejected** for the hydraulic oil LNAPL area.
Active Product Recovery	• LNAPL	• Applicable to hydraulic oil and gasoline LNAPL.	• More aggressive rate of recovery. • Capable of influencing a large area.	• Requires groundwater recovery, treatment, and disposal, and active operation and maintenance. • Not necessarily effective for viscous fluids over short restoration time frame.	• Active product recovery was implemented at the Site and shown not to be effective in recovering sufficient hydraulic oil LNAPL.	Active recovery methods are not expected to attain the RAO. ○ Rejected for remediation of LNAPL.

Note:

[1] RAOs refer to the Remedial Action Objectives and additional RI/FS remedial action considerations discussed in Section 7.0.

Abbreviations:

BTEX	Benzene, toluene, ethylbenzene, and xylenes
COC	Contaminant of concern
DRO	Diesel-range organics
IC	Institutional Control
GRO	Gasoline-range organics
LNAPL	Light non-aqueous phase liquid
PRB	Permeable reactive barrier
RAO	Remedial Action Objective
Site	K Ply Site
TPH	Total petroleum hydrocarbons

Table 9.1
Summary of Remedial Alternative Components[1]

RAO or Minor Cleanup Area	Summary of Remedial Approach to Address RAO or Minor Cleanup Area			
	Alternative 1	**Alternative 2**	**Alternative 3**	**Alternative 4**
RAO 1. Prevent COCs in groundwater from discharging to surface water at concentrations greater than CULs protective of surface water.	Air Sparge Curtain at Bulkhead (smear zone soil). Excavate vadose hotspot soil near bulkhead to: • 30 mg/kg GRO • 2,000 mg/kg ORO	Chemical oxidation of groundwater to attain at point of compliance: • 51 µg/L benzene • 800 µg/L GRO • 500 µg/L ORO Chemical oxidation of soil in Gasoline Area smear zone to: • 30 mg/kg GRO • 0.3 mg/kg benzene • 2,000 mg/kg ORO Capping of Vadose Soil. Contingent enhanced bioremediation.	Excavation of soil from Hydraulic Oil Area to Bulkhead including both vadose and smear zone soil to achieve site CULs: • 30 mg/kg GRO • 0.3 mg/kg benzene • 2,000 mg/kg ORO Excavation of upgradient Gasoline Area soil to achieve: 1) CULs in the vadose zone: • 30 mg/kg GRO • 0.3 mg/kg benzene • 2,000 mg/kg DRO 2) Remediation Levels in the Smear Zone: • 3,000 mg/kg GRO • 10 mg/kg benzene Follow on enhanced bioremediation in the excavation areas and for the benzene plume under Cedar Street	Full excavation vadose and smear zone soils in both the Gasoline and Hydraulic Oil Areas: • 30 mg/kg GRO • 0.3 mg/kg benzene • 2,000 mg/kg ORO Enhanced bioremediation in excavation areas and for the benzene plume under Cedar Street
RAO 2. Remove, to the extent practicable, LNAPL accumulations on the water table.	Excavate LNAPL in within Hydraulic Oil Area. Product recovery inserts in PZ-6 and other wells with measureable gasoline LNAPL.	Excavate LNAPL within Hydraulic Oil Area. Product recovery inserts in PZ-6 and other wells with measureable gasoline LNAPL.	Excavate LNAPL in Hydraulic Oil Area. Excavate gasoline LNAPL in PZ-6. Both addressed by the excavation discussed for RAO 1.	Excavate LNAPL in Hydraulic Oil Area. Excavate gasoline LNAPL in PZ-6. Both addressed by the excavation discussed for RAO 1.
RAO 3. Prevent inhalation exposure in potential future buildings with underlying soil contamination to indoor air with volatile COC concentrations greater than CULs.	Institutional controls for evaluation and mitigation of the indoor air pathway prior to redevelopment.	Institutional controls for evaluation and mitigation of the indoor air pathway prior to redevelopment.	Institutional controls for evaluation of the indoor air pathway prior to any site redevelopment. Depending on the results of the evaluation, mitigation may be required.	Institutional controls for evaluation of the indoor air pathway prior to any site redevelopment. Depending on the results of the evaluation, mitigation may be required.
Other Soil Areas: • Stack Area • PCP Area • Log Pond Area • Hog Fuel Storage Area	Institutional controls at PCP Area and Log Pond Fill Area. Excavation of soil at Hog Fuel Storage Area and Stack Area.	Institutional controls at PCP Area and Log Pond Fill Area. Excavation of soil at Hog Fuel Storage Area and Stack Area.	Excavate PCP Area. Institutional controls at Log Pond Fill Area. Excavation of soil at Hog Fuel Storage Area and Stack Area. Excavation of dioxin-contaminated surface soil and reuse on-site for backfill	Excavate PCP Area. Institutional controls at Log Pond Fill Area. Excavation of soil at Hog Fuel Storage Area and Stack Area. Excavation of dioxin-contaminated surface soil and reuse on-site for backfill

Note:

1 "Excavation" assumes lower cost of on-site treatment and re-use or off-site disposal.

Abbreviations:

COC	Contaminant of concern
CUL	Cleanup level
GRO	Gasoline-range organics
LNAPL	Light non-aqueous phase liquid
µg/L	Micrograms per liter
mg/kg	Milligrams per kilogram
NA	Not applicable
ORO	Oil-range organics
PCP	Pentachlorophenol
RAO	Remedial Action Objective

Table 9.2
Estimated Soil Excavation Volumes[1]

Major Cleanup Areas

Alternative	Excavation Area	Contaminated Soil				Overburden			
		SF	Thickness (ft)	CY	Tons[2]	SF	Thickness (ft)	CY	Tons[2]
Alternative 1	Full Smear and Vadose Zone LNAPL, Hydraulic Oil LNAPL Area[3]	12,782	8	3,787	5,681	12,782	4	1,894	2,651
	Partial Smear Zone ORO and GRO[4], at Bulkhead	3,664	4	543	869	3,664	8	1,086	1,520
	Vadose Zone GRO[5], at Bulkhead	424	4	63	88	424	4	63	88
	Total	**--**	**--**	**4,393**	**6,637**	**--**	**--**	**3,042**	**4,259**
Alternative 2	Hydraulic Oil LNAPL Area[3]	12,782	8	3,787	5,681	12,782	4	1,894	2,651
	Total	**12,782**	**8**	**3,787**	**5,681**	**12,782**	**4**	**1,894**	**2,651**
Alternative 3	Hydraulic Oil LNAPL Area[3]	12,782	8	3,787	5,681	12,782	4	1,894	2,651
	Smear Zone ORO and GRO Downgradient of LNAPL Area to Bulkhead[4]	23,839	4	3,532	5,651	21,861	8	6,477	9,068
	Vadose Soil ORO and GRO Downgradient of LNAPL Area to Bulkhead[5]	1,978	4	293	410	1,978	4	293	410
	Smear Zone GRO under Loading Dock Concrete Pad[4]	24,451	4	3,622	5,796	4,104	8	1,216	1,702
	Vadose Zone GRO under Loading Dock Concrete Pad[5]	20,347	4	3,014	4,220	20,347	4	3,014	4,220
	Smear Zone >3,000 ppm between LNAPL Area and Loading Dock Area	8,100	4	1,200	1,920	8,100	8	2,400	3,360
	Shallow Soil, PCP Area	360	4	53	75	--	--	--	--
	Loading Dock Concrete Pad Overburden[6]	--	--	--	--	20,347	5	3,768	5,275
	Total	**--**	**--**	**15,502**	**23,752**	**--**	**--**	**19,062**	**26,687**
Alternative 4	Hydraulic Oil LNAPL Area[3]	12,782	8	3,787	5,681	12,782	4	1,894	2,651
	GRO and ORO in Smear Zone[4]	105,401	4	15,615	24,984	86,759	8	25,706	35,989
	GRO and ORO in Vadose Zone[5]	18,642	4	2,762	3,866	18,282	4	2,708	3,792
	Shallow Soil, PCP Area	360	4	53	75	--	--	--	--
	Loading Dock Concrete Pad Overburden[6]	--	--	--	--	33,703	5	6,241	8,738
	Total	**--**	**--**	**22,217**	**34,606**	**--**	**--**	**36,550**	**51,170**

Minor Cleanup Areas

Alternative	Excavation Area	Contaminated				Overburden			
		SF	Thickness (ft)	CY	Tons	SF	Thickness (ft)	CY	Tons
Alternatives 1 through 4	Surface Soil, Stack Area	15,740	2	1,166	1,632	--	--	--	--
	Smear, Hog Fuel Pile Area K-92	670	4	99	159	670	8	199	278
	Shallow Soil, Hog Fuel Pile Area KT-11	706	4	105	167	--	--	--	--

Notes:

-- Not applicable.

1 Estimated volumes are approximate, based on the available data indicating the extent of soil contamination and LNAPL.

2 Estimated tonnages are based on an assumption of 1.4 tons per CY for vadose zone soil and 1.6 tons per CY for smear zone soil.

3 LNAPL contamination assumed present beginning at approximately 4 feet bgs in vadose zone soils and extending to 12 feet bgs; refer to Figure 5.6 for aerial extent of hydraulic oil LNAPL area.

4 Smear zone soils include contaminated soil from approximately 8 to 12 feet bgs; includes both GRO and ORO and GRO/DRO comingled. Refer to Figures 5.6 through 5.8.

5 Vadose zone soils include contaminated soil beginning at approximately 4 feet bgs and extending to 8 feet bgs; includes both GRO and GRO commingled with ORO. Refer to Figures 5.6 through 5.8.

6 Includes the above-grade backfill under the concrete pad. The concrete pad itself is not included in the estimate.

Abbreviations:

bgs	Below ground surface
CY	Cubic yards
DRO	Diesel-range organics
ft	Feet
GRO	Gasoline-range organics
LNAPL	Light non-aqueous phase liquid
ORO	Oil-range organics
PCP	Pentachlorophenol
SF	Square feet

Table 9.3
Alternatives Evaluation

Alternative	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Alternative Summary Description	Alternative 1 consists of limited excavation to remove hydraulic oil LNAPL and soil contamination near the bulkhead, installation of product recovery inserts for passive gasoline product recovery, installation of an air sparge curtain to attain cleanup levels at the bulkhead conditional point of compliance, institutional controls to address the direct contact pathway and potential future vapor inhalation pathway, and groundwater compliance monitoring.	Alternative 2 includes in situ chemical oxidation (ISCO) to treat soil and groundwater contaminated with GRO, DRO, ORO, and BTEX, followed by enhanced bioremediation as needed to attain the groundwater cleanup levels at the conditional point of compliance. Compliance monitoring of groundwater would be conducted. Hydraulic oil LNAPL would be excavated and disposed of off-site. Areas where vadose zone soils would be left in place would be capped, and institutional controls would be placed to address the direct contact pathway and potential future vapor inhalation pathway.	Alternative 3 consists of excavation of vadose and smear zone soil within the Hydraulic Oil and Gasoline Areas, excavation in the PCP Area, excavation of hydraulic oil LNAPL and gasoline LNAPL within these areas, treatment of groundwater with enhanced bioremediation agents, compliance monitoring of groundwater, and institutional controls in areas where soil remains on-site at levels greater than cleanup levels, and a requirement to conduct an evaluation of vapor intrusion prior to any building construction.	Alternative 4 consists of excavation of the entire area of contaminated soil within the Hydraulic Oil and Gasoline Areas, excavation of the PCP Area, excavation of hydraulic oil LNAPL and gasoline LNAPL within these areas, treatment of groundwater with enhanced bioremediation agents, compliance monitoring of groundwater, and institutional controls in areas where soil remains on-site at levels greater than cleanup levels and a requirement to conduct an evaluation of vapor intrusion prior to any building construction.
Consideration of Public Concerns • Whether the community has concerns • Degree to which the alternative addresses those concerns	Public concerns will be reviewed following the public comment period and addressed in the final remedial alternative selection and design.	Public concerns will be reviewed following the public comment period and addressed in the final remedial alternative selection and design.	Public concerns will be reviewed following the public comment period and addressed in the final remedial alternative selection and design.	Public concerns will be reviewed following the public comment period and addressed in the final remedial alternative selection and design.
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	• **Moderate (3)** • Alternative 1 provides a moderate degree of risk reduction and improvement in overall environmental quality by treating groundwater to acceptable levels prior to discharge at the point of compliance and by removing a soil hotspot near the bulkhead as well as the hydraulic oil LNAPL. This alternative leaves a substantial amount of soil contamination on-site, and manages this risk with institutional controls. • Under Alternative 1, the groundwater cleanup levels will be attained at the point of compliance shortly after installation and startup of the air sparge curtain; however, the system must continue to be operated until groundwater migrating to the point of compliance is less than cleanup levels. The soil cleanup levels will not be achieved throughout the majority of the Site because Alternative 1 involves little soil treatment/removal. In the places where soil would be removed, the time required to reduce risk is minimal. • Alternative 1 provides low implementation risks. Most of the risk with this alternative would be associated with construction of both the air sparge curtain and contaminated soil removal, as well as transport of contaminated soil. However, limited soil would be removed in this alternative, resulting in lower risk.	• **High (5)** • Alternative 2 provides a high degree of risk reduction and improvement in overall environmental quality by treating both smear zone soil and groundwater to cleanup levels through chemical oxidation, and removing LNAPL. • This alternative leaves vadose zone soil contamination in the ground at levels greater than cleanup levels; however, this soil would be capped to reduce a direct contact risk. • Chemical oxidation and capping provide low off-site risks due to implementation. Most of the risk with this alternative would be associated with the transport of capping materials to the Site. Some risk would be associated with the handling of chemicals involved in the chemical oxidation process; however, these would be addressed by standard health and safety measures. • Chemical oxidation is expected to take a moderate amount of time (approximately 1 to 3 years) to reduce risks due to the time required for implementation. • Capping would reduce risk in a short time frame. The risks associated with leaving soil on-site at levels greater than cleanup levels would still be present, but managed with institutional controls.	• **Moderate to High (4)** • Alternative 3 provides a moderate to high degree of risk reduction and improvement in overall environmental quality by removing, all vadose zone contaminated soil, and all smear zone contaminated soil closest to the bulkhead and the most highly contaminated upgradient smear zone soil, removing LNAPL, and remediating groundwater to cleanup levels through enhanced bioremediation following targeted source control. This alternative leaves soil contamination on-site, and manages this risk with institutional controls. • Targeted excavation and post-excavation bioremediation would provide substantial risk reduction immediately through soil removal, and is expected to require a moderate amount of time (approximately 5 to 10 years) to attain the cleanup level at the conditional point of compliance. • Alternative 3 entails low to moderate implementation risks from excavation, transport, and backfilling activities, which are effectively addressed by standard health and safety measures.	• **High (5)** • Alternative 4 provides a high degree of risk reduction and improvement in overall environmental quality by removing all or nearly all source material and contaminated vadose zone soil, removing LNAPL, and remediating groundwater to cleanup levels through enhanced bioremediation following source control. This alternative leaves comparatively little soil contamination on-site, none of which is in the Gasoline Area, and manages this risk with institutional controls. • Full excavation and bioremediation would provide substantial risk reduction immediately through soil removal, and is expected to require a moderate amount of time (approximately 5 to10 years) to attain the cleanup level at the conditional point of compliance. • Alternative 4 entails low to moderate implementation risks from excavation, transport, and backfilling activities, which are effectively addressed by standard health and safety measures.

Table 9.3
Alternatives Evaluation

Alternative	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Permanence • Degree of reduction of contaminant toxicity, mobility, and volume • Adequacy of destruction of hazardous substances • Reduction or elimination of substance release, and source of release • Degree of irreversibility of waste treatment processes • Volume and characteristics of generated treatment residuals	• **Low to moderate (2)** • Alternative 1 will achieve cleanup levels at the point of compliance but will not be considered a permanent remedy until COCs in groundwater migrating to the treatment area naturally degrade to be less than cleanup levels. For soil, the areas that are being excavated have a high degree of permanence; however, much of the soil contamination will remain on-site. • An estimated 3,300 cubic yards of contaminated soil will be excavated. Removal of contaminated media is irreversible, and will result in immediate destruction of hazardous substances.	• **High (5)** • Alternative 2 has a high degree of reduction of contaminant toxicity, mobility, and volume in smear zone soils and groundwater. Chemical oxidation will reduce contaminants to cleanup levels in these areas. Contaminants in vadose zone soil will not have a reduction in toxicity, mobility, or volume. • Alternative 2 adequately destroys hazardous substances through chemical oxidation; however, capping does nothing to destroy hazardous substances. • Chemical oxidation would eliminate substance release by destroying contaminants to levels less than cleanup levels. • Chemical oxidation is irreversible as once contaminants are destroyed, they will no longer be present. Capping, however, is not irreversible. • This alternative is entirely in situ; therefore, there will be no treatment residuals.	• **Moderate to High (4)** • Alternative 3 will result in a moderate to high degree of permanence associated with the removal of a large volume of contaminated soil, and destruction of hazardous substances through bioremediation. • An estimated 15,700 cubic yards of contaminated soil from excavation activities will be excavated. The entire BTEX/GRO groundwater plume will be treated with bioremediation. • Both removal and bioremediation are irreversible. Bioremediation will result in destruction of hazardous substances. Removal will result in destruction of hazardous substances if on-site soil treatment is used. • Alternative 3 will achieve cleanup levels at the point of compliance permanently.	• **High (5)** • Alternative 4 will result in a high degree of permanence associated with the removal of a large volume of contaminated soil—all or nearly all Gasoline Area contaminated soil—and destruction of hazardous substances through bioremediation. • An estimated 22,200 cubic yards of contaminated soil from excavation activities will be excavated. The entire BTEX/GRO groundwater plume will be treated with bioremediation. • Both removal and bioremediation are irreversible. Bioremediation will result in destruction of hazardous substances. Removal will result in destruction of hazardous substances if on-site soil treatment is used. • Alternative 4 will achieve cleanup levels at the point of compliance permanently.
Effectiveness over the Long-term • Degree of certainty of alternative success • Reliability while contaminants remain on-site greater than cleanup levels • Magnitude of residual risk • Effectiveness of controls implemented to manage residual risk	• **Moderate (3)** • Alternative 1 has a high certainty of success in meeting groundwater cleanup levels at the point of compliance. Air sparging is a well-established remedy for petroleum hydrocarbons in groundwater, and air sparge components are reliable and not often prone to failure. • Long-term effectiveness is lower than other Alternatives because Alternative 1 requires continuous successful air sparge operation. Air sparging remediates soil within its influence, but Alternative 1 does not include substantial source removal. • Residual risk is moderate because of the large volume of contaminated soil remaining on-site and risk of discharge of COCs to surface water over the long term if operations are interrupted. • Institutional controls mitigate risks while contaminants remain on-site at levels greater than cleanup levels.	• **Low (1)** • The success of chemical oxidation, a proven technology for destroying TPH contamination in both soil and groundwater, is highly dependent on site conditions. The large mass loading of organic contaminants is estimated to require a very large volume of oxidant for adequate destruction, which would likely result in the need for closely-spaced and repeated treatments. This is compounded by the technical challenge of effective delivery of in situ treatment reagents to the subsurface, including interstitial pore space. • Residual risk would be low, once effective treatment is completed. Considerable residual risk would remain during implementation. The chemical oxidation process would likely be over a 1-year-long period. • Capping has a high degree of certainty in addressing the direct contact pathway for vadose zone soils. • Institutional controls mitigate risks while contaminants remain on-site at levels greater than cleanup levels.	• **Moderate to High (4)** • Alternative 3 has a moderate-to-high degree of alternative success and long-term effectiveness because it involves a large component of targeted source removal, including the most highly contaminated soil and contaminated soil closest to the bulkhead, and allows for delivery of enhanced bioremediation to the subsurface through large open excavation areas and follow up infiltration trenches. Some uncertainty exists about the rate of bioremediation and potential need for additional nutrients. • Residual risk is low following excavation, because it would remove a large volume of contaminated soil—including all vadose zone contaminated soil immediately, and begin addressing contaminated groundwater via bioremediation. • Institutional controls mitigate risks while contaminants remain on-site at levels greater than cleanup levels.	• **High (5)** • Alternative 4 has a high degree of alternative success and long-term effectiveness because it involves relatively complete source removal, and allows for delivery of enhanced bioremediation to the subsurface through large open excavation areas. Some uncertainty exists about the rate of bioremediation and potential need for additional nutrients. • Residual risk is very low following excavation, because Alternative 4 would remove all or nearly all contaminated soil in the Gasoline Area immediately, and begin addressing contaminated groundwater. • Institutional controls mitigate risks while contaminants remain on-site at levels greater than cleanup levels, in areas outside the Gasoline Area.

Table 9.3
Alternatives Evaluation

Alternative	Alternative 1	Alternative 2	Alternative 3	Alternative 4
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	• **Moderate to High (4)** • Alternative 1 is ranked moderate to high because it provides for relatively modest implementation risks. Most of the risk with this alternative would be associated with construction of both the air sparge curtain and contact with contaminated soil during removal and transport of contaminated soil. Limited soil would be removed in this alternative, resulting in lower risk. • For both the air sparge curtain and excavation, there is low potential for worker exposure to contaminated media. Potential risks to workers would readily be addressed by standard health and safety planning and procedures.	• **Moderate to High (4)** • Alternative 2 is ranked moderate to high because it would include modest short-term risk associated with implementation of chemical injection, transport of capping materials to the Site, and contact with contaminated soils during LNAPL excavation. Limited soil would be removed in this alternative, resulting in relatively lower risk. • Some risk would be associated with the handling of chemicals involved in the chemical oxidation process; however, these would be addressed by standard health and safety measures. • Risks will be adequately addressed with health and safety procedures.	• **Moderate (3)** • Alternative 3 is ranked moderate for short-term risk because it would include some implementation risks from large-scale excavation and backfilling activities, and for transport and disposal of large volumes of contaminated soil. Low risk is attributed to handling of chemicals for enhanced bioremediation. • These risks are effectively addressed by standard health and safety measures.	• **Moderate (3)** • Alternative 4 is ranked moderate for short-term risk because it would include some implementation risks from large-scale excavation and backfilling activities, and for transport and disposal of large volumes of contaminated soil. Low risk is attributed to handling of chemicals for enhanced bioremediation. • These risks are effectively addressed by standard health and safety measures.
Technical and Administrative Implementability (Ability of alternative to be implemented considering the following) • 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, operations, and monitoring • Integration with existing site operations or other current and potential future remedial action	• **Moderate (3)** • The air sparge component of Alternative 1 is technically and administratively implementable, and construction is not overly complex. The design must include consideration of subsurface utilities and structures located along the bulkhead and throughout the area where trenching would take place. Necessary materials and services are available, and permits attainable. • Excavation is moderately implementable, with technical limitations primarily due to shoring adjacent to the bulkhead. There are also no appropriate soil disposal facilities located on the Olympic Peninsula, so contaminated soil would need to be transported to Olympia. • 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. • Alternative 1 would be relatively easy to implement with existing site operations. Currently, the only operation the alternative would affect is the truck road used for the debarking operation. • Institutional controls are administratively implementable. • Monitoring requirements are comparable with the other alternatives.	• **Low (1)** • In situ chemical oxidation is administratively implementable but faces some technical uncertainty regarding whether it would be able to attain cleanup levels throughout the Site because of the large mass loading of organic contaminants, the need for closely-spaced and repeated treatments over a large area, and need for delivery of in situ treatment reagents to the subsurface to result in physical contact between oxidant and contaminant. The capping and LNAPL excavation components of Alternative 2 are technically and administratively feasible. Necessary services and materials are available, and permits attainable. • Site access does not appear to be a problem and this alternative would not interfere with site operations. • Institutional controls are administratively implementable. • Monitoring requirements are comparable with the other alternatives.	• **Moderate to High (4)** • Alternative 3 is technically and administratively implementable. Excavation faces technical limitations primarily due to shoring adjacent to the bulkhead. There are also no appropriate soil disposal facilities located on the Olympic Peninsula, so contaminated soil would either be thermally treated on-site or transported to Tacoma for rail transport to eastern Washington. Necessary materials and services are available, and permits attainable. • Bioremediation is technically implementable in conjunction with targeted source control. The rate of contaminant degradation and the potential need for modifications are technical challenges. • The volume of earth-moving associated with the large excavations increases the complexity and creates some potential for interference with site operations by truck traffic. The scale of excavation of Alternative 3, while smaller than Alternative 4, is considered effectively the same with respect to implementability. • Institutional controls are administratively implementable. • Monitoring requirements are comparable with the other alternatives.	• **Moderate to High (4)** • Alternative 4 is technically and administratively implementable. Excavation faces technical limitations primarily due to shoring adjacent to the bulkhead. There are also no appropriate soil disposal facilities located on the Olympic Peninsula, so contaminated soil would either be thermally treated on-site or transported to Tacoma for rail transport to eastern Washington. Necessary materials and services are available, and permits attainable. • Bioremediation is technically implementable in conjunction with source control. The rate of contaminant degradation and the potential need for modifications are technical challenges. • The volume of earth-moving associated with the large excavations increases the complexity and creates some potential for interference with site operations by truck traffic. • Institutional controls are administratively implementable. • Monitoring requirements are comparable with the other alternatives.

Table 9.3
Alternatives Evaluation

Alternative	**Alternative 1**	**Alternative 2**	**Alternative 3**	**Alternative 4**
Cost • Cost of construction • Long-term monitoring, operations, and maintenance costs • Agency oversight costs	• Total Alternative Cost = $2.4 million	• Total Alternative Cost = $7.0 million	• Total Alternative Cost = $5.2 million	• Total Alternative Cost = $7.4 million

Abbreviations:

BTEX	Benzene, toluene, ethylbenzene, and xylenes	LNAPL	Light non-aqueous phase liquid
COC	Contaminant of concern	ORO	Oil-range organic
DRO	Diesel-range organic	PCP	Pentachlorophenol
GRO	Gasoline-range organic	Site	K Ply Site

Table 9.4
Alternatives Evaluation Ranking Summary

Alternative	**Alternative 1**	**Alternative 2**	**Alternative 3**	**Alternative 4**
Alternative Description	Excavate hydraulic oil LNAPL area, limited excavation of gasoline soil contamination near the bulkhead, installation of product recovery inserts for passive gasoline product recovery, installation of an air sparge curtain, institutional controls, and groundwater compliance monitoring. Excavation in the Hog Fuel Storage Area and the Stack Area and institutional controls in the PCP Area and the Long Pond Fill Area.	Excavate hydraulic oil LNAPL area, in situ chemical oxidation of Gasoline Area followed by enhanced bioremediation, institutional controls, and groundwater compliance monitoring. Excavation in the Hog Fuel Storage Area and the Stack Area and institutional controls in the PCP Area and the Long Pond Fill Area.	Excavate hydraulic oil LNAPL area, excavate two specific source areas within the Gasoline Area, treatment of groundwater by enhanced bioremediation, compliance monitoring of groundwater, and institutional controls. Excavation in the Hog Fuel Storage Area, the Stack Area, and the PCP Area and institutional controls in the Long Pond Fill Area.	Excavate hydraulic oil LNAPL and contaminated soil within the entire Gasoline Area, enhanced bioremediation and compliance monitoring of groundwater. Excavation in the Hog Fuel Storage Area, the Stack Area, and the PCP Area and institutional controls in the Long Pond Fill Area.
Estimated Alternative Cost[1]	$ 2.4M	$7.0M	$4.8M	$7.4M
Benefit Scoring[2]				
Overall Protectiveness	Moderate (3)	High (5)	Moderate to High (4)	High (5)
Permanence	Low to Moderate (2)	High (5)	Moderate to High (4)	High (5)
Long-term Effectiveness	Moderate (3)	Low (1)	Moderate to High (4)	High (5)
Short-term Risk Management	Moderate to High (4)	Moderate to High (4)	Moderate (3)	Moderate (3)
Implementability	Moderate (3)	Low (1)	Moderate to High (4)	Moderate to High (4)
Consideration of Public Concerns	Potentially Negative	Potentially Positive	Likely Positive	Likely Positive
Total Benefit Score	**15**	**16**	**19**	**22**
Cost per Unit Benefit Ratio[3]	**0.16**	**0.44**	**0.25**	**0.33**

Notes:
1 Specific cost estimate information is provided in Appendix E.
2 Higher scores equate to a higher level of relative benefit. Fewer short-term risks result in a higher score.
3 Cost per Unit Benefit Ratio calculated by dividing the total alternative cost (in millions) by the alternative Total Benefit Score. Lower value indicates the most benefit for the associated cost.

Abbreviation:

LNAPL	Light non-aqueous phase liquid

K Ply Site

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Figures

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K Ply Site
Port Angeles, Washington

Figure 1.1
Vicinity Map

G:Project\Clients\Floyd Snider\K Ply\Corel\Figure 1.1

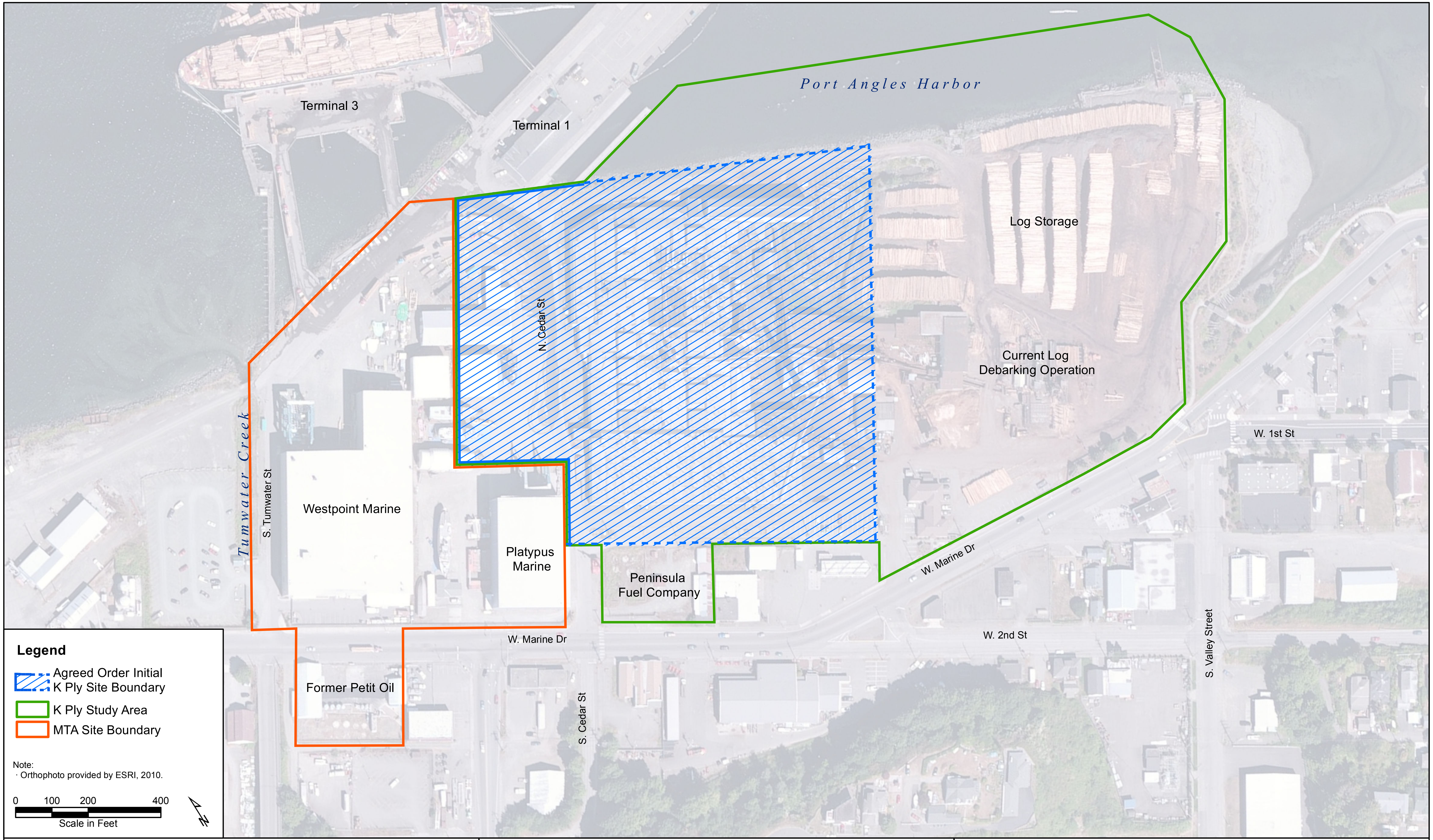

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Figure 2.1
Study Area

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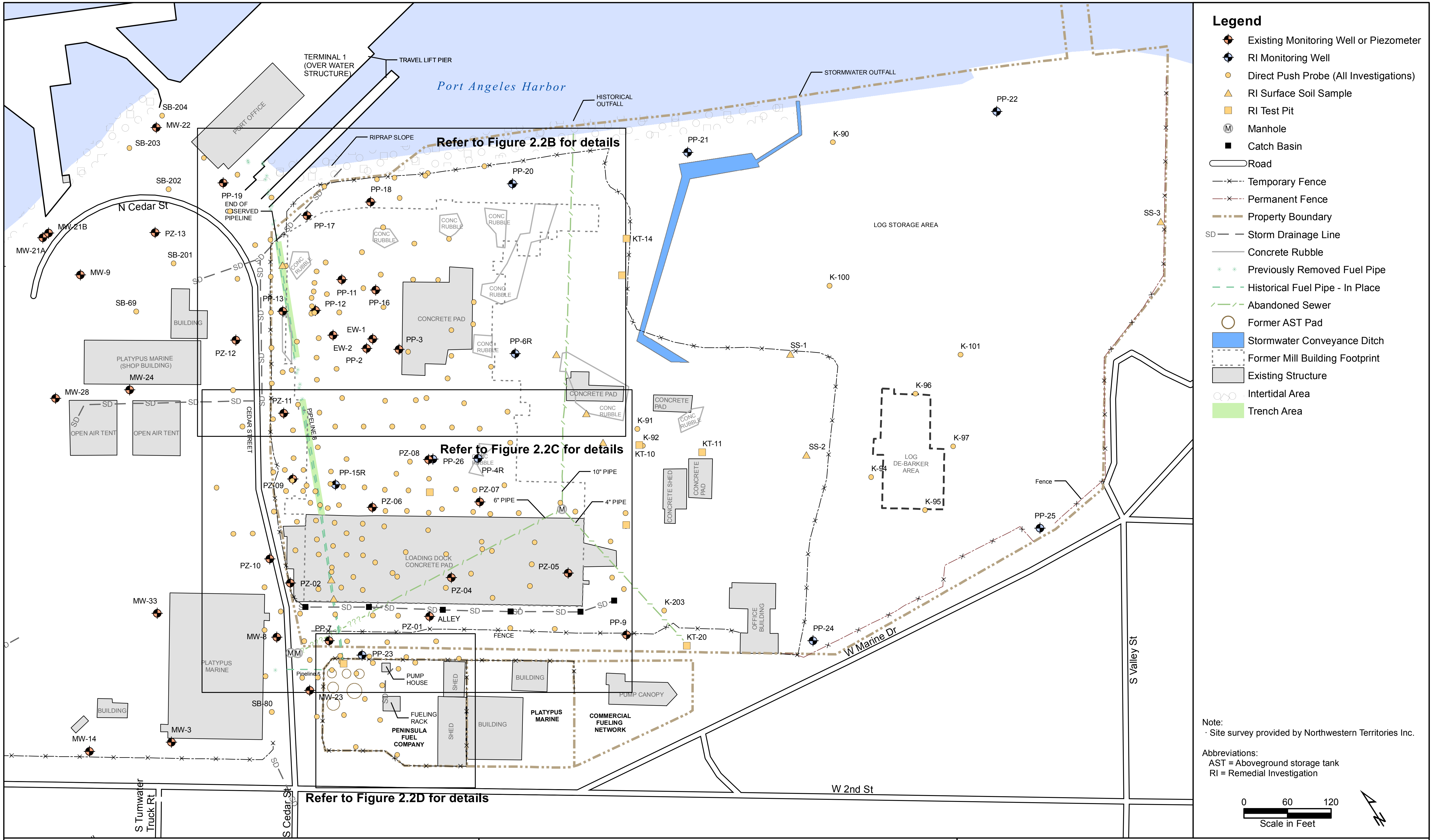

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Figure 2.2A
Site Map and Sample Locations

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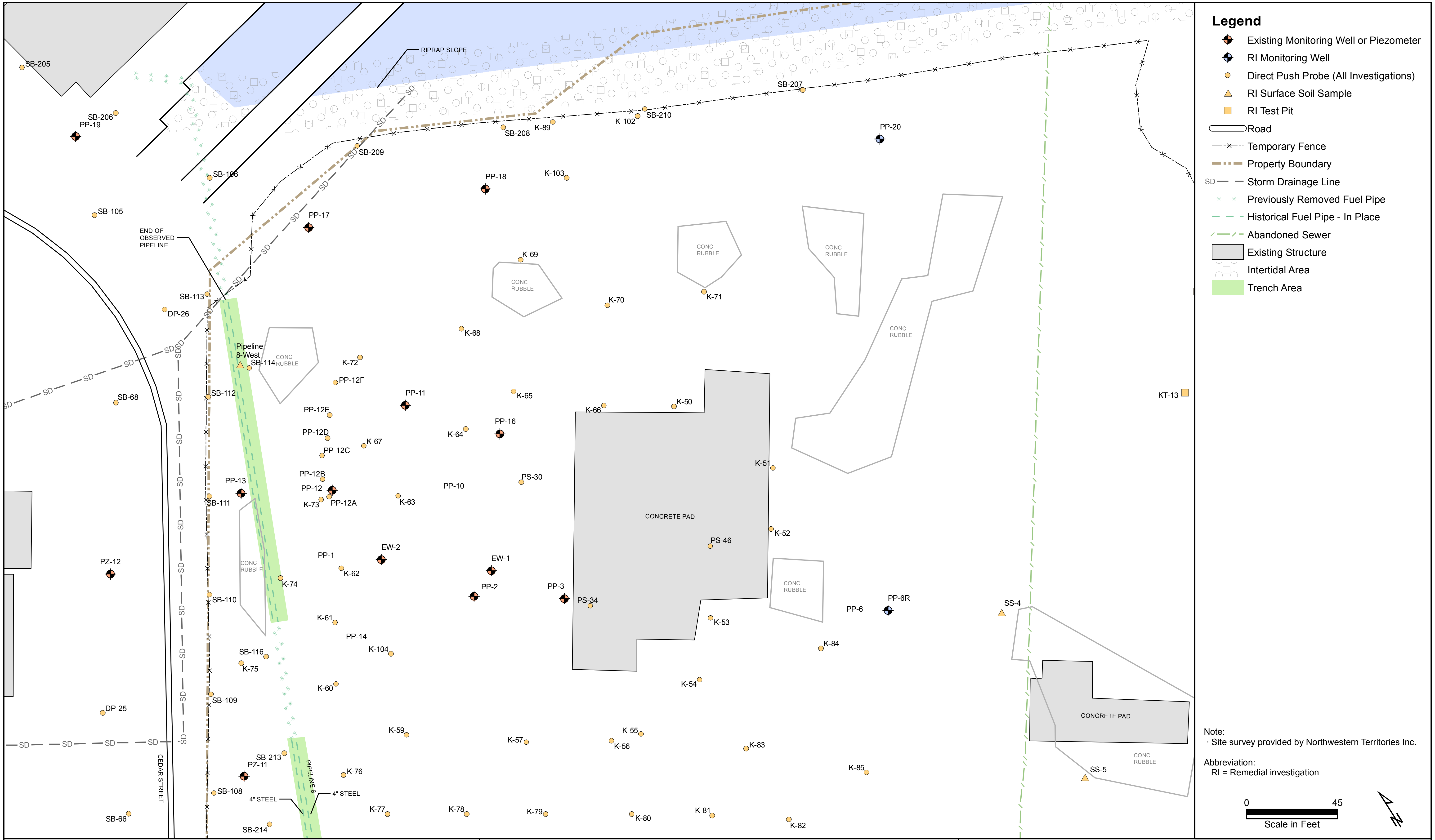

Note:
· Site survey provided by Northwestern Territories Inc.

Abbreviation:
RI = Remedial investigation

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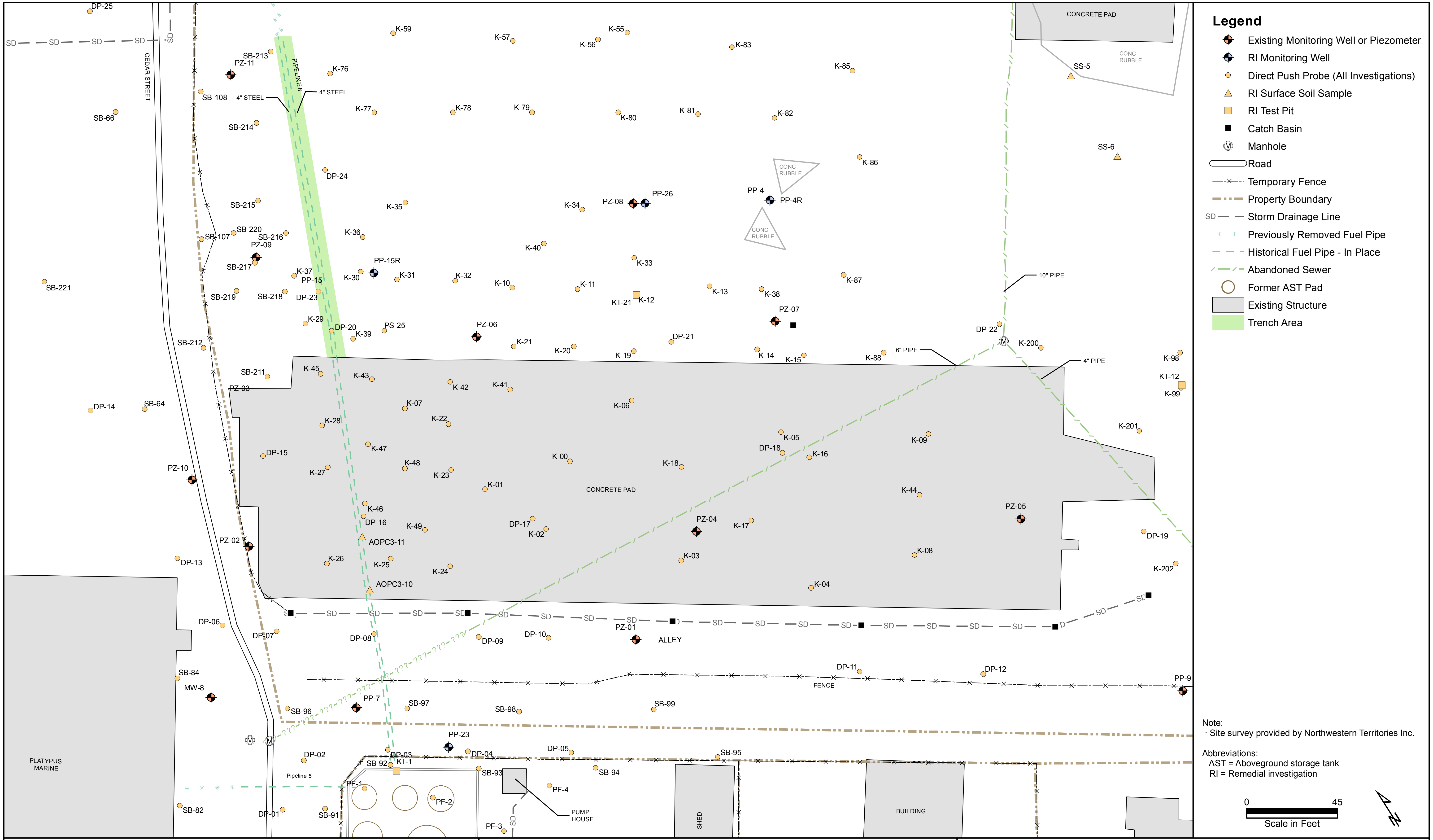
Figure 2.2B
Site Map and Sample Locations

I:\GIS\Projects\PPA_KPLY\MXD\RIFS\Figure 2.2B (RI Site Map and Sample Locations).mxd 3/2/2015



Legend

- Existing Monitoring Well or Piezometer
- RI Monitoring Well
- Direct Push Probe (All Investigations)
- RI Surface Soil Sample
- RI Test Pit
- Catch Basin
- Manhole
- Road
- Temporary Fence
- Property Boundary
- Storm Drainage Line
- Previously Removed Fuel Pipe
- Historical Fuel Pipe - In Place
- Abandoned Sewer
- Former AST Pad
- Existing Structure
- Trench Area

Note:
- Site survey provided by Northwestern Territories Inc.

Abbreviations:
AST = Aboveground storage tank
RI = Remedial investigation

0 45
Scale in Feet

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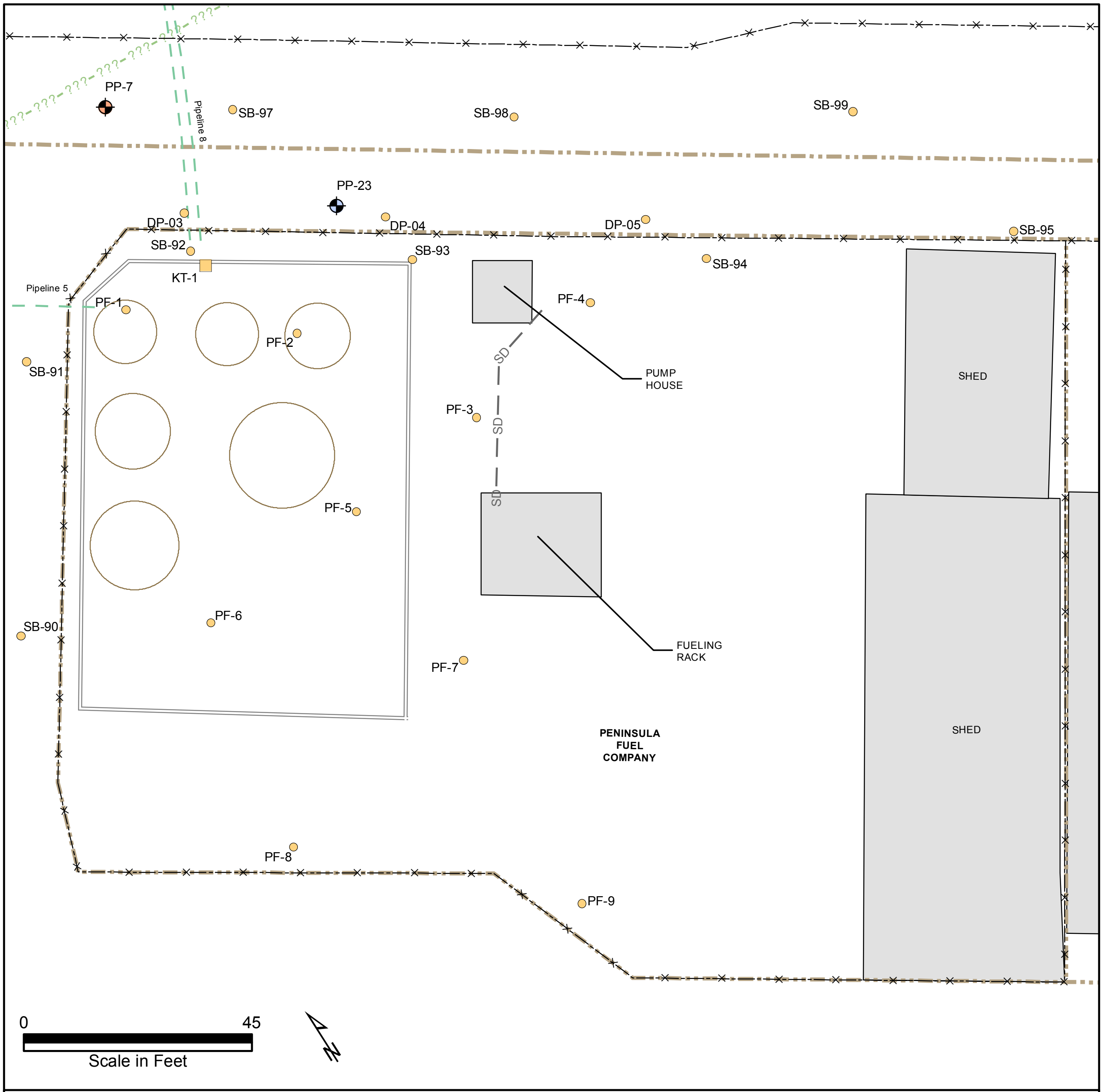
Figure 2.2C
Site Map and Sample Locations

I:\GIS\Projects\PPA_KPLY\MXD\RIFS\Figure 2.2C (RI Site Map and Sample Locations).mxd 3/2/2015



Legend

- ⊕ Existing Monitoring Well or Piezometer
- ⊕ RI Monitoring Well
- ● RI Direct Push Probe
- △ RI Surface Soil Sample
- ■ RI Test Pit
- ○ Former AST Pad
- ▨ Existing Structure
- —×— Temporary Fence
- —··— Property Boundary
- ═ Bermed Area
- — — Historical Fuel Pipe - In Place

Note:
· Site survey provided by Northwestern Territories Inc.

Abbreviations:
AST = Aboveground storage tank
RI = Remedial investigation

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Figure 2.2D
Peninsula Fuel Company
Sample Locations

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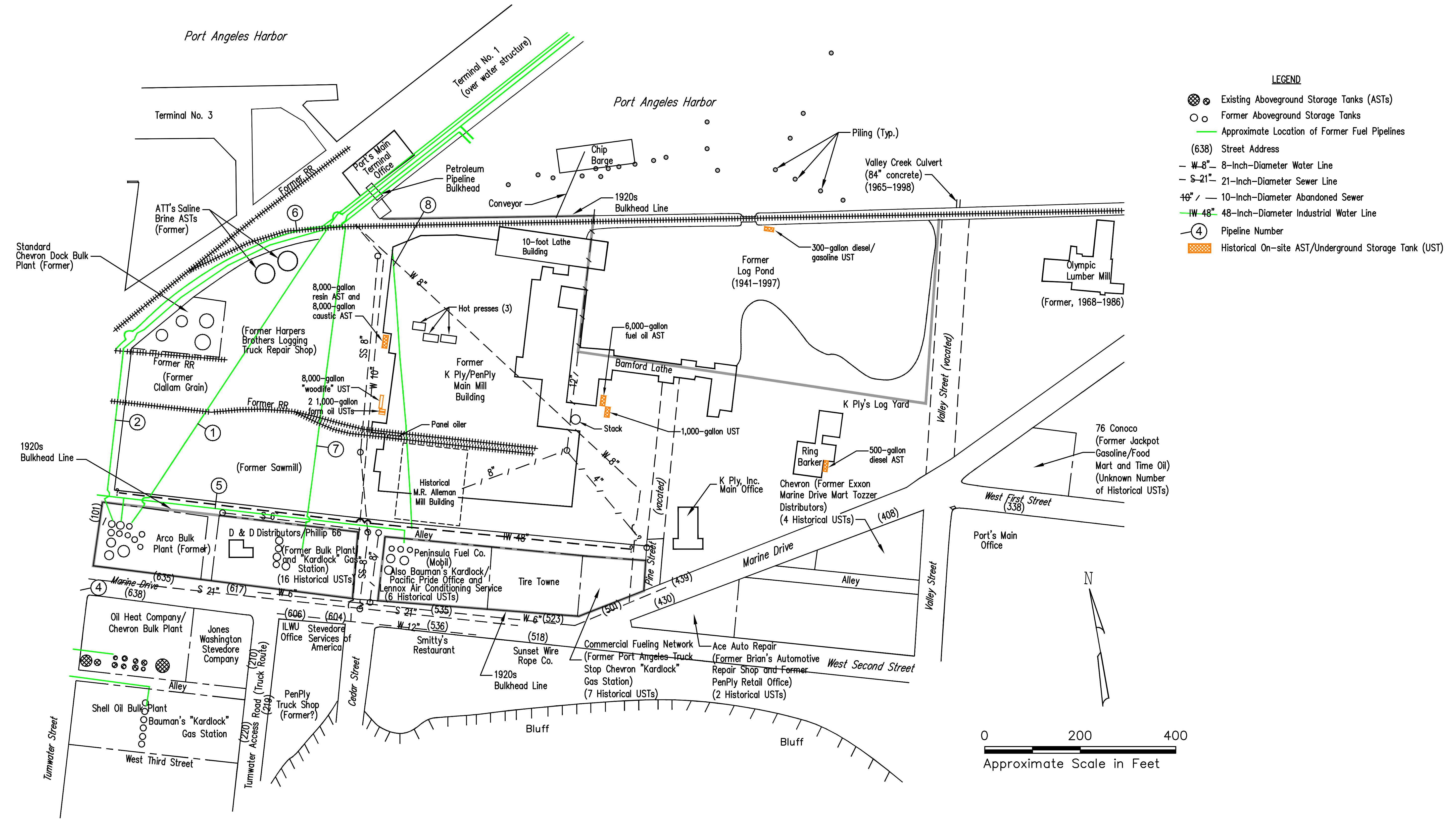
3/2/2015



Source: Shannon & Wilson 1996; Landau Associates Inc. 1988; Ryan and Haworth 1967

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Figure 2.3
Historical Land Use Map through 1996

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DWG NAME: E:\Project\clients\Floyd and Snider\KPly2013\KPLY2013_001_Apr2014update.dwg

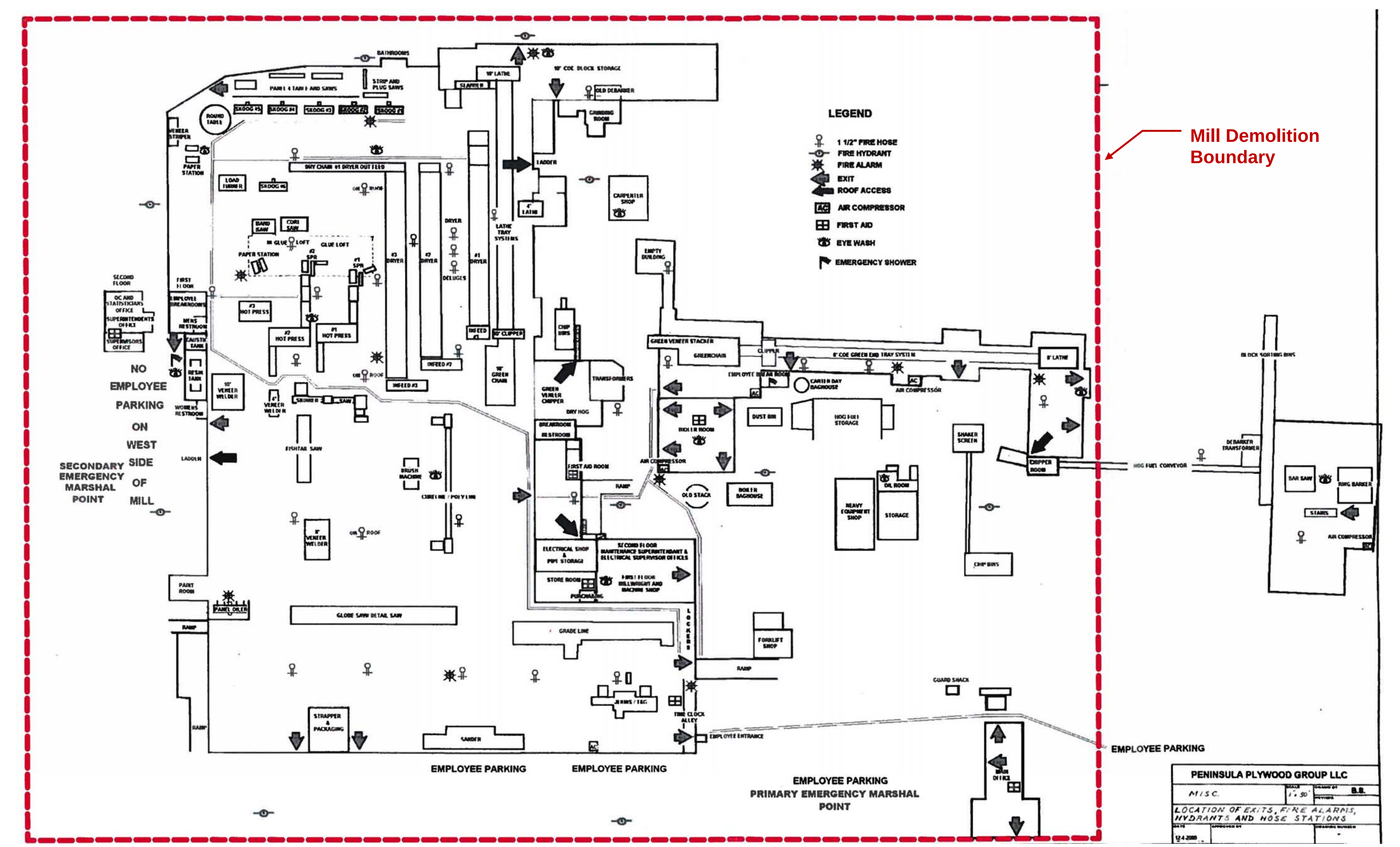

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Figure 2.4
Former PenPly Mill Building Layout

F:\projects\Port of PA KPLY Mill\AO Task 3c Public Review Draft RIFS Report\Figures\Figure 2.4 Mill Layout Figure 042312.docx

09/03/2013

LEGEND

1	Area of Potential Concern (Refer to Table 2.1 for the Areas of Potential Concern)
▪▪▪▪▪▪▪▪	Approximate Location of Former Fuel Pipeline 8
—SS—	Abandoned Sewer Line

Notes:

1. Stormwater flow at the Site following mill demolition is not known. The stormwater flow arrows are approximate and are drawn based on what the existing conditions are thought to be.
2. Existing utilities shown are approximate and possibly incomplete.

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Figure 2.5
Areas of Potential Concern

G:Project\Clients\Floyd Snider\PPA-OMW\Corel\Figure 3.2

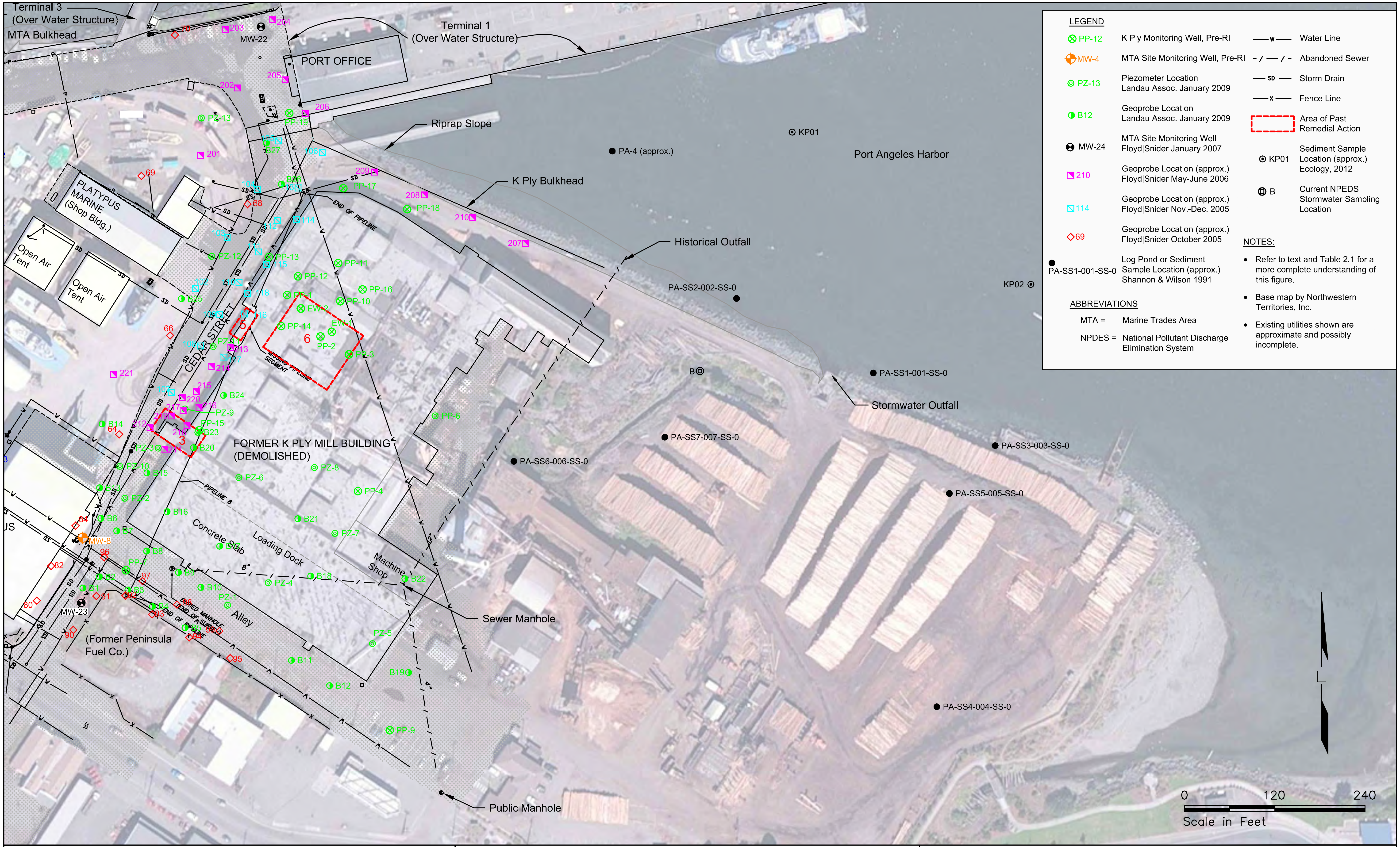

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Figure 3.1
Site Map Showing Prior Investigations,
Locations, and Remedial Actions

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DATE: 9/10/2014 11:13 PM

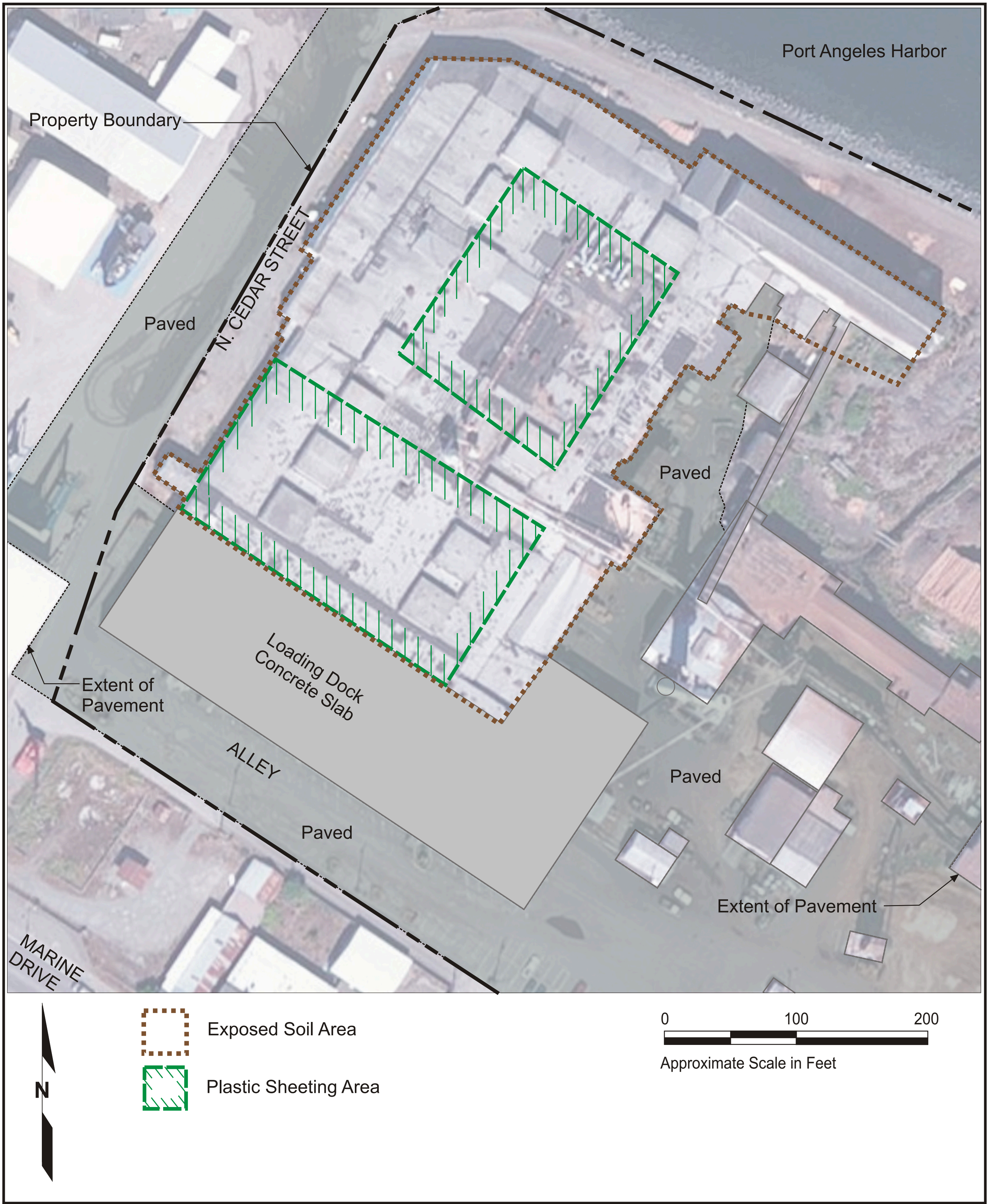

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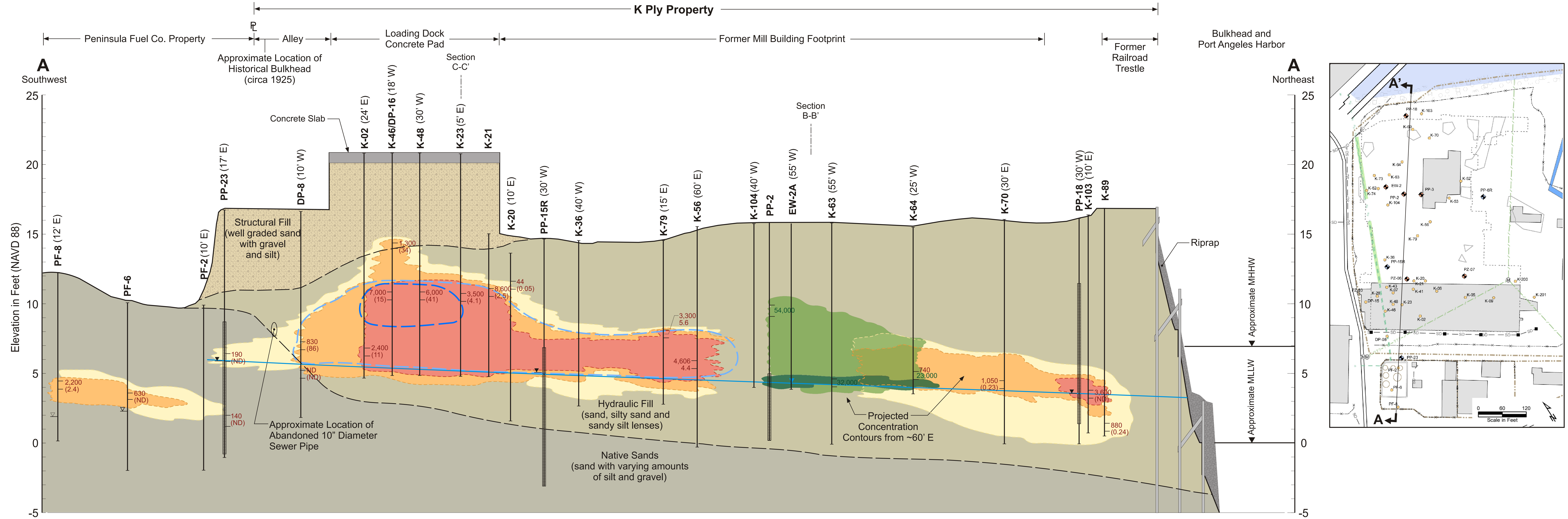
Figure 3.2
Plastic Sheeting Locations

G:Project\Clients\Floyd Snider\K Ply\Corel\Figure 3.2
5/20/14



Gasoline-Range Organics (GRO) and Benzene in Soil

- 🟥 GRO > 3,000 mg/kg — strong field indications of contamination
- 🟧 GRO > 300 mg/kg — moderate field indications of contamination
- 🟨 GRO > 30 mg/kg and/or Benzene 0.03 mg/kg — mild field indications of contamination
- ◯ Benzene > 10 mg/kg
- ◯ Benzene > 0.1-10 mg/kg

Oil-Range Organics (ORO) in Soil

- 🟩 Free Product (in field blot test or well)
- 🟩 > 20,000 mg/kg (moderate field indications of contamination)
- ▼ Water Table Elevation in Well (measured Oct 2013)
- ▽ Water Table Elevation at Time of Drilling

Monitoring Well/Piezometer

Soil Boring

ORO in mg/kg
GRO (benzene) in mg/kg

Horizontal Scale in Feet
0 50 100
0 5 10
Vertical Scale in Feet
Vertical Exaggeration X 10

Abbreviations:
CUL = Cleanup level
mg/kg = milligrams per kilogram
MTCA = Model Toxics Control Act
NAVD 88 = North American Vertical Datum of 1988
ND = Non-detect

Notes:
- Contact between hydraulic fill and native sand deposit based on Port of Port Angeles "Final Soundings before Dredging", December 10, 1925.
- Analytical data include selected data from Floyd|Snider 2013, Landau 2009, Landau 1988. Field screening observations presented in Supplemental Data Collection Technical Memorandum (Floyd|Snider 2014) provided in Appendix C.

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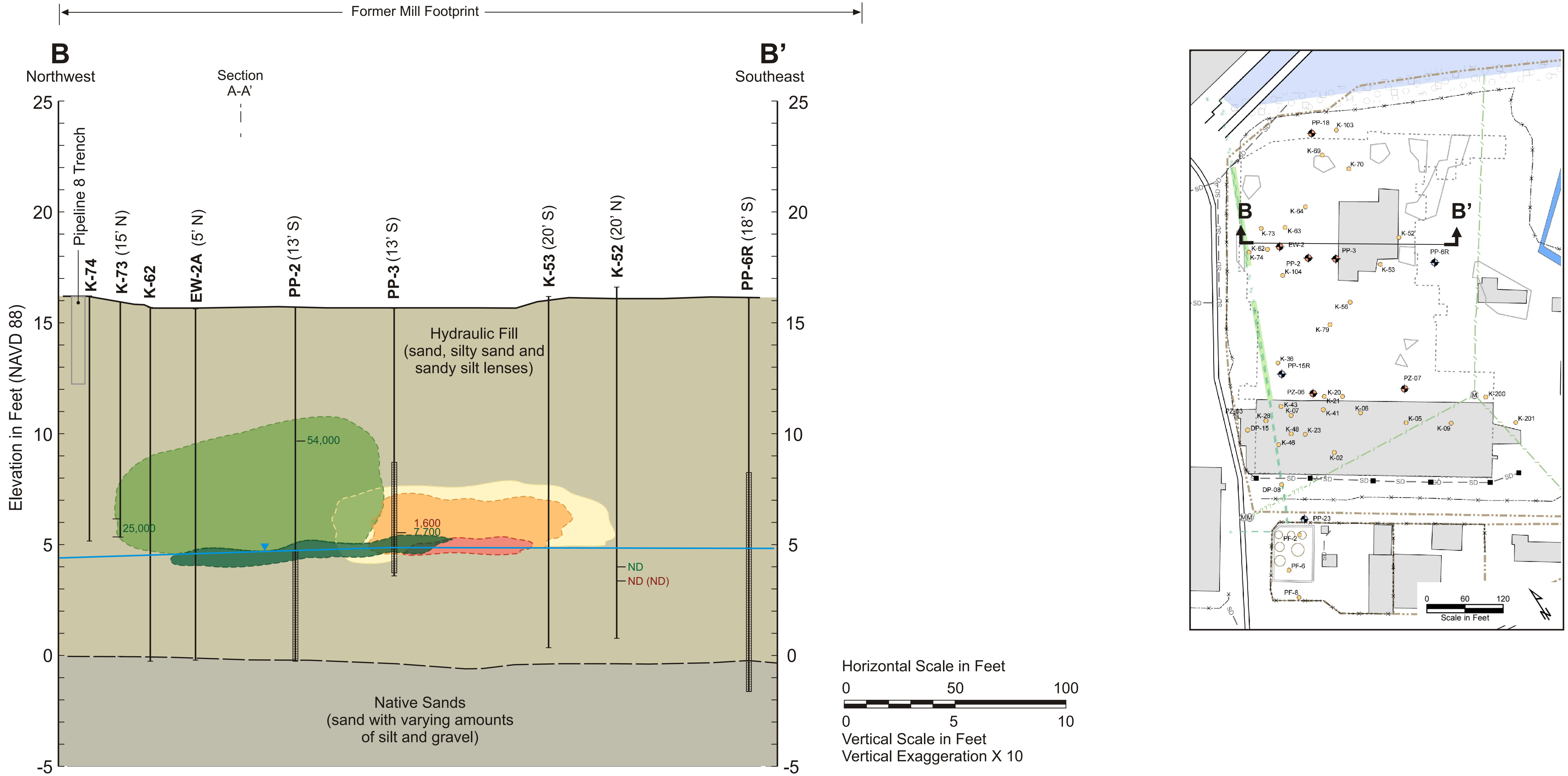
Figure 5.1
North-South Cross Section A-A'

G:Project\Clients\Floyd Snider\K Ply\Corel\Figure 5.1



Gasoline-Range Organics (GRO) in Soil

- 🟥 GRO > 3,000 mg/kg — strong field indications of contamination
- 🟧 GRO > 300 mg/kg — moderate field indications of contamination
- 🟨 GRO > 30 mg/kg — mild field indications of contamination

Oil-Range Organics (ORO) in Soil

- 🟩 Free Product (in field blot test or well)
- 🟩 > 20,000 mg/kg (moderate field indications of contamination)

Water Table Elevation in Well (measured Oct 2013)

Monitoring Well/Piezometer

Soil Boring

ORO in mg/kg
GRO (benzene) in mg/kg

Abbreviations:

CUL =	Cleanup level
mg/kg =	milligrams per kilogram
MTCA =	Model Toxics Control Act
NAVD 88 =	North American Vertical Datum of 1988
ND =	Non-detect

Notes:
- Contact between hydraulic fill and native sand deposit based on Port of Port Angeles “Final Soundings before Dredging”, December 10, 1925.
- Analytical data include selected data from Floyd|Snider 2013, Landau 2009, Landau 1988. Field screening observations presented in Supplemental Data Collection Technical Memorandum (Floyd|Snider 2014) provided in Appendix C.

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Figure 5.2
East-West Cross Section B-B'

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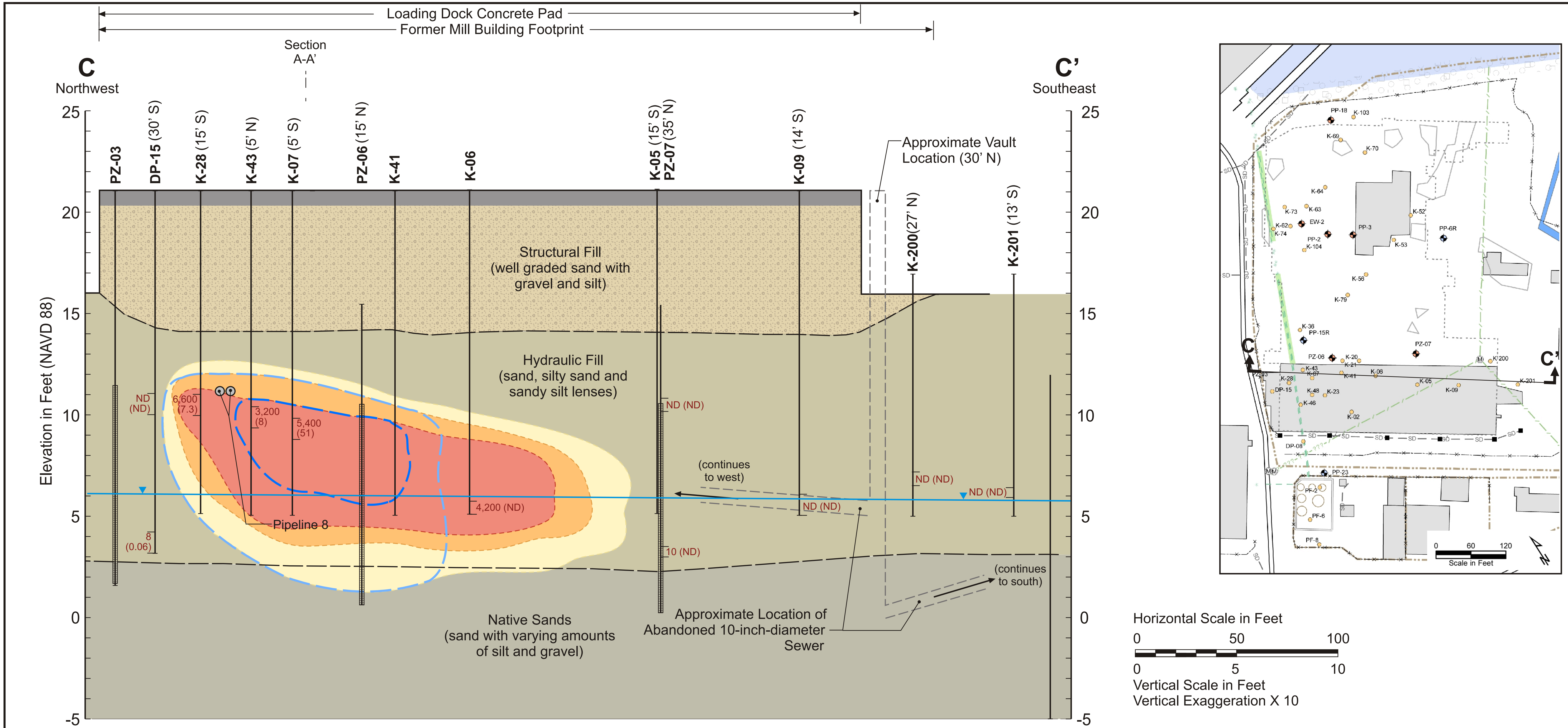

Gasoline-Range Organics (GRO) and Benzene in Soil

- 🟥 GRO > 3,000 mg/kg — strong field indications of contamination
- 🟧 GRO > 300 mg/kg — moderate field indications of contamination
- 🟨 GRO > 30 mg/kg and/or Benzene 0.03 mg/kg — mild field indications of contamination
- Benzene > 10 mg/kg
- Benzene > 0.1-10 mg/kg
- Water Table Elevation in Well (measured Oct 2013)

Monitoring Well/Piezometer

Soil Boring

GRO (benzene) in mg/kg

Abbreviations:

CUL =	Cleanup level
mg/kg =	milligrams per kilogram
MTCA =	Model Toxics Control Act
NAVD 88 =	North American Vertical Datum of 1988
ND =	Non-detect

Notes:

- Contact between hydraulic fill and native sand deposit based on Port of Port Angeles "Final Soundings before Dredging", December 10, 1925.
- Analytical data include selected data from Floyd|Snider 2013, Landau 2009, Landau 1988. Field screening observations presented in Supplemental Data Collection Technical Memorandum (Floyd|Snider 2014) provided in Appendix C.

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Figure 5.3
East-West Cross Section C-C'

G:Project\Clients\Floyd Snider\K Ply\Corel\Figure 5.3

Legend

- ◕ Potentiometric Elevation (feet NAVD 88)
- 〜 Potentiometric Contour (feet NAVD 88)
- ➞ Groundwater Flow Direction

Notes:
- Measurements collected from 6:13–6:53 pm.
- Low tide elevation of 3.00 feet (NAVD 88) occured at 6:32 pm.
- Orthoimage provided by Esri, 7/9/2010.

Abbreviation:
NAVD 88 = North American Vertical Datum of 1988

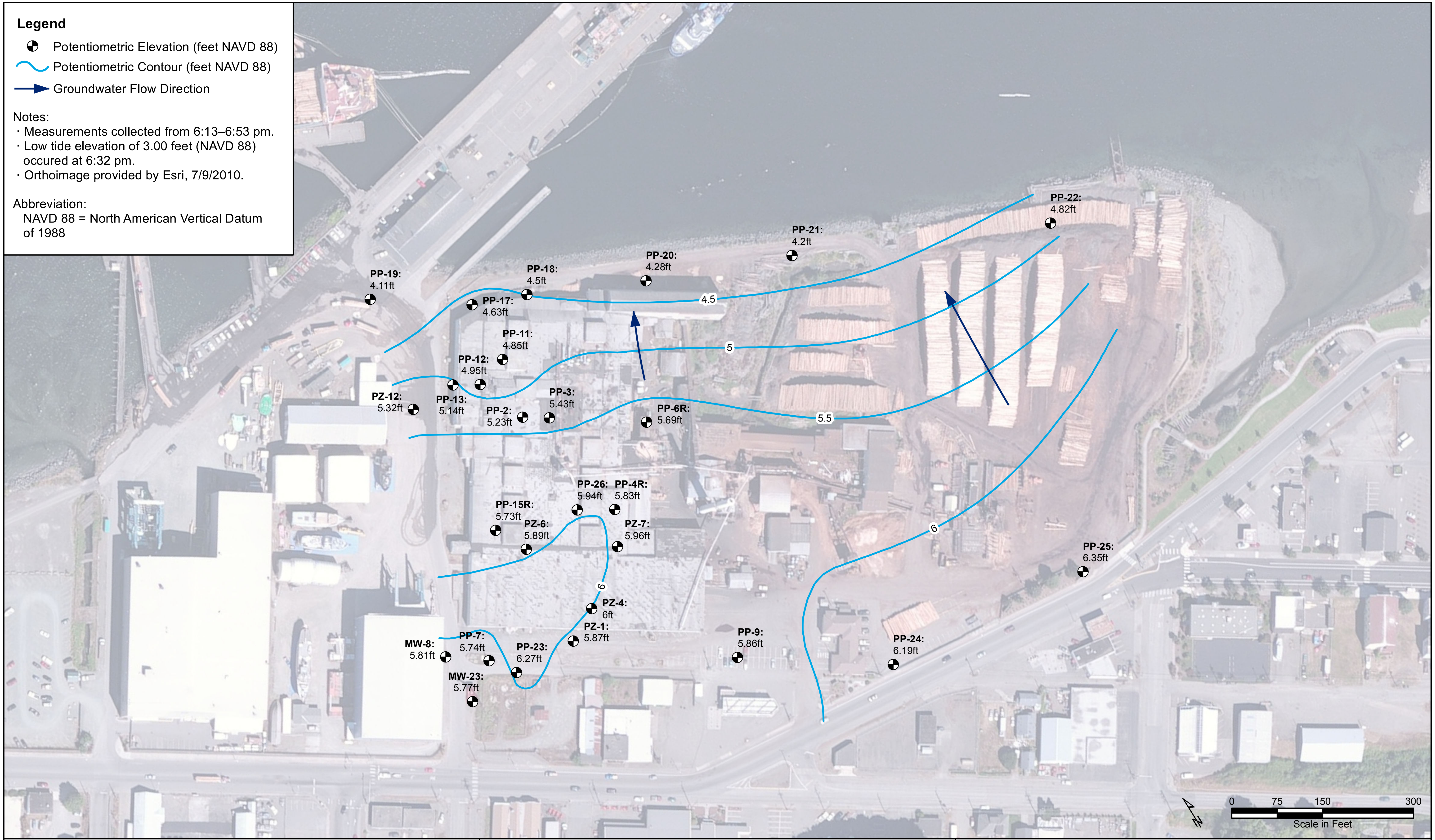

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Figure 5.4
Low Tide Groundwater Elevation Contours October 14, 2013

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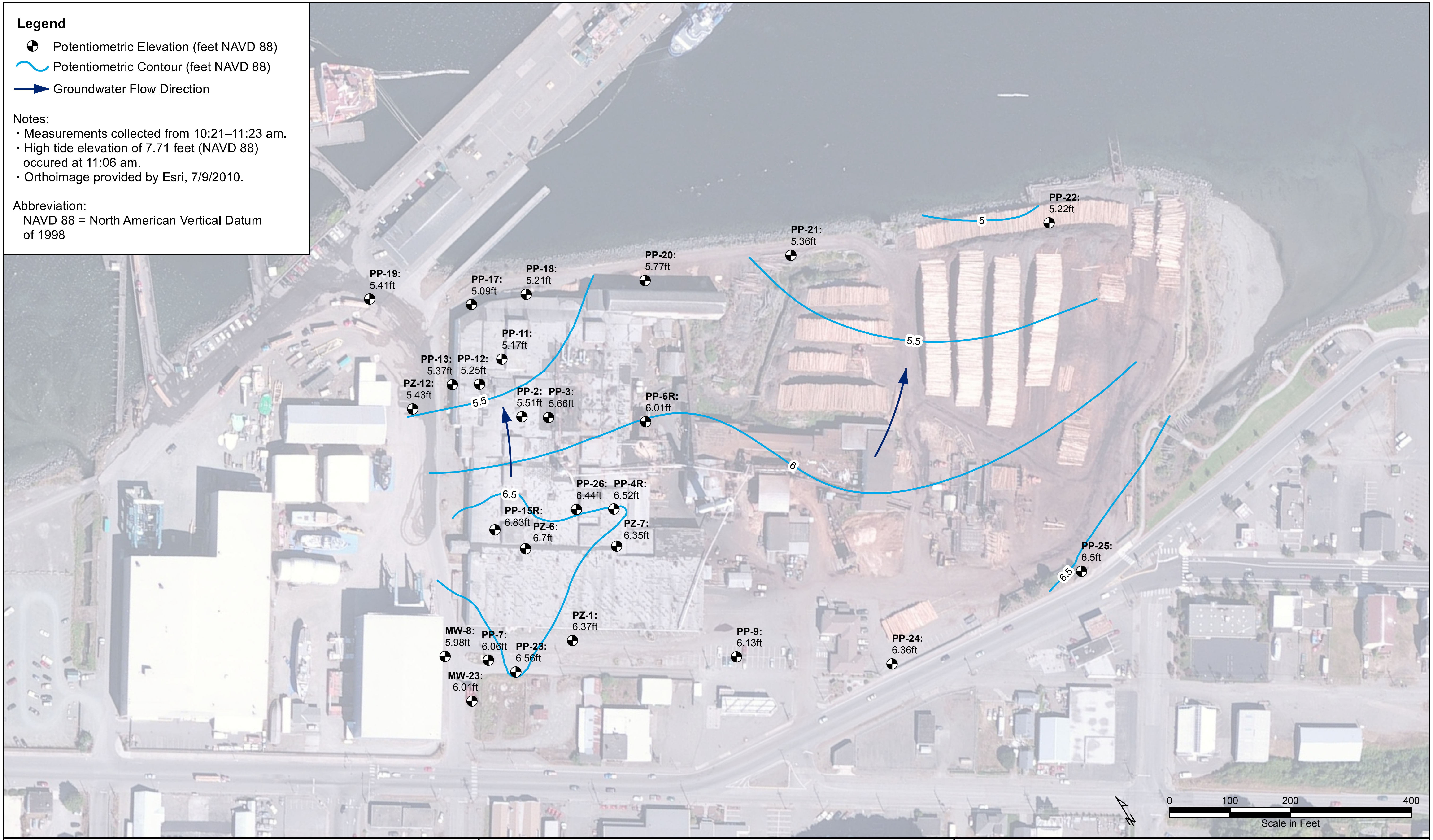
3/16/2015



Legend

● Potentiometric Elevation (feet NAVD 88)

～ Potentiometric Contour (feet NAVD 88)

→ Groundwater Flow Direction

Notes:
- Measurements collected from 10:21–11:23 am.
- High tide elevation of 7.71 feet (NAVD 88) occured at 11:06 am.
- Orthoimage provided by Esri, 7/9/2010.

Abbreviation:
NAVD 88 = North American Vertical Datum of 1998

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Figure 5.5
High Tide Groundwater Elevation Contours January 28, 2014

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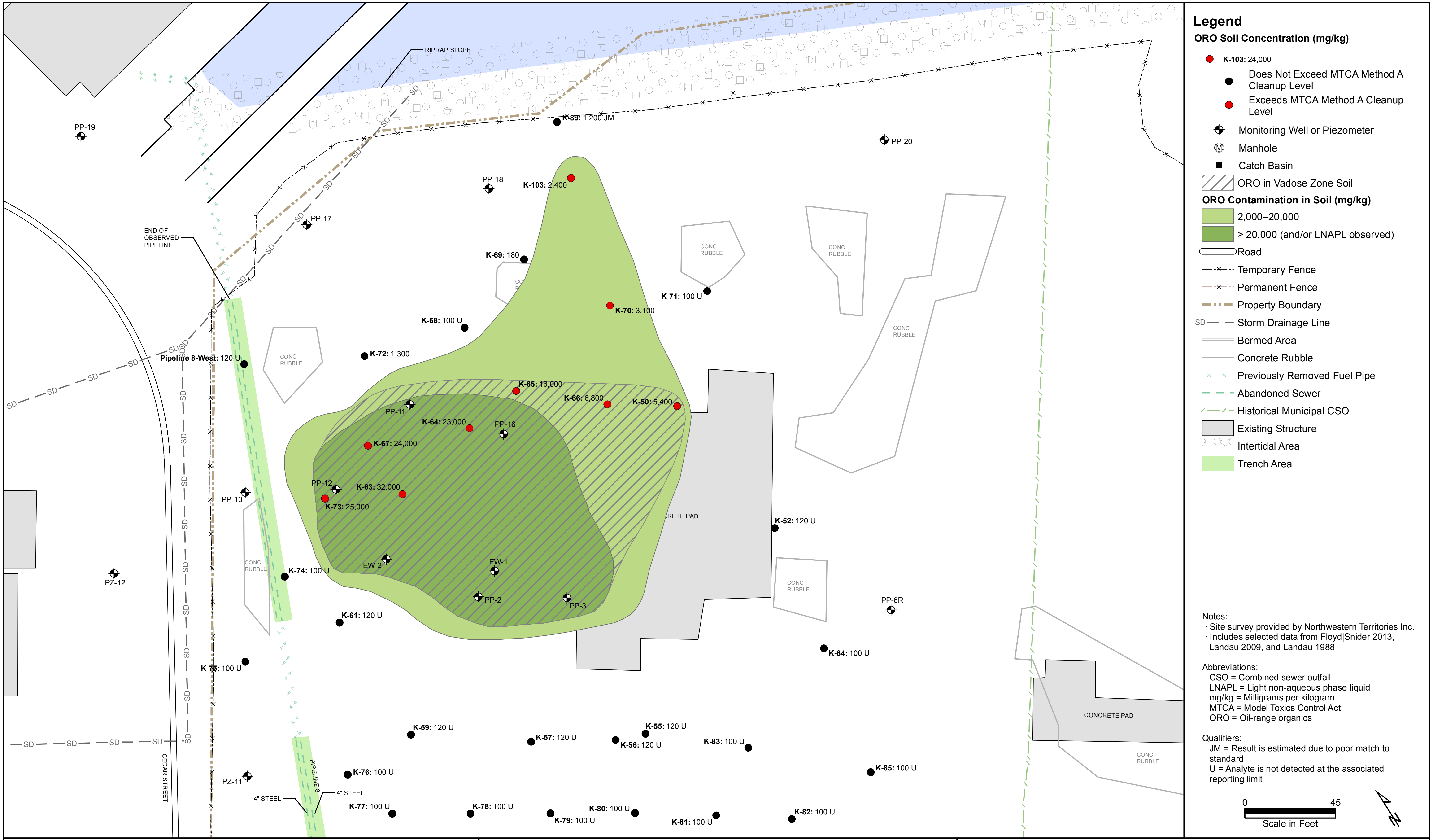
3/16/2015



Notes:
- Site survey provided by Northwestern Territories Inc.
- Includes selected data from Floyd|Snider 2013, Landau 2009, and Landau 1988

Abbreviations:
CSO = Combined sewer outfall
LNAPL = Light non-aqueous phase liquid
mg/kg = Milligrams per kilogram
MTCA = Model Toxics Control Act
ORO = Oil-range organics

Qualifiers:
JM = Result is estimated due to poor match to standard
U = Analyte is not detected at the associated reporting limit

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Figure 5.6
ORO Results in Soil

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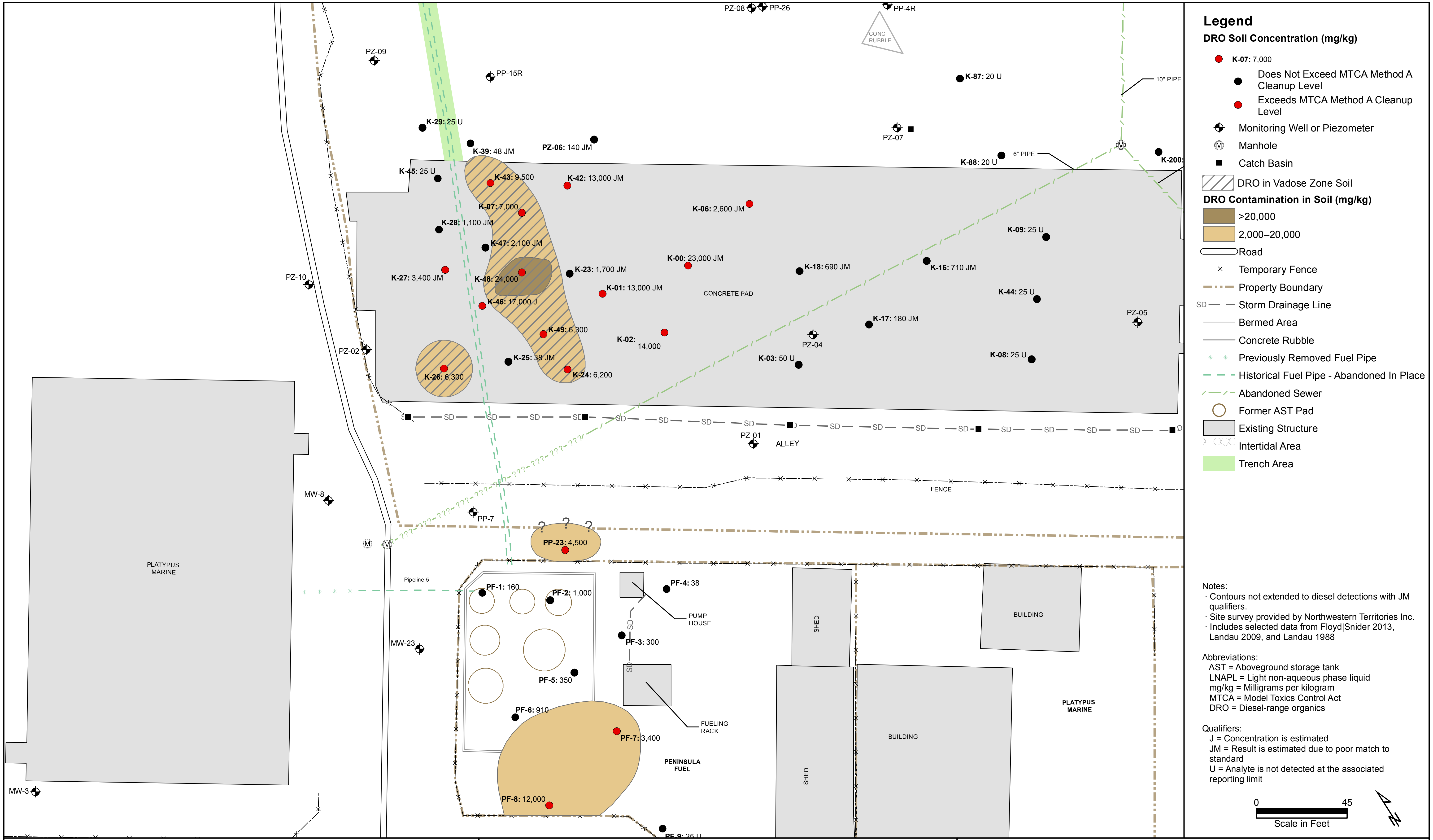

Notes:
- Contours not extended to diesel detections with JM qualifiers.
- Site survey provided by Northwestern Territories Inc.
- Includes selected data from Floyd|Snider 2013, Landau 2009, and Landau 1988

Abbreviations:
AST = Aboveground storage tank
LNAPL = Light non-aqueous phase liquid
mg/kg = Milligrams per kilogram
MTCA = Model Toxics Control Act
DRO = Diesel-range organics

Qualifiers:
J = Concentration is estimated
JM = Result is estimated due to poor match to standard
U = Analyte is not detected at the associated reporting limit

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Figure 5.7
DRO Results in Soil

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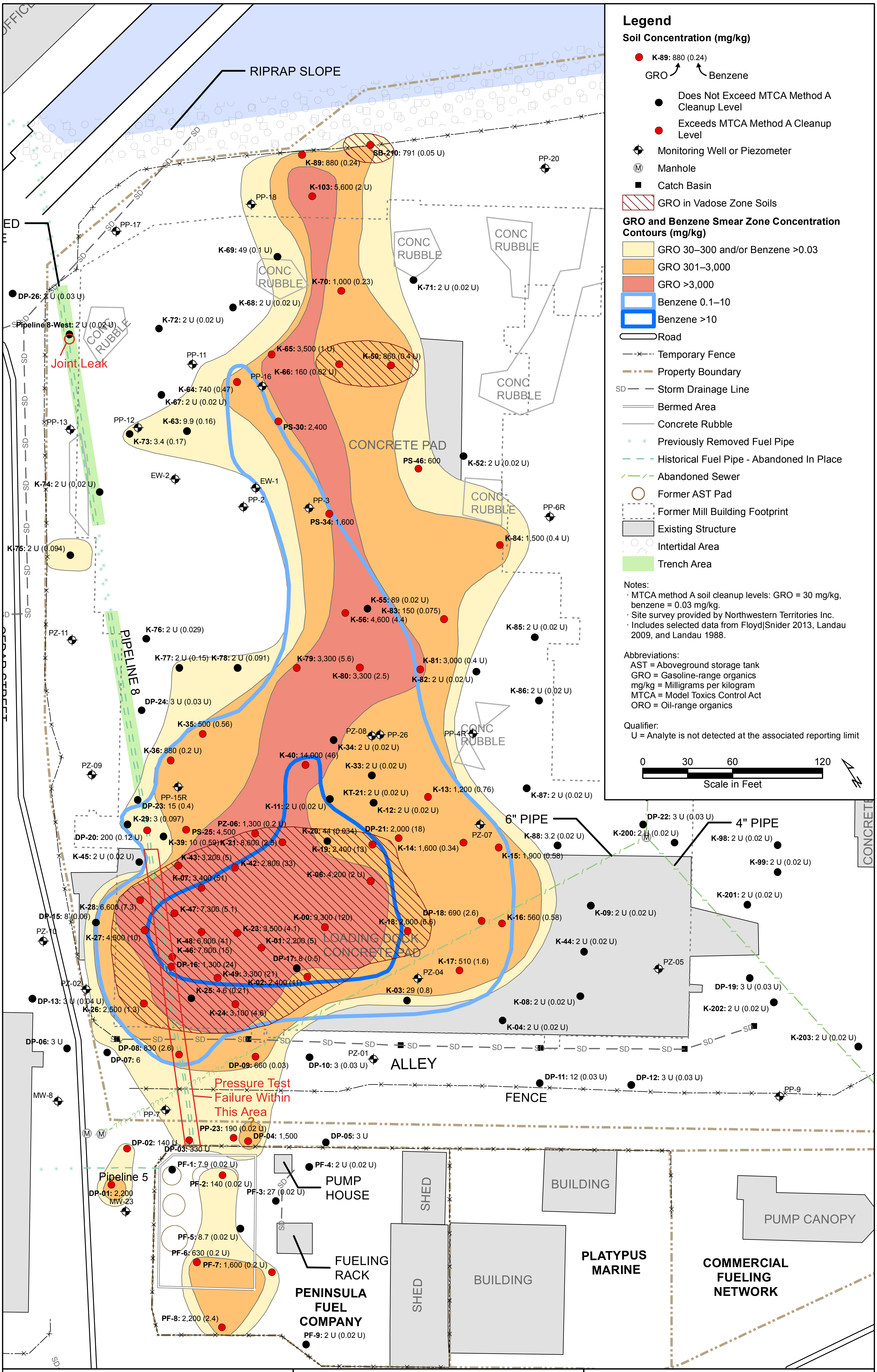

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Figure 5.8
GRO and Benzene Results in Soil

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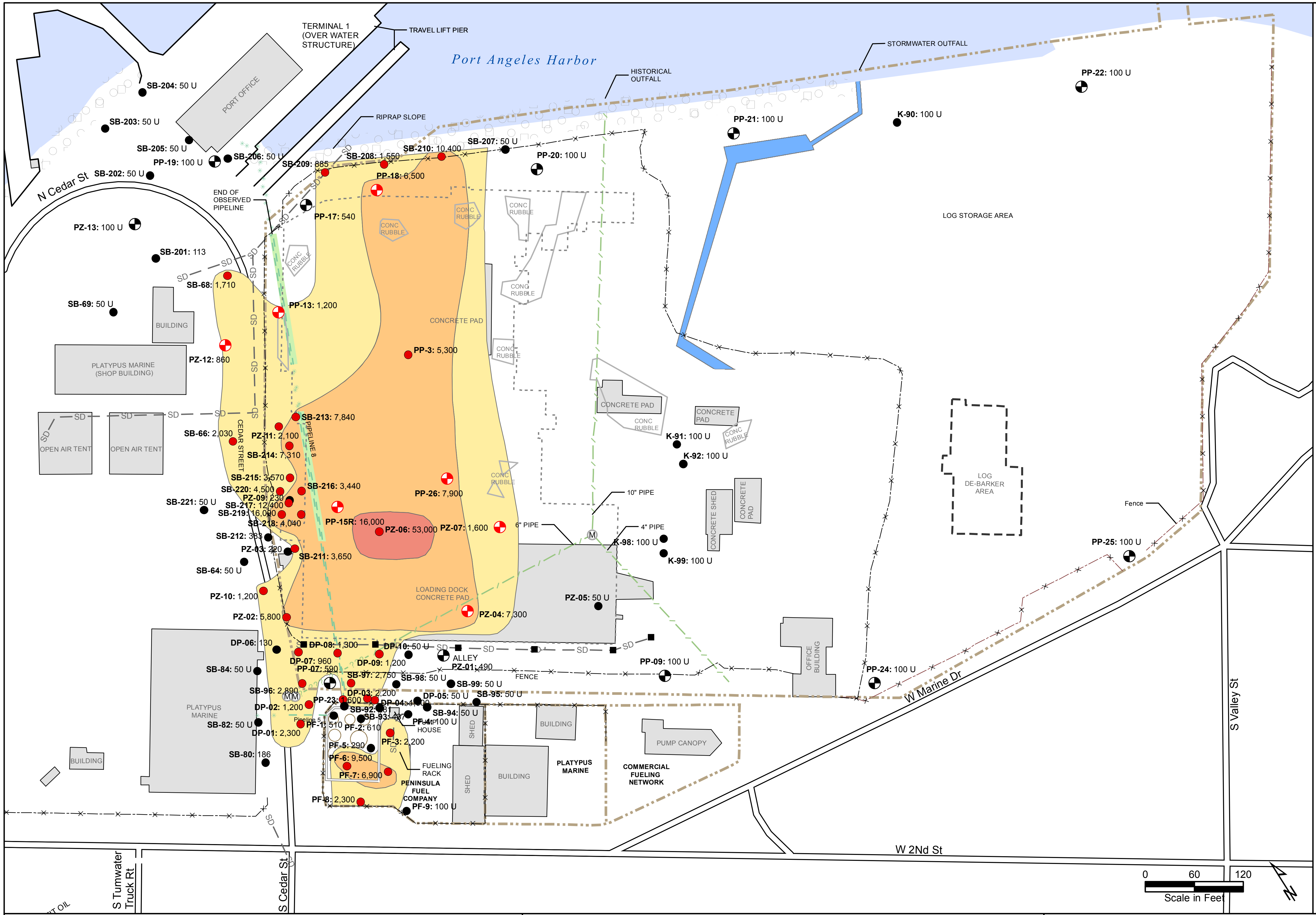

Legend

Groundwater screening grab sample

● **PP-3:** 5,300

● Does Not Exceed MTCA Method A Cleanup Level

● Exceeds MTCA Method A Cleanup Level

Monitoring Well or Piezometer Sample

◐ **PP-18:** 6,500

◐ Does Not Exceed MTCA Method A Cleanup Level

◐ Exceeds MTCA Method A Cleanup Level

Ⓜ Manhole

■ Catch Basin

GRO in Groundwater (µg/L)

🟨 800–5,000

🟧 5,001–50,000

🟥 > 50,000

Road

Temporary Fence

Permanent Fence

Property Boundary

SD Storm Drainage Line

Bermed Area

Concrete Rubble

Previously Removed Fuel Pipe

Historical Fuel Pipe - In Place

Abandoned Sewer

○ Former AST Pad

🟦 Stormwater Conveyance Ditch

Former Mill Building Footprint

Existing Structure

Intertidal Area

🟩 Trench Area

Notes:

- MTCA method A groundwater cleanup level: GRO = 800 µg/L.
- Monitoring well, Geoprobe, and piezometer RI samples collected between September 2013 and January 2014 - highest concentrations shown.
- Sample names begining with 'K-' or 'PF-' were direct-push groundwater screening RI samples.
- Boundaries of plume were drawn based on RI data and data from prior investigations including Floyd|Snider 2013, Landau 2009, and Landau 1988.
- Site survey provided by Northwestern Territories Inc.

Abbreviations:

AST = Aboveground storage tank
GRO = Gasoline Range Organics
µ/L = Micrograms per liter
MTCA = Model Toxics Control Act
RI = Remedial investigation

Qualifier:

U = Analyte is not detected at the associated reporting limit

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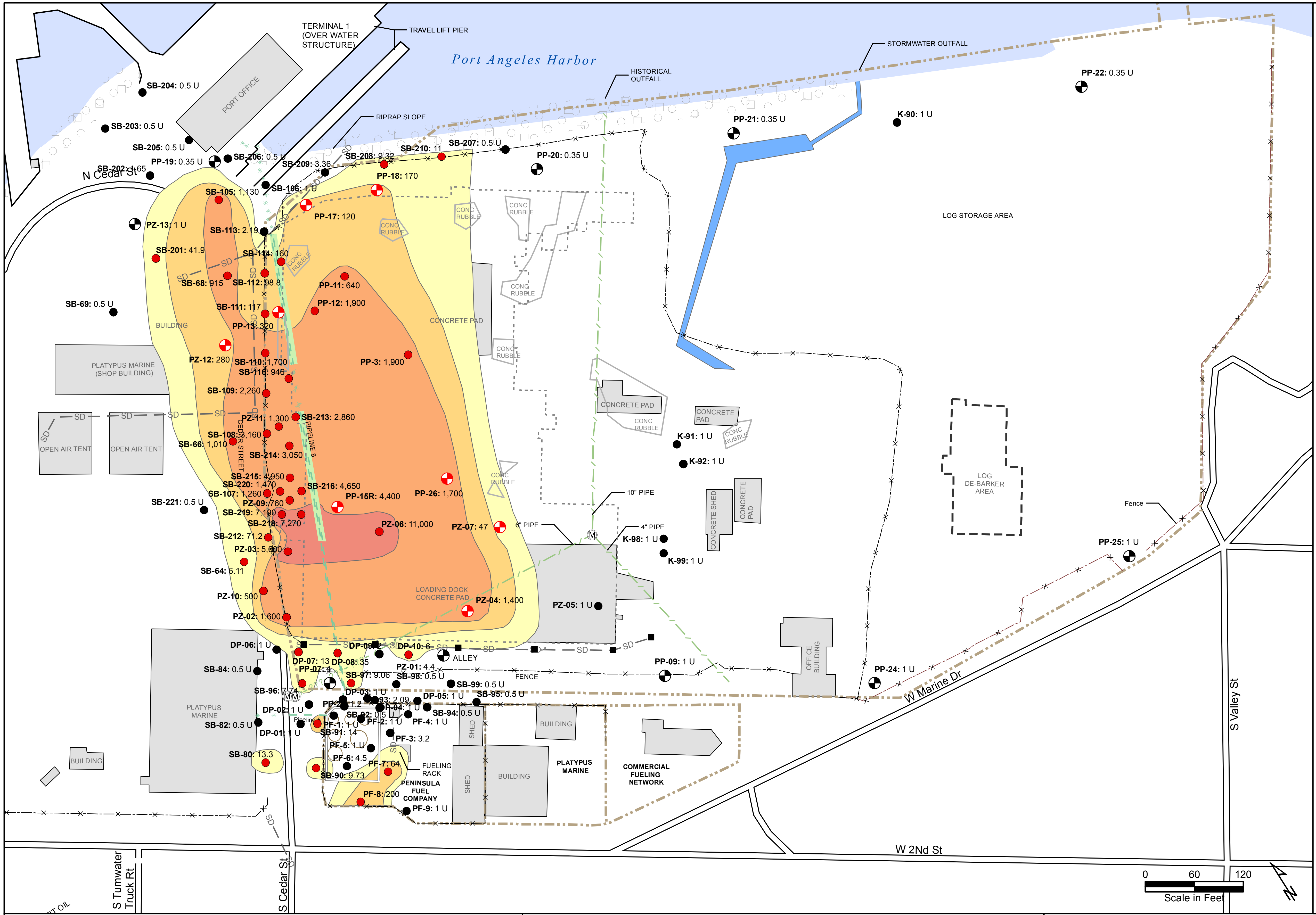
K Ply Site
Port Angeles, Washington

Figure 5.9
GRO Results in Groundwater

I:\GIS\Projects\PPA_KPLY\MXD\PublicReviewDraft\Figure 5.9 - GRO Results in Groundwater.mxd 3/16/2015



Legend

Groundwater screening grab sample

● **PP-11:** 640

● Does Not Exceed MTCA Method A Cleanup Level

● Exceeds MTCA Method A Cleanup Level

Monitoring Well or Piezometer Sample

◐ **PP-26:** 17,000

◐ Does Not Exceed MTCA Method A Cleanup Level

◐ Exceeds MTCA Method A Cleanup Level

Ⓜ Manhole

■ Catch Basin

Benzene in Groundwater (µg/L)

🟨 5–50

🟧 51–500

🟧 501–5,000

🟥 >5,000

Road

Temporary Fence

Permanent Fence

Property Boundary

SD Storm Drainage Line

Bermed Area

Concrete Rubble

Previously Removed Fuel Pipe

Historical Fuel Pipe - In Place

Abandoned Sewer

○ Former AST Pad

🟦 Stormwater Conveyance Ditch

Former Mill Building Footprint

▨ Existing Structure

Intertidal Area

🟩 Trench Area

Notes:

- MTCA method A groundwater cleanup level: Benzene = 5 µg/L.
- Monitoring well, Geoprobe and piezometer RI samples collected between September 2013 and January 2014 - highest concentrations shown.
- Sample names begining with 'K-' or 'PF-' were direct-push groundwater screening RI samples.
- Boundaries of plume were drawn based on RI data and data from prior investigations including Floyd|Snider 2013, Landau 2009, and Landau 1988.
- Site survey provided by Northwestern Territories Inc.

Abbreviations:

µg/L = Micrograms per liter
AST = Aboveground storage tank
MTCA = Model Toxics Control Act
RI = Remedial investigation

Qualifier:

U = Analyte is not detected at the associated reporting limit

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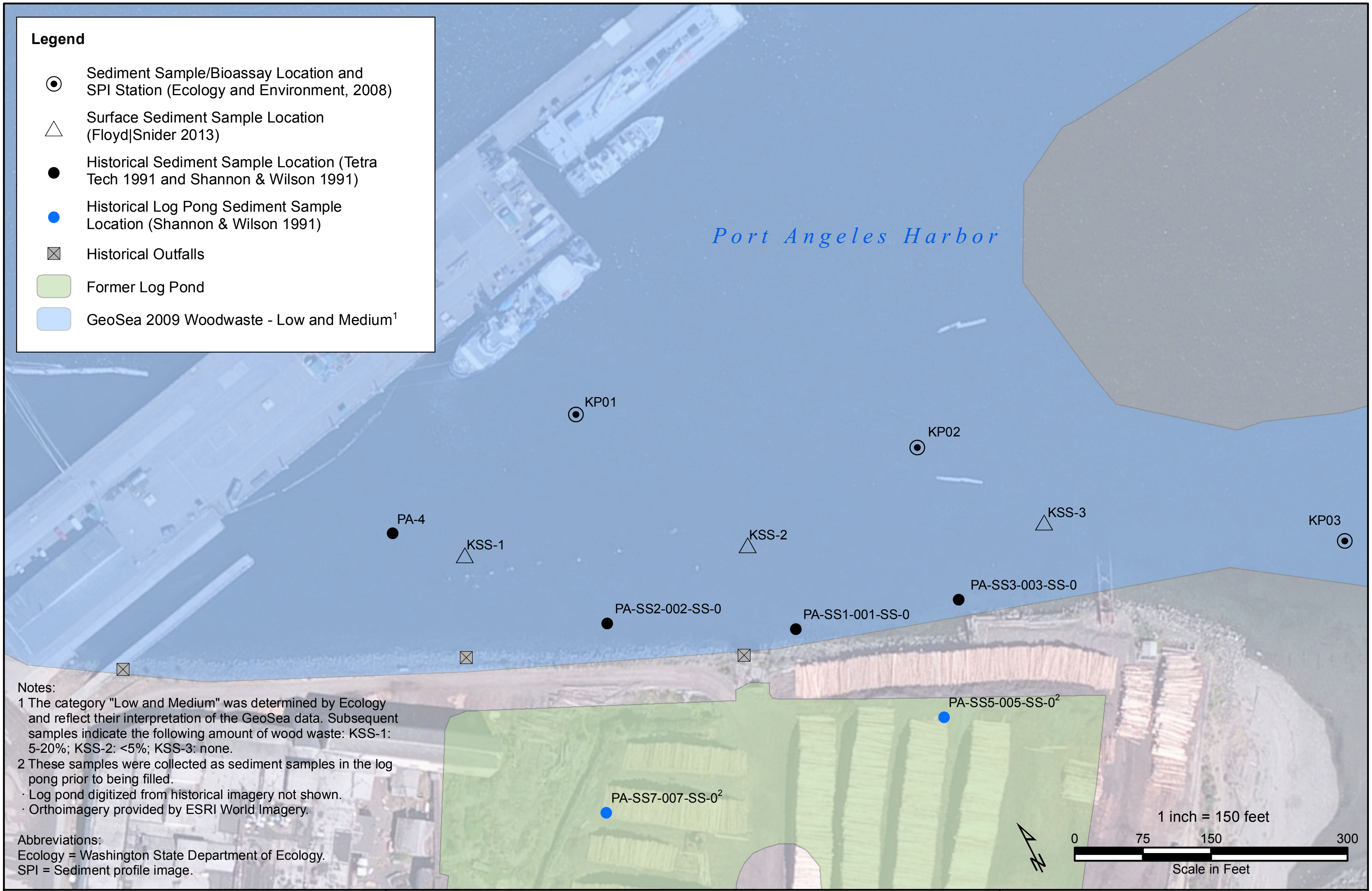
K Ply Site
Port Angeles, Washington

Figure 5.10
Benzene Results in Groundwater

I:\GIS\Projects\PPA_KPLY\MXD\PublicReviewDraft\Figure 5.10 - Benzene Results in Groundwater.mxd 3/16/2015



Legend

⊙ Sediment Sample/Bioassay Location and SPI Station (Ecology and Environment, 2008)

△ Surface Sediment Sample Location (Floyd|Snider 2013)

● Historical Sediment Sample Location (Tetra Tech 1991 and Shannon & Wilson 1991)

● Historical Log Pong Sediment Sample Location (Shannon & Wilson 1991)

☒ Historical Outfalls

🟩 Former Log Pond

🟦 GeoSea 2009 Woodwaste - Low and Medium[1]

Notes:

1 The category "Low and Medium" was determined by Ecology and reflect their interpretation of the GeoSea data. Subsequent samples indicate the following amount of wood waste: KSS-1: 5-20%; KSS-2: <5%; KSS-3: none.

2 These samples were collected as sediment samples in the log pong prior to being filled.

· Log pond digitized from historical imagery not shown.

· Orthoimagery provided by ESRI World Imagery.

Abbreviations:
Ecology = Washington State Department of Ecology.
SPI = Sediment profile image.

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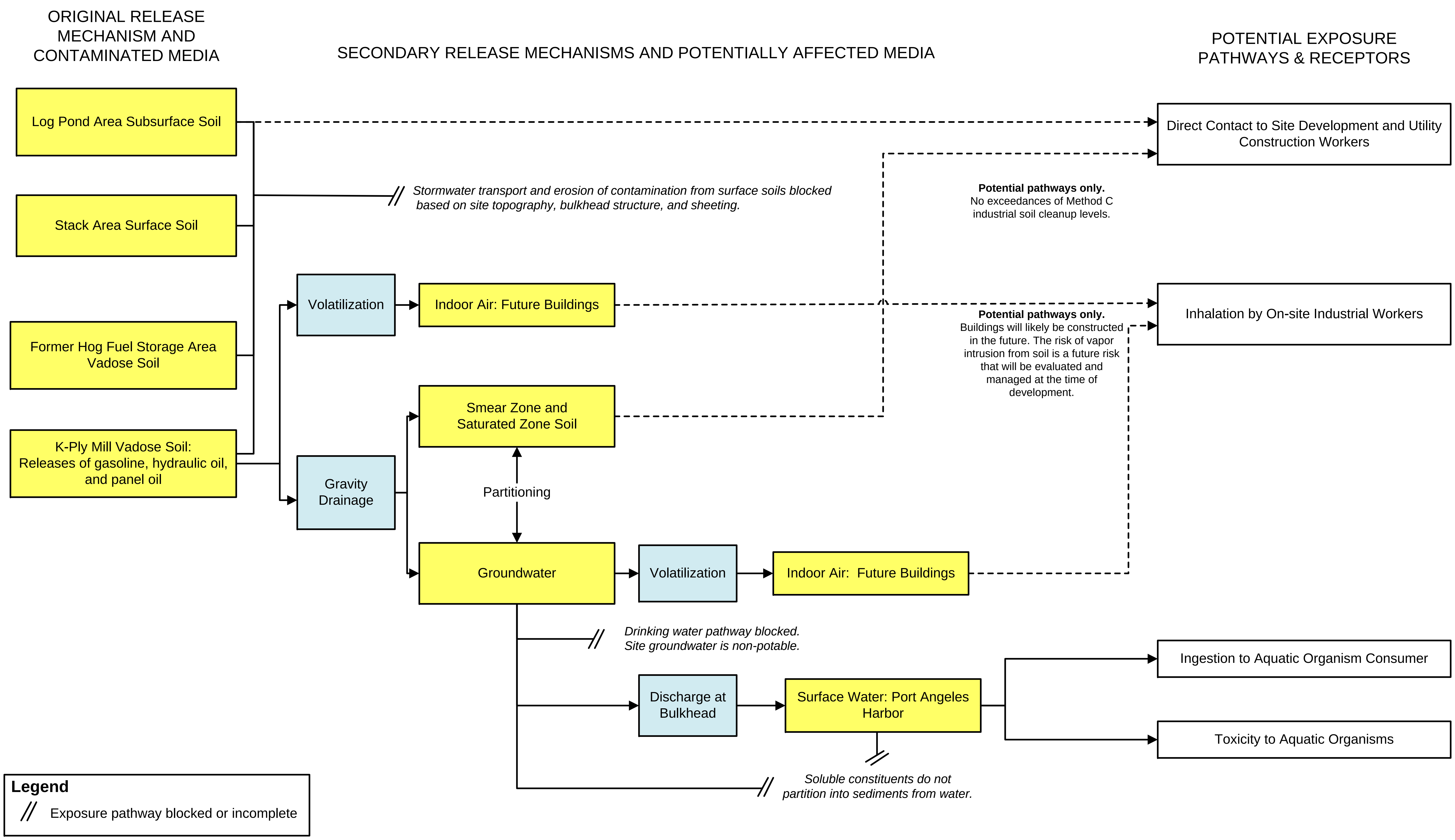
K Ply Site
Port Angeles, Washington

Figure 5.11
Sediment Characterization and Outfall Locations

I:\GIS\Projects\PPA_KPLY\MXD\PublicReviewDraft\Figure 5.11 (Sediment Characterization and Outfall Locations).mxd 3/2/2015



ORIGINAL RELEASE MECHANISM AND CONTAMINATED MEDIA

SECONDARY RELEASE MECHANISMS AND POTENTIALLY AFFECTED MEDIA

POTENTIAL EXPOSURE PATHWAYS & RECEPTORS

Log Pond Area Subsurface Soil

Stack Area Surface Soil

Former Hog Fuel Storage Area Vadose Soil

K-Ply Mill Vadose Soil: Releases of gasoline, hydraulic oil, and panel oil

Stormwater transport and erosion of contamination from surface soils blocked based on site topography, bulkhead structure, and sheeting.

Volatilization

Indoor Air: Future Buildings

Gravity Drainage

Smear Zone and Saturated Zone Soil

Partitioning

Groundwater

Volatilization

Indoor Air: Future Buildings

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

Discharge at Bulkhead

Surface Water: Port Angeles Harbor

Soluble constituents do not partition into sediments from water.

Potential pathways only. No exceedances of Method C industrial soil cleanup levels.

Potential pathways only. Buildings will likely be constructed in the future. The risk of vapor intrusion from soil is a future risk that will be evaluated and managed at the time of development.

Direct Contact to Site Development and Utility Construction Workers

Inhalation by On-site Industrial Workers

Ingestion to Aquatic Organism Consumer

Toxicity to Aquatic Organisms

Legend

// Exposure pathway blocked or incomplete

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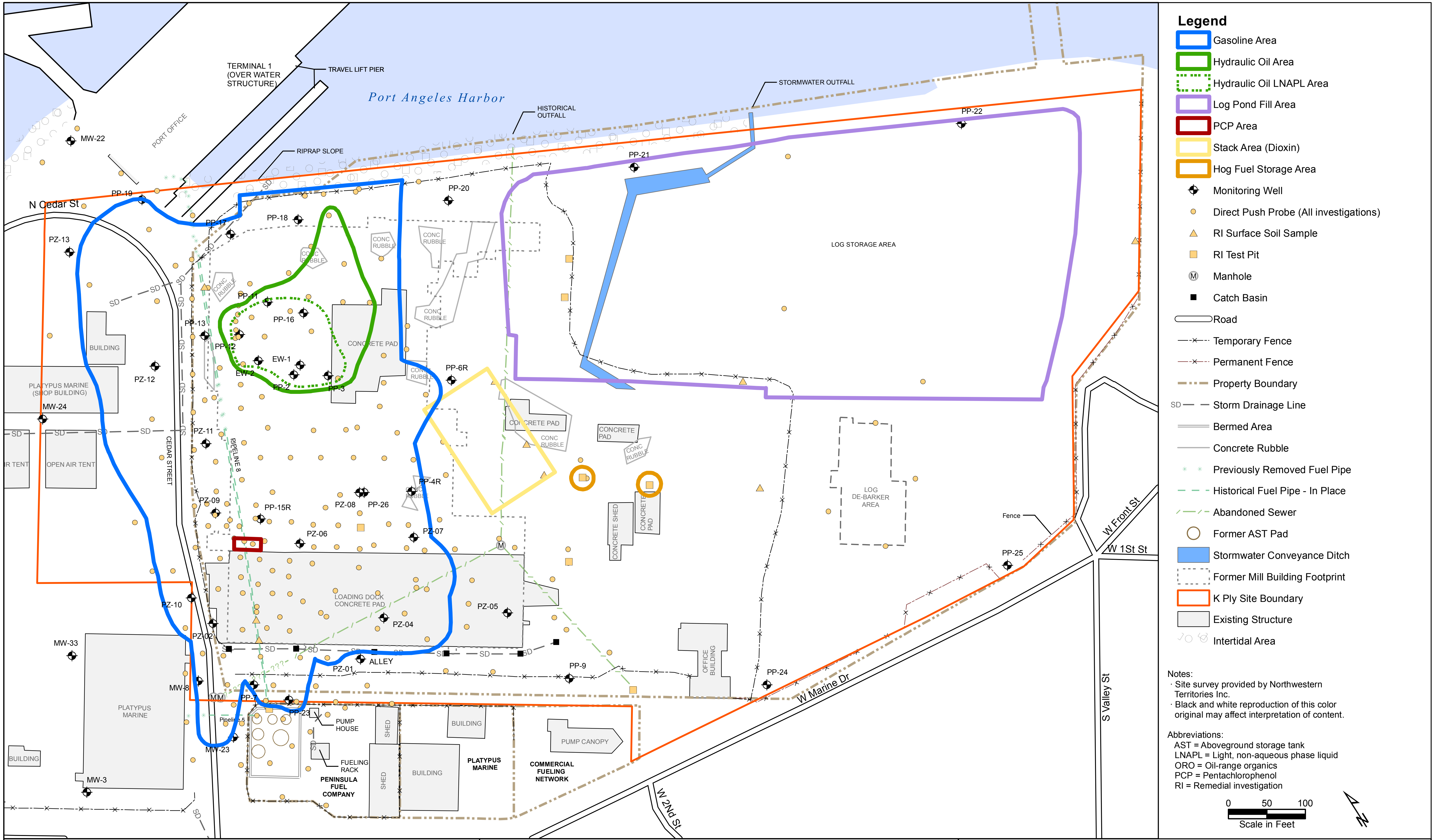
K Ply Site
Port Angeles, Washington

Figure 6.1
Conceptual Site Model of Potential Exposure Pathways and Receptors

\\Merry\data\projects\Port of PA KPLY Mill\AO Task 3c Public Review Draft RIFS Report\Figures\Figure 6.1 Conceptual Site Model_20141030.vsd



Notes:
- Site survey provided by Northwestern Territories Inc.
- Black and white reproduction of this color original may affect interpretation of content.

Abbreviations:
AST = Aboveground storage tank
LNAPL = Light, non-aqueous phase liquid
ORO = Oil-range organics
PCP = Pentachlorophenol
RI = Remedial investigation

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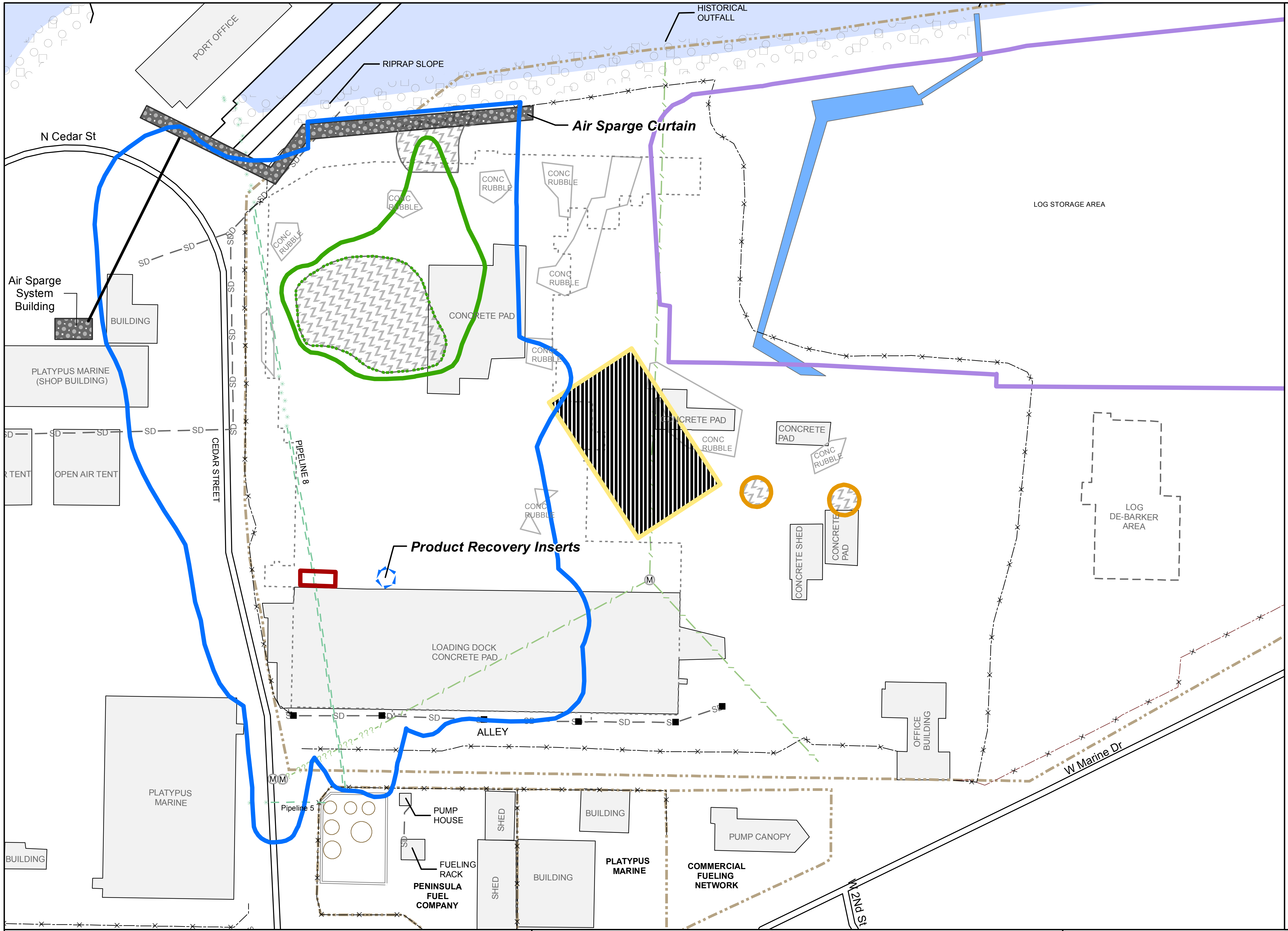
Port Angeles, Washington

Figure 7.1
Site Boundary and Cleanup Areas

I:\GIS\Projects\PPA_KPLY\MXD\PublicReviewDraft\Figure 7.1 - Cleanup Areas.mxd 3/2/2015



Legend

- ▥ Excavate and Relocate On-Site
- ▨ Excavate and Off-Site Disposal or On-Site Treatment and Re-Use
- ▦ Air Sparge Curtain
- 🟦 Gasoline Area
- Approximate Extent of Gasoline LNAPL
- 🟩 Hydraulic Oil Area
- Hydraulic Oil LNAPL Area
- 🟪 Log Pond Fill Area
- 🟥 PCP Area
- 🟨 Stack Area
- 🟧 Hog Fuel Storage Area
- Ⓜ Manhole
- ■ Catch Basin
- Road
- Temporary Fence
- Permanent Fence
- Property Boundary
- SD Storm Drainage Line
- Previously Removed Fuel Pipe
- Historical Fuel Pipe - In Place
- Abandoned Sewer
- ○ Former AST Pad
- Stormwater Conveyance Ditch
- Former Mill Building Footprint
- Existing Structure
- Intertidal Area

Notes:
- Site survey provided by Northwestern Territories Inc.
- Black and white reproduction of this color original may affect interpretation of content.

Abbreviations:
AST = Aboveground storage tank
LNAPL = Light, non-aqueous phase liquid
ORO = Oil-range organics
PCP = Pentachlorophenol

0 50 100
Scale in Feet

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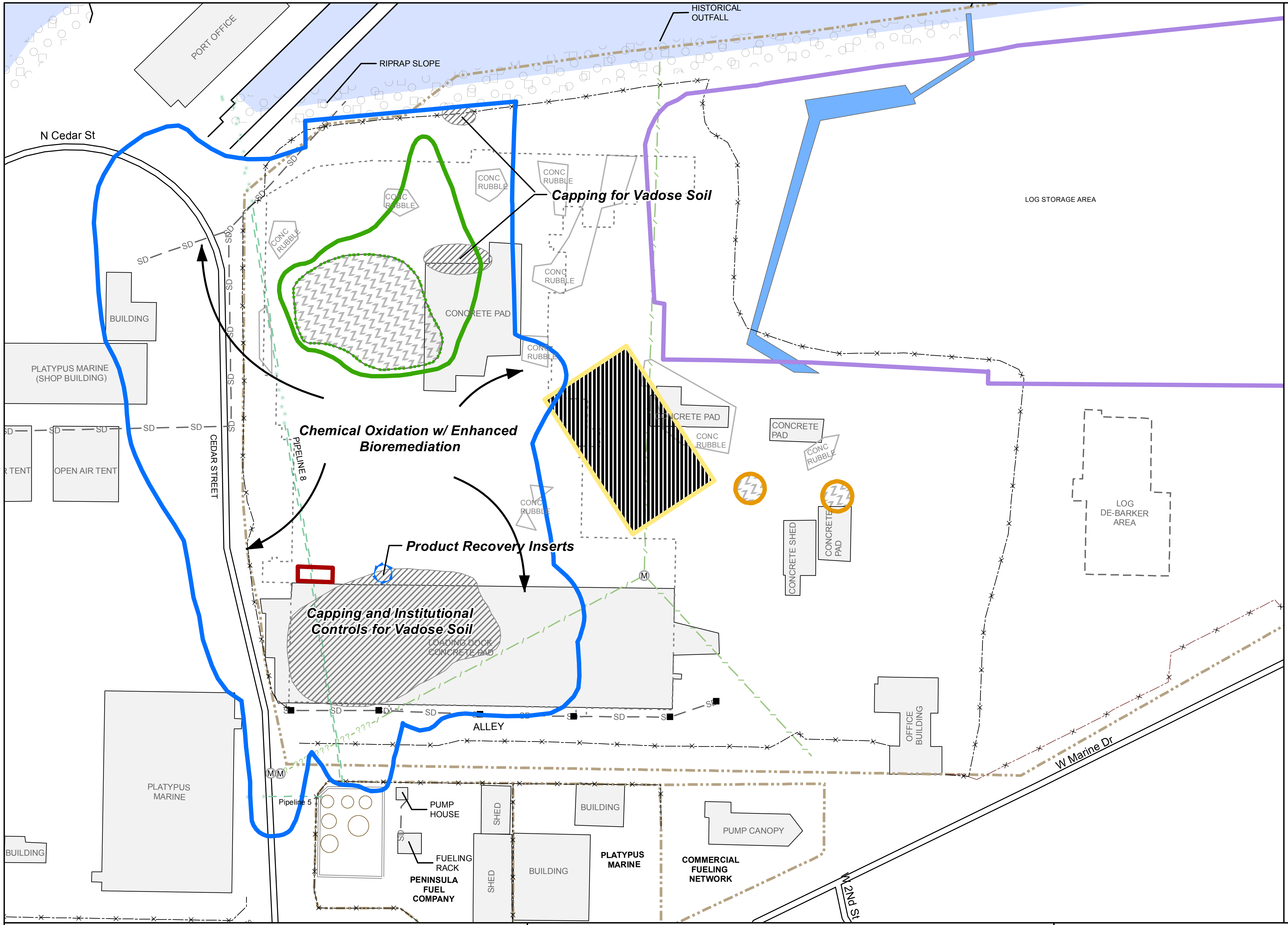
K Ply Site
Port Angeles, Washington

Figure 9.1
Alternative 1: LNAPL/Bulkhead Excavation,
Air Sparge Curtain, and Institutional Controls

I:\GIS\Projects\PPA_KPLY\MXD\PublicReviewDraft\Figure 9.1 - Alternative 1 - LNAPL Bulkhead Excavation, Air Sparge Curtain, and Institutional Controls.mxd 3/2/2015



Legend

- ▥ Excavate and Relocate On-Site, under Future Pavement
- ▨ Capping
- ▨ Excavate and Off-Site Disposal or On-Site Treatment and Re-Use
- ☐ Gasoline Area
- ☐ Approximate Extent of Gasoline LNAPL
- ☐ Hydraulic Oil Area
- ☐ Hydraulic Oil LNAPL Area
- ☐ Log Pond Fill Area
- ☐ PCP Area
- ☐ Stack Area
- ☐ Hog Fuel Storage Area
- Ⓜ Manhole
- ■ Catch Basin
- Road
- —×— Temporary Fence
- —×— Permanent Fence
- Property Boundary
- SD — Storm Drainage Line
- Previously Removed Fuel Pipe
- Historical Fuel Pipe - In Place
- Abandoned Sewer
- ○ Former AST Pad
- Stormwater Conveyance Ditch
- Former Mill Building Footprint
- Existing Structure
- Intertidal Area

Notes:
- Site survey provided by Northwestern Territories Inc.
- Black and white reproduction of this color original may affect interpretation of content.

Abbreviations:
AST = Aboveground storage tank
LNAPL = Light, non-aqueous phase liquid
ORO = Oil-range organics
PCP = Pentachlorophenol

0 50 100
Scale in Feet

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K Ply Site
Port Angeles, Washington

Figure 9.2
Alternative 2: Chemical Oxidation, Capping, and Institutional Control

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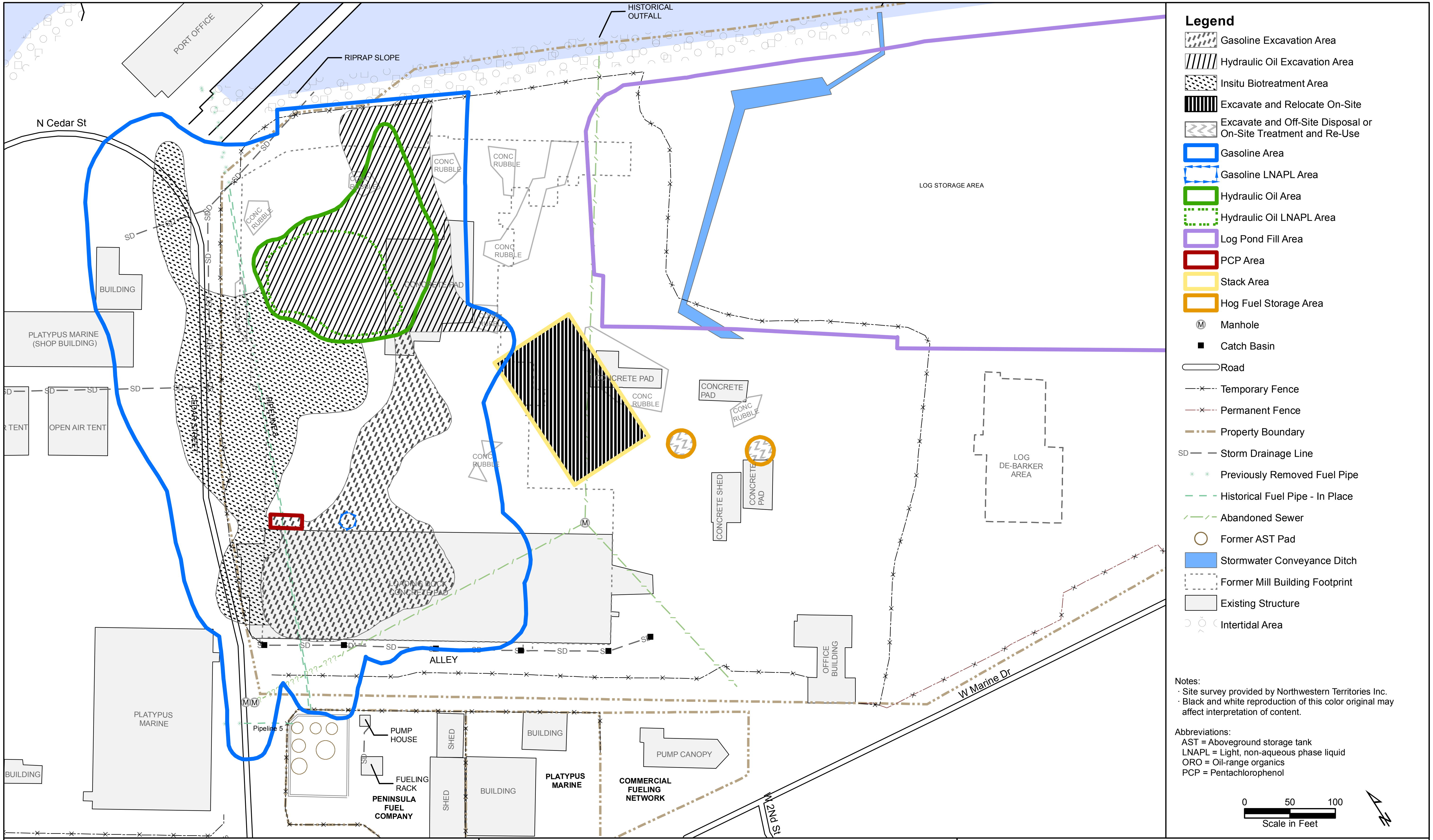

Notes:
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ORO = Oil-range organics
PCP = Pentachlorophenol

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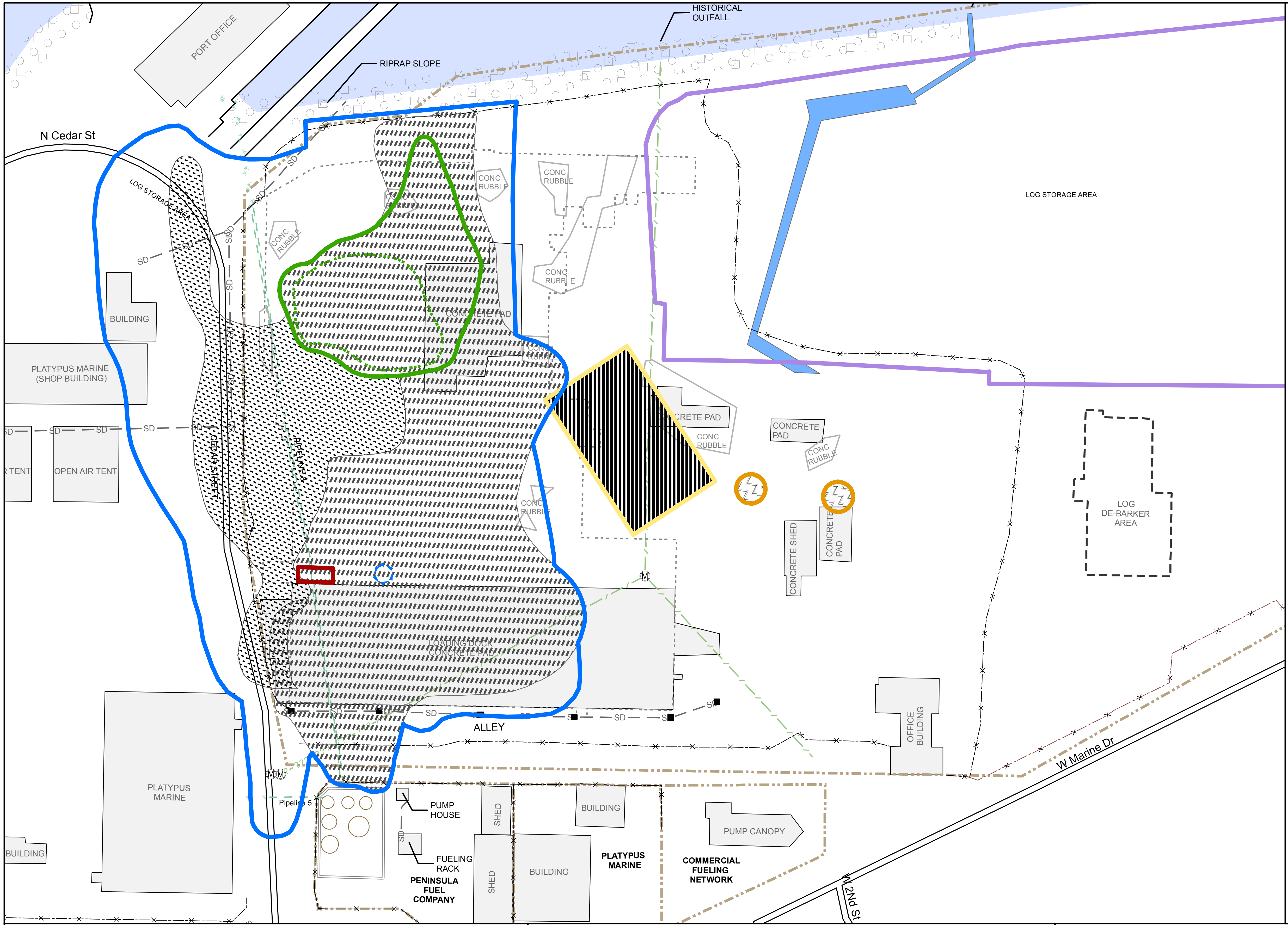
Port Angeles, Washington

Figure 9.3
Alternative 3: Focused Source Control Excavation, Bioremediation, and Institutional Controls

I:\GIS\Projects\PPA_KPLY\MXD\PublicReviewDraft\Figure 9.3 - Alternative 3 - Focused Source Control Excavation, Bioremediation, and Institutional Controls.mxd 3/2/2015



Legend

▨	Insitu Biotreatment Area
▨	Excavate both Smear and Vadose Zone Soils with Enhanced Bioremediation to Follow
▥	Excavate and Relocate On-Site
▨	Excavate and Off-Site Disposal or On-Site Treatment and Re-Use
▭	Gasoline Area
▭	Gasoline LNAPL Area
▭	Hydraulic Oil Area
▭	Hydraulic Oil LNAPL Area
▭	Log Pond Fill Area
▭	PCP Area
▭	Stack Area
▭	Hog Fuel Storage Area
Ⓜ	Manhole
■	Catch Basin
▭	Road
-x-	Temporary Fence
-x-	Permanent Fence
-·-	Property Boundary
SD —	Storm Drainage Line
· ·	Previously Removed Fuel Pipe
— —	Historical Fuel Pipe - In Place
/ — /	Abandoned Sewer
○	Former AST Pad
■	Stormwater Conveyance Ditch
▭	Former Mill Building Footprint
■	Existing Structure
○	Intertidal Area

Notes:
- Site survey provided by Northwestern Territories Inc.
- Black and white reproduction of this color original may affect interpretation of content.

Abbreviations:
AST = Aboveground storage tank
LNAPL = Light, non-aqueous phase liquid
ORO = Oil-range organics
PCP = Pentachlorophenol

0 50 100
Scale in Feet

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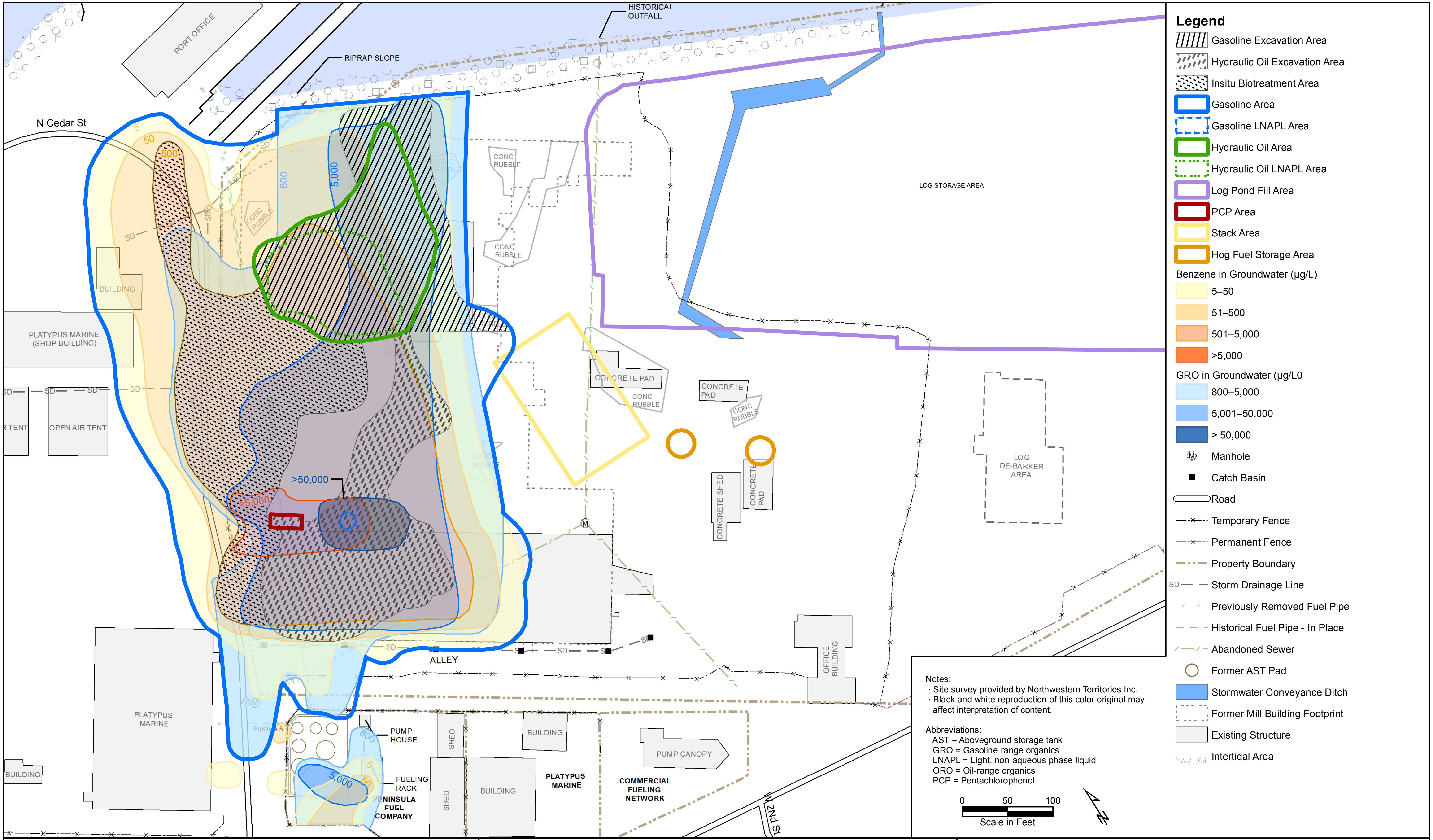
K Ply Site
Port Angeles, Washington

Figure 9.4
Alternative 4: Excavation, Bioremediation, and Institutional Controls

I:\GIS\Projects\PPA_KPLY\MXD\PublicReviewDraft\Figure 9.4 - Alternative 4 - Excavation, Bioremediation, and Institutional Controls.mxd 3/2/2015



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ORO = Oil-range organics
PCP = Pentachlorophenol

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K Ply Site
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Figure 10.1
Proposed Excavation and Groundwater Treatment Areas

I:\GIS\Projects\PPA_KPLY\MXD\PublicReviewDraft\Figure 10.1 - Proposed Excavation and Groundwater Treatment Areas.mxd 3/2/2015

K Ply Site

Remedial Investigation/ Feasibility Study

Appendix A
Key Background Reports
(Provided on disc)

K Ply Site

Remedial Investigation/ Feasibility Study

Appendix B
Three-Phase Rule Calculation for Benzene

MTCA THREE PHASE RULE :

$$Cs = Cw\,(UCF)\,DF\left[Kd + \frac{\theta w + \theta d\ Hcc}{\rho}\right]$$

Calculated Cs

Given:

If Cw= 51 ug/L Proposed Site Cleanup Level

Acceptable concentration in unsaturated soil, calculated with MTCA Three Phase Model

Unsaturated zone soil Cs= 0.29 mg/kg **Proposed Soil Cleanup Level for benzene**

Table 1. Description of three-phase Model Inputs

Saturated Soil

Input	**Symbol**	**Value**	**Unit**	**Notes**
Unit conversion factor	UCF	0.001	mg/ug	
Dilution factor	DF	1	dimensionless	MTCA Default; https://fortress.wa.gov/ecy/clarc/FocusSheets/Default%20Hydrogeologic%20Parameter%20Data.pdf
Distribution coefficient	Kd	0.062	L/kg	MTCA Default Koc for benzene multiplied by MTCA Default foc (0.001)
Water-filled soil porosity	Θw	0.43	mL water/mL soil	MTCA Default; https://fortress.wa.gov/ecy/clarc/FocusSheets/Default%20Hydrogeologic%20Parameter%20Data.pdf
Air-fillled soil porosity	Θa	0	mL air/mL soil	MTCA Default; https://fortress.wa.gov/ecy/clarc/FocusSheets/Default%20Hydrogeologic%20Parameter%20Data.pdf
Henry's Law constant	Hcc	0.228	dimensionless	MTCA Default Hcc
Dry bulk soil density	ρb	1.5	kg/L	MTCA Default; https://fortress.wa.gov/ecy/clarc/FocusSheets/Default%20Hydrogeologic%20Parameter%20Data.pdf

Unsaturated Soil (Vadose Zone)

Input	**Symbol**	**Value**	**Unit**	**Notes**
Unit conversion factor	UCF	0.001	mg/ug	
Dilution factor	DF	20	dimensionless	MTCA Default; https://fortress.wa.gov/ecy/clarc/FocusSheets/Default%20Hydrogeologic%20Parameter%20Data.pdf
Distribution coefficient	Kd	0.062	L/kg	MTCA Default Koc for benzene multiplied by MTCA Default foc (0.001)
Water-filled soil porosity	Θw	0.3	mL water/mL soil	MTCA Default; https://fortress.wa.gov/ecy/clarc/FocusSheets/Default%20Hydrogeologic%20Parameter%20Data.pdf
Air-fillled soil porosity	Θa	0.13	mL air/mL soil	MTCA Default; https://fortress.wa.gov/ecy/clarc/FocusSheets/Default%20Hydrogeologic%20Parameter%20Data.pdf
Henry's Law constant	Hcc	0.228	dimensionless	MTCA Default Hcc
Dry bulk soil density	ρb	1.5	kg/L	MTCA Default; https://fortress.wa.gov/ecy/clarc/FocusSheets/Default%20Hydrogeologic%20Parameter%20Data.pdf

K Ply Site

Remedial Investigation/ Feasibility Study

Appendix C
Cultural Resources Monitoring Report

REDACTED VERSION—Archaeological Monitoring Report for the K Ply Site Remedial Investigation, City of Port Angeles, Washington

Submitted to:
Floyd|Snider

Submitted by:
Historical Research Associates, Inc.
Angus Raff-Tierney, MA
Jennifer Gilpin, MA

Seattle, Washington
April 2014

HISTORICAL
RESEARCH
ASSOCIATES, INC.

This redacted version of the K Ply Site Remedial Investigation Project's archaeological monitoring report was prepared by Angus Raff-Tierney, MA, and by Jennifer Gilpin, MA, who meet the Secretary of the Interior's professional qualifications standards for archaeology. This report is intended for use by the public, at the discretion of the Client and its representatives. It contains professional conclusions regarding the results of archaeological monitoring during the project.

Executive Summary

Floyd|Snider is assisting the Port of Port Angeles (Port) with investigation and cleanup of environmental contamination at the K Ply Site under Agreed Order No. DE 9546 (Agreed Order [1]) with the Washington State Department of Ecology (DOE). The first phase of Floyd|Snider's investigative work across the K Ply Site includes surface samples on the site, direct-push geoprobe borings, the installation of several new monitoring wells; and the excavation of test pits. The K Ply Site is located along the Port Angeles Harbor shoreline in Clallam County, Washington.

Due to the involvement of the DOE, the associated archaeological monitoring work was completed in compliance with State of Washington regulations regarding the consideration of cultural resources, including those outlined in the State Environmental Protection Act (SEPA), and RCW 27.53 and 27.44. In addition, the Port, the City of Port Angeles (City) and the Lower Elwha Klallam Tribe (LEKT) have an agreement that all ground disturbing activities along the City's waterfront (between the bluff to the south and the shoreline) be monitored, with oversight by the City and/or LEKT representatives.

During monitoring, two historic period resources were identified: a pair of 1940s era fuel pipes (Pipeline 8) and a railroad spur dating to the early 1900s. The 1940s fuel pipelines were exposed to investigate the exterior condition of the pipes and for the purpose of pressure testing to verify their integrity. HRA has not yet recorded the pipes as an archaeological site because it is anticipated that, as remediation activities continue, the pipes may eventually be identified as an element of the larger archaeological site complex and its potential association will then be more evident.

The railroad spur (recorded as another segment of previously recorded railroad site 45CA458) is in good condition. This segment of Site 45CA458 has not been evaluated for eligibility for listing in the National Register of Historic Places (NRHP) at this time, as relatively little of the grade is currently visible and it is beyond the scope of the current monitoring project.

In keeping with the agreement between the Port, City and LEKT, HRA recommends archaeological monitoring of future excavations associated with the remediation work. At that time, additional features may be exposed and more information may be added to our knowledge of the observed archaeological resources. If future work will impact the resources, HRA recommends that they be evaluated for eligibility for listing in the State and National historic registers.

If additional archaeological deposits are inadvertently discovered during construction, and a professional archaeologist is not present, procedures outlined in the LEKT Monitoring Plan should be followed.

If additional ground-disturbing activities encounter human skeletal remains during the course of construction, then all activity that may cause further disturbance to those remains must cease, and the area of the find must be secured, covered from view, and protected from further disturbance. In addition, the finding of human skeletal remains must be reported to the Clallam County Coroner and local law enforcement (Port Angeles Police Department) in the most expeditious manner possible. The remains should not be touched, moved, or further disturbed.

The Coroner will assume jurisdiction over the human skeletal remains and make a determination of whether those remains are forensic or non-forensic. If the coroner determines the remains are non-forensic, the coroner will report that finding to the Department of Archaeology and Historic Preservation (DAHP), which will then take jurisdiction over the remains. The State Physical Anthropologist will make a determination of whether the remains are Indian or Non-Indian, and report that finding to any appropriate cemeteries and the affected tribes. The DAHP will then handle consultation with the affected parties as to the future preservation, excavation, and disposition of the remains.

Table of Contents

List of Figures

List of Tables

1. Introduction and Project Description

Floyd|Snider is assisting the Port of Port Angeles (Port) with investigation and cleanup of environmental contamination at the K Ply Site under Agreed Order No. DE 9546 (Agreed Order [1]) with the Washington State Department of Ecology (DOE). The K Ply Site is located along the Port Angeles Harbor shoreline in Clallam County, Washington (Figure 1-1).

The first phase of Floyd|Snider's investigative work included surface samples on the site and nearshore locations (including the removal of sediments up to 6 inches below ground surface); direct-push geoprobe borings; the installation of several new monitoring wells; and the excavation of test pits (Floyd|Snider 2013, Figure 1-2). This work took place over two phases, in September and October, 2013.

1.1 Regulatory Context

Due to the involvement of the DOE, the associated archaeological monitoring work was completed in compliance with State of Washington regulations regarding the consideration of cultural resources, including those outlined in the State Environmental Protection Act (SEPA), and RCW 27.53 and 27.44. In addition, the Port, City of Port Angeles (City) and the Lower Elwha Klallam Tribe (LEKT) have an agreement that all ground disturbing activities along the City's waterfront (between the bluff to the south and the shoreline) be monitored, with oversight by the City and/or LEKT representatives.

Historical Research Associates, Inc. (HRA) informally contacted the LEKT's cultural resources archaeologist, William White, to inform him of the two phases of archaeological monitoring. Contact took the form of emails and telephone conversations. HRA emailed daily monitoring forms and selected photographs to Mr. White as a method of project update reports.

1.2 Area of Impacts

The Area of Impacts (AI) is defined as the portions of the proposed Project wherein ground-disturbing activities could impact human remains or archaeological deposits that are eligible for listing in national, state, or local registers. The project AI is proposed to consist of the entire parcel under investigation, where environmental testing may occur. This area measures approximately 21.5 acres.

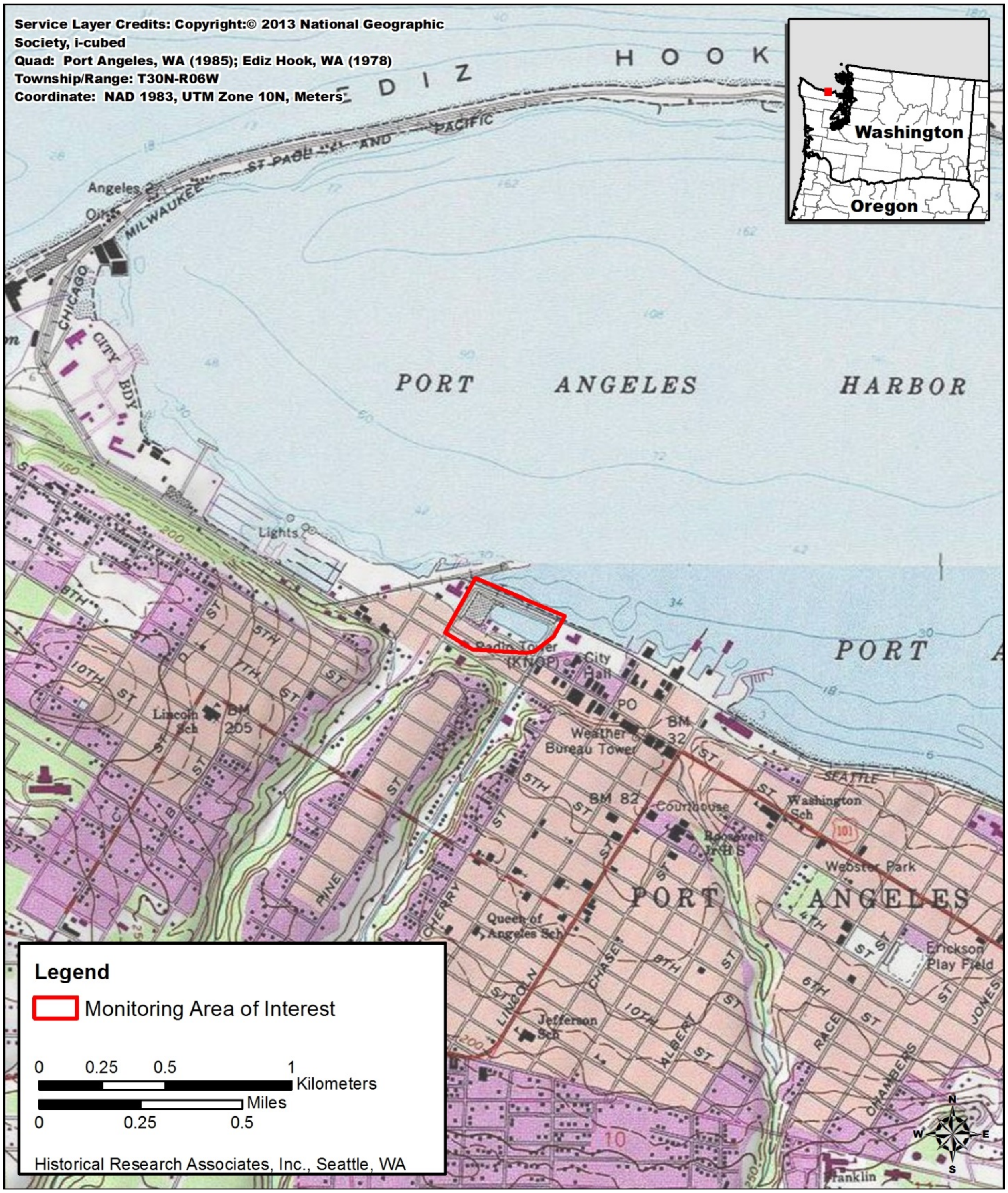

Figure 1-1. Location of the Project.

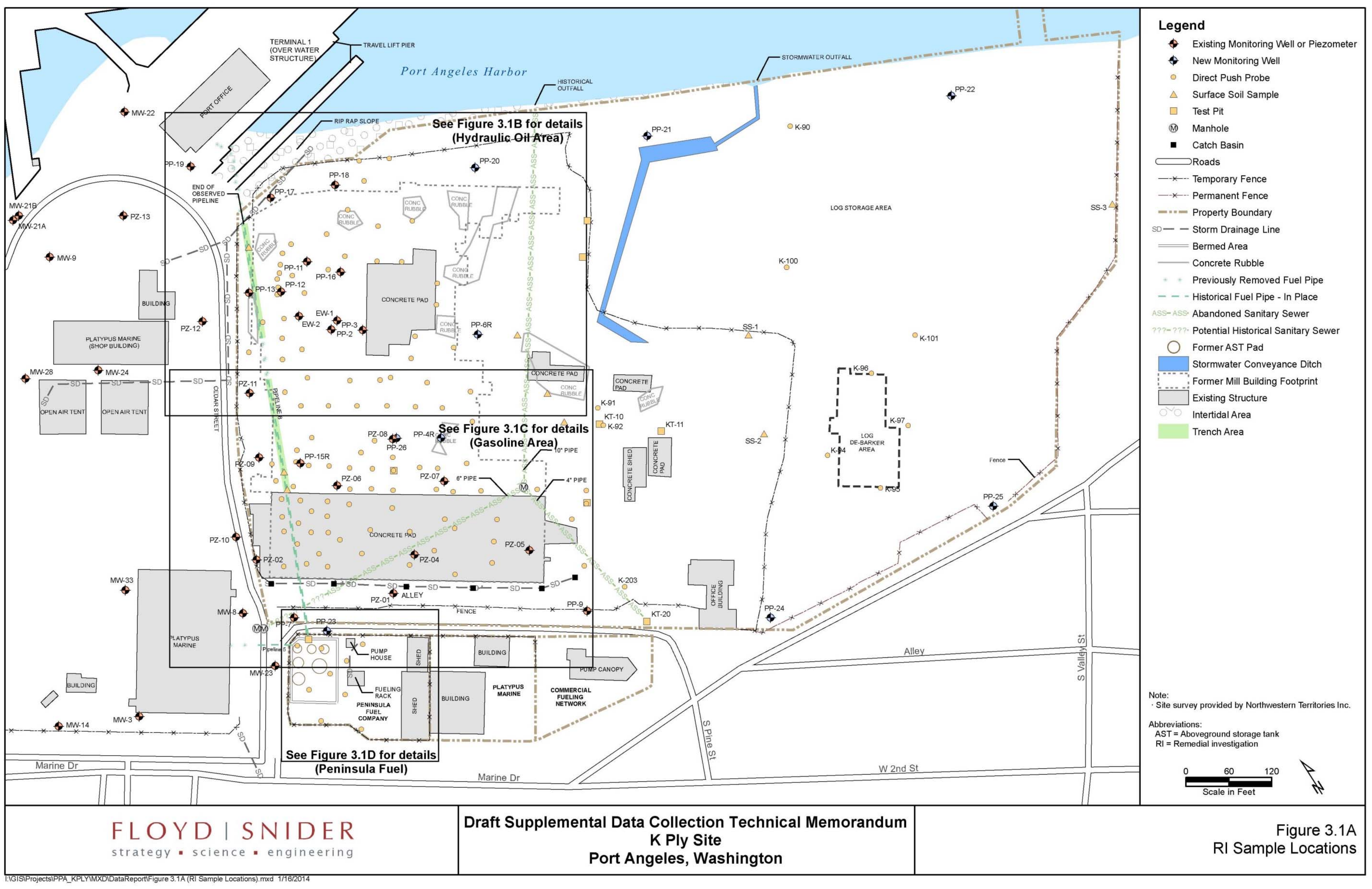

Figure 1-2. Figure prepared by Floyd|Snider, showing the locations of environmental sampling activities in the monitoring Area of Interest.

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2. Archival Research

2.1 Methods

Previous archaeological monitoring of the AI was conducted by Floyd|Snider and Landau Associates, and archival research was performed prior to each of these investigations (Meoli 2008; Tingwall and Rust 2009). Ahead of archaeological monitoring at the K Ply AI in 2013, HRA conducted a brief review of the Department of Archaeology and Historic Preservation's (DAHP) Washington Information System for Architectural and Archaeological Records Data (WISAARD) to supplement the previous research, to prepare an environmental and cultural context, and to develop probabilities for cultural materials in the AI.

HRA archaeologist Jennifer Gilpin, MA, conducted an archival research update to determine if additional cultural resource studies had been conducted and archaeological resources had been recorded since 2009. Gilpin reviewed WISAARD for archaeological site records and cultural resource survey reports. Gilpin and HRA field archaeologist Angus Raff-Tierney, MA, also reviewed historic-period nineteenth-century maps from the United States Surveyor General (USSG) General Land Office (GLO), the United States Geological Service (USGS), and assorted maps available online at the Washington State Digital Archives, the University of Washington Libraries, and other local and regional repositories.

2.2 Results

2.2.1 Cultural Resources Studies

As mentioned in Section 2.1, two archaeological monitoring projects have been performed within the AI (Table 2-1). Floyd|Snider (Meoli 2008) and Landau Associates (Tingwall and Rust 2009) performed archaeological monitoring during previous phases of environmental testing at the K Ply project area. Neither phase of archaeological monitoring recorded precontact archaeological materials or historic-period archaeological sites.

Floyd|Snider monitored the excavation of direct-push geoprobe bore samples and split spoon samples extracted from monitoring well locations. The monitoring archaeologist observed low densities of marine shell in soil samples—determined to be natural—along with mixed historic-period to modern debris. Fill dredge sands were also observed to depths of 16 feet below surface (ftbs) (Meoli 2008:2–3). Landau Associates monitored the excavation of trackhoe test pits and direct-push geoprobe borings. Grayish-brown to olive brown fill was observed between 1.5 and 12 ftbs. The fill overlay greenish black to dark grayish green to gray fine to coarse sand with gravels, interbedded with silty sand to sandy silt, and moderately to highly broken shell. It appeared that portions of the lower level, which was interpreted as intertidal sands, was likely disturbed and/or redeposited as fill (Tingwall and Rust 2009:6–7).

Table 2-1. Cultural resources investigations close to the AI.

NADB #	**Reference**	**Title**	**Distance from AI**
1351311	Meoli 2008	*Marine Trades Area – Cultural Resource Monitoring Project Number: SJZ-MTA Task 6*	Within AI
1352816	Tingwall and Rust 2009	*Results of Cultural Resources Monitoring, MTA/K-Ply Cedar Street Benzene Investigation, Clallam County, Washington*	Within AI
1353719	Wengler Surveying & Mapping Co. 2007	*Maps Showing the Location of the Shoreline Between 1864 and 2007, Port Angeles Harbor, Clallam County, Washington*	Within AI
1354363	Kiers 2010	*Section 106 Compliance, State Route 117, Tumwater Truck Route – Major Electrical CRP Report No. 10-10.*	Approximately 150 ft W
1354857	Wessen 2010	*A Report of Archaeological Monitoring of Construction Activities at the East Boat Haven Sheet Pile Retaining Wall Repair Project Area, Port Angeles, Clallam County, Washington*	Approximately 1,500 ft W
1680016	Beery 2010a	*Combined Sewer Overflow Project: Cultural Resources Assessment for CSO Phase I Project, City of Port Angeles, Clallam County, Washington*	Approximately 0.2 mi SE
1680863	Beery 2011a	*Lower Elwha River Restoration Project: Archaeological Monitoring for Stormwater Separation to Mitigate Lower Elwha Flow to City of Port Angeles (Task Agreement No. 16 Mod 1), Clallam County, Port Angeles.*	<100 ft SE
1681854	Gall and Holshuh 2011	*Archaeological Monitoring of the Tumwater Creek Bridge Replacement Project, Port Angeles, Washington*	Approximately 1,500 ft W

Wengler Surveying & Mapping Company prepared a series of maps showing the changing shoreline along the Port Angeles Harbor between 1864 and 2007. This document covers the AI, although it is not technically a cultural resources survey report. Sheets 7 and 8 in the map set, showing the 1924 shoreline, depict the Chicago, Milwaukee & St. Paul Railway trestle enclosing what appear to be tidal flats. By 1940, on Sheet 10, this area is depicted as being filled in (Wengler Surveying & Mapping Co. 2007).

An additional five surveys have been conducted within approximately 0.25 mi of the AI since 2009, ahead of proposed stormwater and sewer improvement projects (Table 2-1). Two of the surveys specifically call out archaeological sites that are applicable to the AI. Beery (2010a:118–121) cites nearby archaeological and historic sites—including the Milwaukee Road (45CA458) and Puget Sound Cooperative Community (45CA236h)— but did not find evidence of archaeological materials in that Area of Potential Effects (APE). During an archaeological monitoring project, Gall and Holshuh (2011) observed portions of a railroad spur line, likely associated with the Milwaukee Road (45CA458; see Section 2.2.2).

2.2.2 Archaeological Sites

Five previously-recorded archaeological sites and two isolated precontact finds were identified during archival research. Tingwall and Rust (2009:5) address the majority of these sites. The four precontact sites comprise several places of temporary to more permanent occupation and/or resource processing. Two precontact isolated finds have been recorded in the search radius by former City of Port Angeles archaeologist Derek Beery (Beery 2008, 2011b).

The historic-period archaeological site is 45CA458, the Chicago, Milwaukee, St. Paul & Pacific Railroad (also known as the Milwaukee Road) (Beery 2010b; Ferland 2010; Speulda et al. 1994). The line has not been formally evaluated for listing in the NRHP, although in WISAARD it is listed as "potentially eligible." The line, originally conceived as a logging railroad in the early 1900s by Michael Earles, was extended to Port Angeles with the help of investors. The right-of-way through Port Angeles was secured by 1914 and the railroad was constructed by 1916 under the name Seattle, Port Angeles, and Western Railroad Company. In December 1918/January 1919, the project was transferred to the Chicago, Milwaukee, St. Paul & Pacific Railroad. During World War I, the railroad was utilized as part of the Spruce Railroad, intended to ship the strong, light wood for use in aircraft. During the 1920s and 1930s, the railroad was utilized by commercial logging companies, although the line also operated a passenger service at this time. The railroad was sold to the Seattle and North Coast Railroad in 1980, and it was abandoned by 1985 (Beery 2010b; Ferland 2010; Secrest 1997; Wiersema n.d.).

3. Environmental and Cultural Setting

The following sections provide a brief overview of the environmental and cultural background for the Project vicinity. This overview is primarily drawn from *Marine Trades Area – Cultural Resource Monitoring Project Number:SJZ-MTA Task 6* (Meoli 2008), *Results of Cultural Resources Monitoring, MTA/K-Ply Cedar Street Benzene Investigation, Clallam County, Washington* (Tingwall and Rust 2009), and *K-Ply Mill Remedial Investigation/ Feasibility Study Work Plan* (Floyd|Snider 2013).

3.1 Environmental Context

3.1.1 Topography and Geology

The AI is located adjacent to Port Angeles Harbor on flat land at 15 ft above mean sea level. Ediz Hook, a sand spit that began development approximately 9,000 years ago, divides this protected harbor from the main body of the Strait of Juan de Fuca. Elevation rises quickly inland and to the south, where bluffs line the beach and lowland hills give way to the northern Olympic Mountains. The project area is flanked on either side by the Tumwater and Valley creeks (Tingwall and Rust 2009). Fill deposits dredged from the harbor, and possibly derived from the 1914 sluicing project (see Section 3.2), overlie native beach deposits and measure 8 to 16 ft thick. Native beach deposits developed and deposited during the Holocene are about 30 ft thick and overlie approximately 300-ft-thick glacial deposits and bedrock. Bedrock in the vicinity of the AI is from the Twin River Formation, which consists of olive to greenish gray claystone, mudstone, and siltstone and dates to the late Eocene to early Miocene (Floyd|Snider 2013).

Examination of the historic-period maps presented in Wengler Surveying & Mapping Co. (2007) and the 1879 GLO map (Figure 3-1) show that the historic-period shoreline was located within the southern portion of the AI. As Wessen points out, a sea level curve taken by Gowan (2007) indicates that the sea level had risen to "within a few meters of the modern level by ca. 5,000 years B.P.," meaning that during the Late Pleistocene and early Holocene, the harbor shoreline was somewhat farther north, and that the AI would have largely been a terrestrial environment. These deposits, if extant (and not eroded away), would likely be deeply buried (Wessen 2010:5).

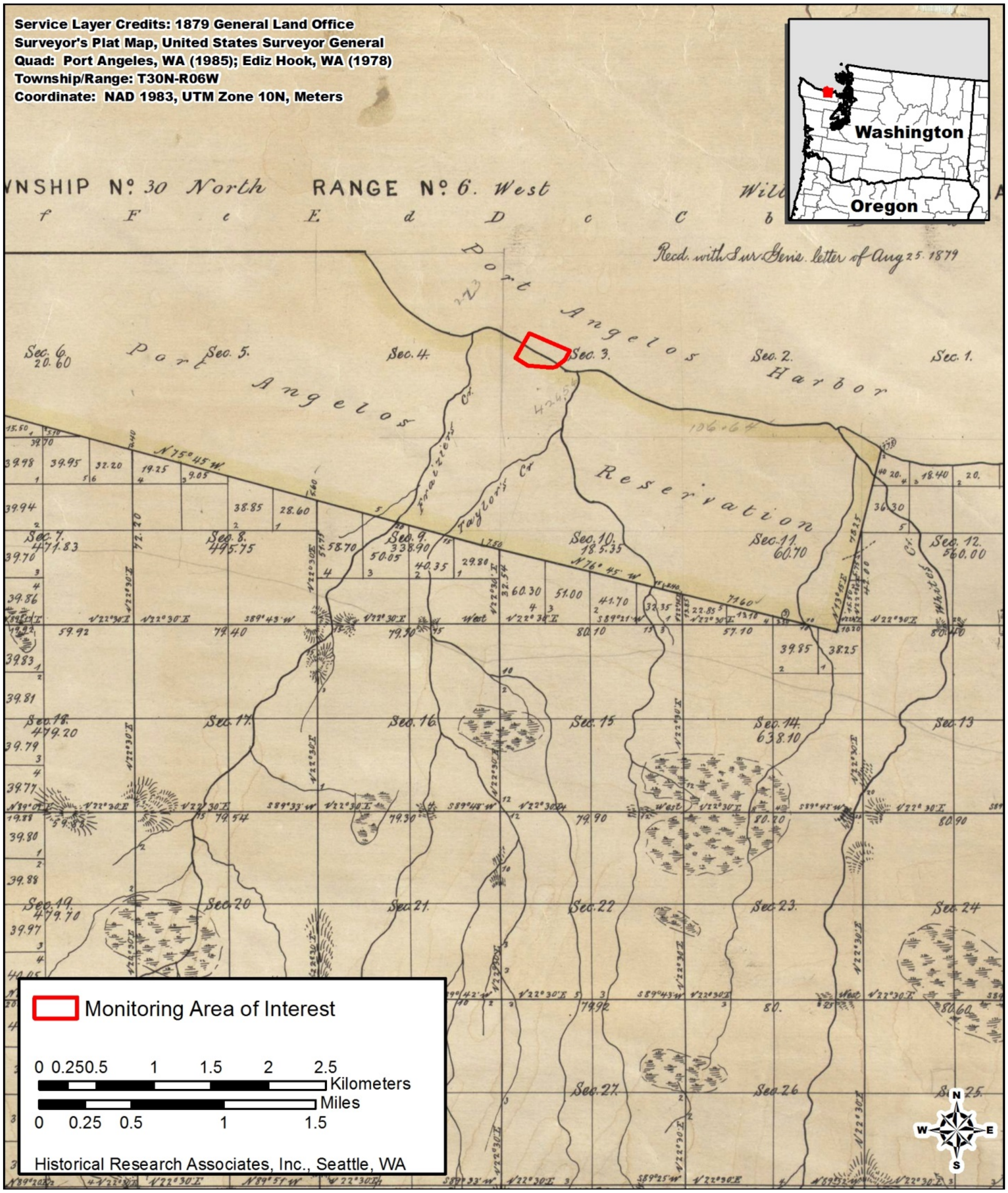

Figure 3-1. General Land Office map from 1879, showing the location of the AI on the historic shoreline of Port Angeles Harbor.

3.1.2 Flora and Fauna

The protected harbor provided by Ediz Hook provided an ecosystem bountiful in flora and fauna available to the region's inhabitants over the past several millennia. The lower elevations of the Olympic Peninsula, historically, have been dominated by coniferous forests including Douglas fir (the dominant species), western hemlock, and western red cedar. Moist areas also include stands of bigleaf and vine maple, or red alder, along with black cottonwood and a variety of willow species. The moderate to dense undergrowth in drier areas includes sword fern, salal, Oregon grape, red huckleberry, and elderberry. Riparian zones, including those closer the AI, include understories of reeds, cattail, nettles, skunk cabbage, and hydrophilic species (Franklin and Dyrness 1973).

Larger land mammals, including Roosevelt elk, black-tailed deer, black bear, and wolf, were historically available in the region surrounding the AI, as were marine mammals such as orcas and harbor seals. Non-migratory elk and deer may have foraged along stream courses in lower elevations, close to the AI. Smaller mammals, including waterfowl, raccoon, rabbit, and squirrel, would also have utilized the vicinity of the AI. Salmon were present in the larger creeks, and they were certainly readily available to inhabitants of the AI vicinity. Marine invertebrates available along the coastline, within or close to the AI, included butter and horse clams, sea and bay mussels, scallop, native oysters, cockles, limpets, barnacles, and sea urchins (Schalk 1988; Suttles 1990).

3.2 Cultural Context

3.2.1 Prehistory

Human occupation of the Port Angeles area began soon after the last glacial retreat approximately 11,500 years ago. Ediz Hook formed between 9,000 and 5,000 years ago, creating a protected harbor with broad beaches and lagoons. Such ecosystems nurtured a local abundance of plant and animal life which would have encouraged human occupation around the AI (Tingwall and Rust 2009:3). The overall climatic regime did not settle into a modern pattern until circa 5,000 years ago, coinciding with the establishment of more permanent settled village occupations (Kovanen and Easterbrook 2001).

Ames and Maschner's (1999) generally accepted cultural chronology for the Central Northwest Coast is used here. Their phases are based on specific technologies and increasing sedentism, resulting in a five-period schema: Paleo-Indian (~12,500 to 10,500 B.C.), Archaic (10,500 to 4400 B.C.), Early Pacific (4400 to 1800 B.C.), Middle Pacific (1800 B.C. to A.D. 500), and Late Pacific (A.D. 500 to 1775). The Paleo-Indian and Archaic people were nomadic and primarily hunters who would have left minimal trace in the archaeological record. Early sites in the Puget Sound consist of lithic scatters, and may represent camping or foraging locations. High acid content in soils in the

Puget Sound region tends to decompose bone, shell, wood and textiles, while allowing for the preservation of lithic artifacts (Nelson 1990:481). Due to preservation and macro-level changes to the topography, older archaeological remains in the AI are most likely to be related to the Late Pacific period and Ethnohistoric period (after 1775 A.D.) (Ames and Maschner 1999).

3.2.2 Ethnographic Context and Native American Traditional Land Use

The area is the traditional home of the Klallam people, who relied on the project area vicinity for hunting, fishing, and gathering (Eells 1889; Gunther 1927). Three Klallam villages have been reported in the vicinity of Port Angeles in historic and ethnographic documents - the *Tze-whit-zen* village, the *I'e'nis* village, and a third unnamed village are listed(Tingwall and Rust 2009:4). This information heightens the probability that archaeological materials associated with ethnographic- to historic-period Native American residential activities, as well as resource procurement, could be identified in the AI.

3.2.3 Historic Period Non-Native Context

Port Angeles Harbor was first sighted by Europeans in 1791 and named by Don Francisco de Eliza. White settlement of the area began in the 1860s, and by the late 1800s lumber mills and railroads were expanding in the area. Port Angeles soon became one of the largest suppliers of lumber products on the West Coast (Tingwall and Rust 2009:2–4).

Outside of the AI, Port Angeles was undergoing drastic physical changes in the first decades of the twentieth century. In 1914, the "Hog Back" hillside near Lincoln Street, followed by the steep Front Street Hill, were regraded using water pumped from the bay. The sluiced sediments were used as fill to raise up the downtown Port Angeles streets by 10 to 14 ft (Martin 1983:106, 109-119).

The Milwaukee Road (45CA458) was constructed by 1916 (Beery 2010b). At this time, much of the AI was still intertidal shoreline. A rail spur from the main line was extended into the AI, to what would eventually be the K Ply Mill. Wood products from the mill were loaded and transported to Port Townsend. Timbers associated with the railroad trestle, and the eventual bulkhead, were largely creosote treated (Floyd|Snider 2013:2-3).

The AI was first partially filled in 1926 with hydraulic fill from Port Angeles Harbor. The current, northern bulkhead wall was built at this time, and a second bulkhead was built further inland (Floyd|Snider 2013:2-1). The M. R. Alleman mill, a small lumber mill about which little is known, was constructed just behind this second bulkhead. Sometime before 1941 this mill closed and the entire area south of the outer bulkhead except the log pond was filled (Floyd|Snider 2013:2-3).

In 1941, the Peninsula Plywood Corporation constructed the PenPly Mill at this site. Plywood constructed at the mill was utilized for the war effort in World War II and during the post-war boom. The mill operated under various owners, including ITT Rayonier, Klukwan, Inc. (who renamed the mill "K Ply"), and Peninsula Plywood Company, until it was closed permanently in 2011 (Floyd|Snider 2013:2-3 to 2-4; Martin 1983:140; Tingwall and Rust 2009:4–5). Operations through these years included log storage (in the yard and log pond, which was excavated in 1941 and periodically filled from 1946 until it was completely filled in 1997), hog fuel burning, and log debarking and peeling (Floyd|Snider 2013:2-3, 2-6).

4. Procedures for Archaeological Monitoring and the Treatment of Archaeological Resources

The LEKT, as part of the agreement with the City, has prepared a general monitoring plan for construction work along the City's waterfront.

The State of Washington requires oversight of all cultural resources related activities to be overseen by a Professional Archaeologist who meets the Secretary of the Interior's qualifications (36 CFR part 61; RCW 27.53.030.8). The Archaeological Monitor (Angus Raff-Tierney) and Monitoring Supervisors (Jennifer Gilpin and Jenny Dellert) followed the plan set out in the LEKT's Monitoring and Inadvertent Discovery Plan (Floyd|Snider 2013:Appendix D). Due to the concerns about contamination of the soils at the K Ply project AI, the monitor was also required to hold a current 40-hour HAZWOPER certification.

The Archaeological Monitor followed these procedures:

- Monitor conformed to all on site safety regulations including wearing a hard hat, safety glasses, steel-toed boots, and high visibility vest, and performed safe behaviors such as making eye contact with the operator when approaching heavy machinery, notifying them to stop work when approaching within the swing zone of their machine, and staying away from all unsecured ledges and pits over 5 ft deep.
- Monitor carried a cellphone, camera, trowel, notebook, and tape measure at all times on the construction site.
- Daily notes were recorded on a notebook, transcribed to HRA's standard monitoring form, and submitted for the Supervisor's review. These notes recorded the depth, location, and description of soil strata, finds, and debris not considered significant. The composition of soil probes was recorded on graph paper, noting changes in stratigraphy and any observations of disturbances or cultural materials. HRA recorded the sample locations that were monitored as well as discussions regarding the project and any findings. Monitoring notes are held on file at HRA's Seattle office pending final archival storage.

- Every few days, a summary of monitoring activities was emailed by Gilpin, with daily monitoring forms and selected photographs to Mr. White, as a form of project update reports.
- All soil deposits with the potential for cultural materials were examined carefully in excavations and spoil piles using equipment, as appropriate, such as a shovel, trowel, and screen of ¼-inch mesh.
- One or more photographs were taken daily to record the work progress, as well as overviews of particular construction areas, soil profiles, cultural materials, and work in progress.
- Under RCW 27.53, it is presumed that historic-period resources are eligible for listing on the NRHP until and unless DAHP makes a determination that they are not.
- The Monitor kept in daily contact with the Monitoring Supervisor to describe construction work, monitoring methods, and findings, and to discuss questions.

The Monitoring Supervisor followed these procedures:

- Supervisor was prepared to conform to on site safety regulations as described above (including proper gear and holding a current 40-hour HAZWOPER certification).
- Supervisor was available to visit site to view finds that were questionable and/or needed immediate attention.

5. Monitoring Results

Archaeological monitoring was conducted by Angus Raff-Tierney, MA, and supervised by Professional Archaeologists Jennifer Gilpin, MA, and Jenny Dellert, MA, who both meet the Secretary of the Interior's qualifications. The Archaeological Monitor was present during all days that included ground disturbance: September 9–13, 18–20, 23 and October 14–16, 2013.

The archaeologist monitored continuous bore geoprobe sampling, split-spoon sampling, and excavation of test trenches.

5.1 Geoprobes

Geoprobes, using a truck-mounted drill, were performed across the K Ply project area in order to locate and assess levels of soil contamination (Figure 5-1). The geoprobes captured sediments in a 1-inch diameter tube, 4 ft at a time, to a depth of between 12 and 20 ft deep. After capturing soil, these tubes were split open and sediments were examined for cultural materials, and for changes between sediment types (Figure 5-2). Three distinct sediments were encountered in the geoprobes: glacial outwash fill, harbor dredge, and native beach sands. The glacial outwash fill consists of brown, tan, or orange fine sand, with 20 to 40 percent subrounded gravel to depths of up to 8 ftbs. This fill may have been left over from the 1914 regrading project on Front Street Hill (Martin 1983:106, 109-119). Some geoprobes, such as K-38, encountered a lens of crushed shell and round gravel within this fill layer from 0 to 4 ftbs; as will be discussed in Section 5.2, this shell-rich lens was identified in broader exposures elsewhere. Below the fill, project personnel noted a layer of sediments 2 to 4 ft thick, dredged from the harbor, which consists of gray or orange oxidized fine sands that sometimes include small shell fragments and fine wood fragments. Native beach deposits were encountered between 7 and 13 ftbs and consist of dark olive-gray medium-grain sand with 10 percent rounded small gravel and shell fragments, interbedded with lenses of fine sand and silts with fine woody debris.

Stratigraphy was fairly uniform across the whole site, but with some variation. There was a trend of shallower native beach deposits farther inland. For example, probes excavated within the former Peninsula (Mobil) fuel yard (see Figure 1-2) encountered native beach sand approximately 5 ftbs, while those in the log yard encountered native sands at 11 to 13 ft deep. Probes excavated in the log yard had the most heavily disturbed profiles, and contained large amounts of wood chips and fragments. This area used to contain a log pond which likely explains the unique contents of these bores.

Figure 5-1. Holocene Drilling geoprobing the K Ply mill yard with the Power Probe 9500D. View west.

Figure 5-2. Soil Probe K-201 next to the former machine shop. .

Two geoprobes advanced within the northern bulkhead next to the harbor yielded unique soil stratigraphies. Both probes contained a 12-ft-thick layer of mixed brown and grey fine to coarse grained sand with shell fragments and 50 percent small to large angular gravel, above native beach sands. The high percentage of large angular gravel, and the thickness of this layer, is different from the rest of the site and is consistent with the Floyd|Snider (2013) report, which contends this outer bulkhead was constructed long before the rest of the site was filled. Soil probe K-89 encountered heavy creosote contamination from 13 to 16 ftbs within the native sands. Creosote is commonly used as a wood preservative for pilings, which were likely a component of the bulkhead.

A few artifacts were found within the soil probes, but most were buried less than 1 ft deep and consisted of modern artifacts consistent with twentieth century milling activities. On a concrete slab present in the AI, a soil probe encountered an object past which it could not drill. The drill rig was repositioned a few feet southeast, and this time it hit a metal object part of which became embedded in the soil probe. Based on maps created by Floyd|Snider depicting the locations of historic-period features within the K Ply complex, it was thought that the first impediment was a rail grade. This rail grade feature was recorded as a continuation of Site 45CA458 (Section 5.4). The second, deeper blockage may also be related to this feature, but this is uncertain. A layer of wood a few inches thick was also encountered in several probes. This wood was observed to separate rockier fill above from fine sand fill below, and may represent boards placed on the former ground surface. It could also be a feature associated with the original mill that existed in the 1920s and 1930s. Further exposures would be necessary to test these observations.

5.2 Test Pits

Four test pits and one trench were excavated within the AI using a small back hoe. The trench was excavated to expose two circa-1940s fuel pipes. The trench measured approximately 250 ft long by 3 ft wide, and 3 ft deep. Above the pipe, one historic-period Pepsi Cola bottle was found in brown fine sandy fill with rounded cobbles and pebbles (See section 5.4). Whole and crushed marine shells were exposed above and beside the fuel pipeline, and surrounding another concrete pipe buried at a depth of 1 to 2 ftbs (Figure 5-3). The shell-rich layer measures approximately 1 ft thick and also includes rounded gravels. It is located within the top brown fine sand fill layer. No evidence of fire was observed in the shell (i.e., no charcoal, fire-modified rock [FMR], or black staining). No artifacts were observed within the shell lens and it was determined to be a natural beach deposit deposited as fill within the pipe trench.

Four test pits were excavated around the AI to depths between 1 and 9 ftbs. Test pit KT-13 was excavated to 7 ftbs on a mound in the northeastern area of the K Ply mill, and consisted entirely of decomposed wood. Test pit KT-12, excavated southwest of the extant K Ply office, consisted entirely of fill characterized by tan to brown sandy silt with subrounded, unsorted pebble- to cobblesized rocks. This fill—identified as glacial till—was seen in two shallow 1- to 2-ft deep test pits in the center of the K Ply mill area (KT-21 and KT-10), and in the southern exposure of the fuel pipelines. In test pit KT-12, excavated in a dry well catch basin, a fragment of a shirt and a modern tape measure were found amid wood fragments and black liquid 7 ft down within this fill. Native beach sands consisting of olive gray medium grain sands with small shell fragments were encountered at the bottom of the 9-ft pit.

Figure 5-3. Shell layer within sand fill surrounding a concrete utility pipe found within the trench.

5.3 Augering for Monitoring Wells

Augering to install monitoring wells occurred on September 18–20, 2013, using a 40 ft long, 9 ft wide truck mounted drilling rig with a 30 ft high mast (Figure 5-4). Split spoons sampled 1.5 ft of dirt every few feet, starting at 2.5 ft deep to a maximum depth of 19 ft. Augering occurred in the K Ply mill area and around the edges of the log yard to the east. Augering in both the southeast and northeast corners of the log yard revealed gray, medium-grain native beach sand at 15 ftbs. In the K Ply mill yard, augering yielded sediments not significantly different to those found in nearby geoprobes. However, because a wider area is disturbed by the auger, it uncovered larger rock class sizes. In auger PP-21 in the northwest corner of the K-Ply mill, large angular pebbles reminiscent of quarry spalls were brought up from around 9 ftbs. This location is in close proximity to the bulkhead, and the spalls may be of its construction.

Figure 5-4. Overview of auger at PP-22 in the northwest corner of the log yard. View west.

5.4 Observed Archaeological Materials

During archaeological monitoring, no precontact artifacts or features, and several historic period artifacts and/or features were identified. The two 1940s-era fuel pipelines have a 4 inch diameter and are spaced parallel a foot apart (Figure 5-5). They are not currently in use, and they have been cut at both ends. One historic red applied color labeled Pepsi Cola bottle was discovered in fill deposits above this pipe. Applied color labels on fountain syrup bottles began in 1943 (Lockhart 2004), while a double dash hyphen in the logo dates the bottle to pre-1951(Kovel and Kovel 2006). This date range aligns with Floyd|Snider's assertion that the fuel pipes date to the 1940s, when the PenPly/K Ply mill was constructed. These features may eventually be considered elements within an overall historic-period mill complex, and they have not yet been recorded as an archaeological site.

Figure 5-5. Overview of a joint in the westernmost fuel pipe.

An industrial railroad spur was discovered when the geoprobe drill halted beneath a concrete slab remnant. An approximate 100-ft segment of the spur is still visible under the concrete slab along with two small cart platforms sitting in position (Figure 5-6). The observed example is one of two rail spurs that extended across the Marine Trades Area Site to the Mill and was used to load rail cars with wood products (Floyd|Snider 2013:2-3). The railroad spur grade was recorded as a continuation of previously-recorded site 45CA458, the Chicago, Milwaukee, St. Paul & Pacific Railroad (a.k.a. the Milwaukee Road).

The visible rail spur consists of two parallel 2 ¾-inch (in) rails placed 52 in apart and attached to 8 in-wide wooden ties with base plates attached by four rail spikes. The ties extend 20 in beyond each side of the rail. The rail sits on a level grade of round and angular pebbles within dark brown silty sand, which extends 2 ft beyond the edge of the ties, and rises 2 ft above the ground surface. The rail spur is depicted on a 1928 plan of the Chicago, Milwaukee, St. Paul & Pacific Railroad, and it continues to be shown on USGS maps between 1950 and 1978 (USGS 1950, 1961, 1978). Interestingly though, the rail spur is not present in an aerial photograph taken of the mill in 1977 and had likely been buried by that time (WSDOE 2010).

Figure 5-6. Overview of Site 45CA458, showing the rail spur with a cart. View south.

Two diagnostic historic-period artifacts were found in close association with the rail line. These are: a matchbook with Snider's Catsup advertised, and a Velvet brand tobacco tin. The matchbook displays the head of a person with a horned devil costume and reads, "Snider's HOTTEST Catsup." The reverse depicts a bottle of the catsup with chili peppers tied to the neck and reads, "Snider's Catsup chili pepper flavor." The inside of the matchbook reads, "Whatever tastes good with catsup…tastes better with Snider's the hotter catsup. Snider's chili-pepper flavor heightens your enjoyment, but never bites your tongue. Why don't you try it?" Snider's catsup was founded in 1879 by Thomas A. Snider and became an internationally renowned provider of tomato based condiments by the 1910s (Smith 1996:40). An identical matchbook was found online in good condition with a date of 1958 printed on it; no date was observed in this example (Zlighters 2013).

The tobacco tin depicts a smoking pipe and a cigarette on a red background and reads, "Velvet/ PIPE & CIGARETTE/ TOBACCO." The reverse has additional advertising in white and yellow letters on a red background. The can measures 4.5 in by 3 in. It was manufactured by Liggett & Myers and dates from the 1930s to 1940s (Valentine Richmond History Center 2013). The manufacture dates for these artifacts support additional sources that put the operation of the rail spur in the 1940s to 1960s (Floyd|Snider 2013:2-3).

6. Conclusions and Recommendations

HRA archaeologist Angus Raff-Tierney monitored all ground disturbing activities in the AI associated with the current remediation testing conducted by Floyd|Snider. Geoprobes, test pits, and auger probes were monitoring in the K-Ply complex and adjacent log yard.

During monitoring, two historic-period archaeological features were identified: a pair of 1940s-era fuel pipelines and a 100-ft segment of railroad spur. The pipelines may be part of a larger historic-period archaeological site complex, associated with the PenPly/K Ply mill that could include such other features as the bulkheads and possibly mill building foundations (neither of which were exposed during monitoring to the degree required for recordation). HRA did not record the pipelines as an archaeological site at this time because it is anticipated that, as remediation activities continue, the pipes may eventually be identified as elements of the larger, historic-period archaeological site complex. This further exposure and concomitant research will elucidate potential associations between the mill complex and pipelines.

HRA also recorded a 100-ft segment of railroad associated with the previously recorded Site 45CA458, the Chicago, Milwaukee, St. Paul & Pacific Railroad. The portion of the site present in the AI consists of a railroad spur and nearby tobacco smoking-related artifacts. The railroad spur is in good condition and still has artifacts present that are related to its intended use. Two cart bases were observed on the tracks, and these carts were probably used to move mill products. HRA also noted mid-twentieth century smoking related artifacts such as a matchbox and tobacco tin on and close to the rail grade. The site as it is currently been observed appears to retain a moderate to high degree of integrity; however, additional exposure of the site is recommended prior to a formal evaluation for eligibility for listing in the NRHP.

HRA has not evaluated either resource as to its eligibility for listing in local, state, or national registers. Any project-related impacts to these resources are currently uncertain. As historic-period sites, under state law (RCW 27.53 Archaeological Sites and Resources), the archaeological resources recorded in the AI are to be protected, and would require a permit from the DAHP to disturb, unless they are evaluated and determined not eligible for listing in the WHR or NRHP.

HRA recommends continued archaeological monitoring at the AI, in accordance with the agreement between the City and LEKT. HRA also recommends that, when remediation activities at the K Ply project are determined, a professional archaeologist assess impacts to recorded cultural resources and, as necessary, update and evaluate recorded resources.

6.1 Inadvertent Discovery of Cultural Materials

If additional subsurface work occurs in the project area without a professional archaeologist present, and archaeological deposits are inadvertently discovered during construction, ground-disturbing activities at the encounter location should be halted immediately. Procedures outlined in the LEKT Monitoring and IDP document (Floyd|Snider 2013:Appendix D) will be followed regarding notification procedures and the treatment of archaeological materials.

6.2 Inadvertent Discovery of Human Remains

Any human remains that are discovered during construction of the Project will be treated with dignity and respect.

If additional ground-disturbing activities encounter human skeletal remains during the course of construction, then all activity that may cause further disturbance to those remains **must** cease, and the area of the find must be secured, covered from view, and protected from further disturbance. In addition, the finding of human skeletal remains **must** be reported to the Clallam County Coroner **and** local law enforcement (Port Angeles Police Department) in the most expeditious manner possible. The remains should not be touched, moved, or further disturbed.

The Coroner will assume jurisdiction over the human skeletal remains and make a determination of whether those remains are forensic or non-forensic. If the Coroner determines the remains are non-forensic, the ME will report that finding to the DAHP, which will then take jurisdiction over the remains. The State Physical Anthropologist will make a determination of whether the remains are Indian or Non-Indian, and report that finding to any appropriate cemeteries and the affected tribes. The DAHP will then handle consultation with the affected parties as to the future preservation, excavation, and disposition of the remains.

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K Ply Site

Remedial Investigation/ Feasibility Study

Appendix D
Contaminant Volume Calculations

Table D.1
Hydraulic Oil LNAPL Volume Calculation

LNAPL Measurement Location	LNAPL Thickness in Well Casing (ft)[1]	LNAPL Thickness in Adjacent Soil (ft)[2]
PP-2	2.23	0.892
PP-3	0.33	0.132
PP-12	1.88	0.7
PP-11	1.04	0.416
PP-2	2.2	0.88
PP-3	0.5	0.2
PP-12	1.59	0.636
PP-11	1	0.4
PP-16	0.35	0.14
EW-2	2.5	1
LNAPL Volume Estimate	**Well Casing**	**Soil**
Average LNAPL thickness (feet)	1.362	0.5396
LNAPL area (square feet)[3]	12,782	12,782
NAPL volume (cubic feet)	17,409	6,897
EW-2A soil sample porosity (fraction)[4]	0.374	0.374
EW-2A NAPL pore fluid saturation (fraction)[4]	0.507	0.507
Estimated LNAPL in soil (cubic feet)	3,301	1308
Gallons per cubic foot conversion	7.48	7.48
Estimated LNAPL volume in soil (gallons)	24,692	9,783

Notes:

1 Well NAPL thickness calculations are presented in Table 5.1.

2 Soil NAPL thickness measured in the field or calculated using a conversion factor of (0.4 * measured thickness in well), based on field observations.

3 NAPL area square footage from Table 9.2.

4 Petrophysical test results from K Ply Site Supplemental Data Collection Technical Memorandum (Floyd|Snider 2014).

Abbreviations:

ft	Feet
LNAPL	Light non-aqueous phase liquid
NAPL	Non-aqueous phase liquid

Calculated by: K. Anderson, 5/15/2014
Checked by: J. Graves, 5/19/2014
Checked by: B. Beaulieu, 5/20/2014

Table D.2
GRO Volume Calculations

Smear Zone Soil	
Area of GRO contaminated smear zone soil (square feet)[1]	109,084
Thickness of smear zone (feet)[2]	4
Volume of GRO contaminated smear zone soil (cubic feet)	436,336
Volume of GRO contaminated smear zone soil (cubic yards)	16,161
Average TPH concentration, dry weight (mg/kg)[3]	2,393
Total GRO in soil (mg)	56,121,238,965
Total GRO in soil (pounds)	123,726
Vadose Zone Soil	
Area of GRO contaminated vadose zone soil (square feet)[1]	22,685
Thickness of vadose zone (feet)[2]	4
Volume of soil containing GRO contaminated groundwater (cubic feet)	90,740
Volume of GRO contaminated vadose zone soil (cubic yards)	3,361
Average TPH concentration, dry weight (mg/kg)[3]	4,732
Total GRO in soil (mg)	20,193,661,380
Total GRO in soil (pounds)	44,519
Site-Wide Groundwater	
Area of GRO contaminated groundwater (square feet)[1]	91,404
Approxmiate thickness of contaminated groundwater zone (feet)	4
Volume of GRO contaminated vadose zone soil (cubic feet)	365,616
Volume of GRO contaminated groundwater zone (cubic yards)	13,541
Porosity (fraction)[3]	0.37
Volume of GRO contaminated groundwater (cubic yards)	5,010
Volume of GRO contaminated groundwater (liters)	3832874.4
Average GRO Concentration (mg/L)[3]	5,933
Total GRO in groundwater (milligrams)	22,740,443,815
Total GRO in groundwater (pounds)	50,134
Total GRO	
Total pounds GRO	218,380
Density of GRO (gallons/pound)	0.167
Total Gallons TPH	36,397

Notes:

1 Gasoline contaminated square footage from Table 9.2.

2 Refer to RI/FS Section 5.3.

3 Analytical data and petrophysical test results from K Ply Site Supplemental Data Collection Technical Memorandum (Floyd|Snider 2014).

Calculated by: K. Anderson, 5/15/2014
Checked by: J. Graves, 5/19/2014
Checked by: B. Beaulieu, 5/20/2014

K Ply Site

Remedial Investigation/ Feasibility Study

Appendix E
Terrestrial Ecological Evaluation

Washington State Department of Ecology
Toxics Cleanup Program

Table 749-1

Simplified Terrestrial Ecological Evaluation-Exposure Analysis Procedure

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).	
1) From the table below, find the number of points corresponding to the area and enter this number in the field to the right.	
Area (acres) 0.25 or less 0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 or more	Points 4 5 6 7 8 9 10 11 12
2) Is this an industrial or commercial property? If yes, enter a score of 3. If no, enter a score of 1	
3)[a] Enter a score in the box to the right for the habitat quality of the site, using the following rating system[b]. High=1, Intermediate=2, Low=3	
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.[c]	
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.	
6) Add the numbers in the boxes on lines 2-5 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 evaluation may be ended.	

Notes for Table 749-1

[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 of (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 b 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.

[Area Calculation Aid] [Aerial Photo with Area Designations] [TEE Table 749-1] [Index of Tables]

[Exclusions Main] [TEE Definitions] [Simplified or Site-Specific?] [Simplified Ecological Evaluation] [Site-Specific Ecological Evaluation] [WAC 173-340-7493]

[TEE Home]

K Ply Site

Remedial Investigation/ Feasibility Study

Appendix F
Cost Estimates

Alternative 1
Light Non-Aqueous Phase Liquid/ Bulkhead Excavation, Air Sparge Curtain, and Institutional Controls

Capital					
Item	**Quantity**	**Unit**	**Unit Cost**	**Cost**	**Assumptions**
EXCAVATION					
Engineering and Permitting					
Design Report	1	LS	$25,000	$ 25,000	Design for shoring, excavation, and disposal.
Plans and Specs	1	LS	$10,000	$ 10,000	
Bidding	1	LS	$5,000	$ 5,000	
Institutional Controls					
Legal and Consulting Fees	1	LS	$30,000	$ 30,000	
Soil Removal					
Mobilization/Demobilization	1	EA	$25,000	$ 25,000	
Stockpile Area Preparation/Site Setup	1	EA	$10,000	$ 10,000	Includes set-up and management of stormwater BMPs, bermed clean and dirty stockpile areas.
Utility Clearance	8	HR	$125	$ 1,000	Assumes standard utility location, mobilization/demobilization included.
Well Abandonment by Licensed Driller	6	EA	$800	$ 4,800	Assumes abandonment by bentonite and concrete plug, by licensed driller, includes materials and mob.
Installation of Temporary Shoring	4,500	SF	$45	$ 202,500	Assumes installation of temporary, 30-foot-deep sheetpile structure to reinforce 150 feet of bulkhead. Based on contractor-provided estimate.
Removal of Temporary Shoring	1	LS	$10,000	$ 10,000	Based on contractor-provided estimate.
Decontaminate Shoring	4,500	SF	$3	$ 14,625	Based on contractor-provided estimate.
Excavation, Segregation, and Stockpiling of both Contaminated and Overburden Soil	9,000	CY	$12	$ 108,000	Estimated volumes are approximate, based on available data indicating extent of soil contamination. Assumes vertical excavation of sidewalls. Excavation of Stack Area (1,200 CY) and Hog Fuel Pile Area (400 CY) are also included.
Vacuum Truck Extraction of LNAPL	24	HR	$300	$ 7,200	Assumes open excavation will be vac-ed to remove LNAPL.
Loading of Contaminated Soil	4,600	CY	$5	$ 23,000	
Soil Waste Transport and Disposal	7,000	TON	$57	$ 399,000	Assumes 1.4 tons/CY for vadose zone soil and 1.6 tons/CY for smear zone soil. Assumes material transported by truck (32 tons/truck to Olympia; 6-hr RT 1-hr load/unload, $85/hr), transfer to rail for non-hazardous disposal. Assumes tipping fee of $40/ton.
Laboratory Analytical Sampling	15	EA	$125	$ 1,875	Assumes TPD-Dx and TPH-G w/BTEX in soil. Assumes field screening to limit sampling. TPD-Dx and TPH-G w/BTEX in soil.
Backfill and Compaction (on-site source)	3,200	CY	$9	$ 28,800	Re-use of clean overburden and Stack Area soils, compaction in 12-inch lifts.
Backfill and Compaction (off-site source)	5,800	CY	$15	$ 87,000	Includes material, haul, and 12-inch layer compaction with roller.
AIR SPARGE CURTAIN					
Predesign Studies					
Pilot Study	1	LS	$10,000	$ 10,000	Field testing to determine radius of influence, air distribution and flow rates, volatilization rate, safety hazards, etc.
Engineering and Permitting					
Design Report	1	LS	$40,000	$ 40,000	
Plans and Specs	1	LS	$13,000	$ 13,000	
Bidding	1	LS	$10,000	$ 10,000	
Permitting	1	LS	$6,000	$ 6,000	ORCAA air permit, state, county and local shoreline construction and grading permits if applicable.
Air Sparge/SVE System					
Mobilization	1	LS	$10,000	$ 10,000	
Vactor Clearance	2	DAY	$3,000	$ 6,000	Vactor borings to 5 feet per safety requirements; assumes 10/day, includes disposal of soil.
Well Installation	26	EA	$1,350	$ 35,100	Assumes two rows with 25-foot centers, drilling and materials cost for air sparge wells; assumes direct-push installation.
Well Vaults	26	EA	$500	$ 13,000	Assumes heavy duty vaults with covers for heavy loading capacity.
Surveying	1	DAY	$1,500	$ 1,500	Based on quote from Barghausen.
Soil Vapor Extraction Piping	800	LF	$8	$ 6,400	Assumes 1 SVE pipe installed per air sparge transect, installed in same trench as air supply lines.
Air Supply Piping	800	LF	$20	$ 16,000	Assumes trenching/backfill, PVC secondary containment pipe, hose, installed at wellheads.
Air Sparge System	1	EA	$15,000	$ 15,000	Assumes 10 rotary vane compressors @ $500/ea ($5,000; 20 CFM each or 10 CFM per sparge well), manifolds, flow meters, misc. connections, electrical control panel ($5000), installation.
SVE System	1	ES	$50,000	$ 50,000	SVE blowers ($7,000), vapor treatment system (assumes 250 cfm catox; $35,000), controls, installation.
Air Sparge System Startup	1	LS	$6,000	$ 6,000	Assumes 1 week by technician.
Storage Shed Construction	1	EA	$16,000	$ 16,000	Includes framing, sheathing, concrete slab, and electrical connections.
Soil Transport and Disposal	13	DRUM	$250	$ 3,250	Assumes soil cuttings at two 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 transpiration, disposal, characterization sampling, and oversight labor.
Surface Restoration, Paving	300	SF	$12	$ 3,600	Cost assumes heavy load rating to match existing pavement. 9-inch AC (asphalt) paving ($8/SF), with subgrade preparation, or 8-inch PCC.
MONITORING WELL INSTALLATION					
Well Installation	6	EA	$3,000	$ 18,000	Includes site mobilization, oversight, and materials.
OVERSIGHT AND CONSTRUCTION MANAGEMENT					
Well Installation Oversight	2	DAY	$1,500	$ 3,000	Assumes 1 FTE for 10 hour days at $135/hr plus travel and per diem.
Field Oversight	3	WEEK	$7,500	$ 22,500	Assumes 1 FTE for 10 hour days at $135/hr plus travel and per diem.
Construction Management		%	$5	$ 35,926	Assumes 5% of construction costs, does not include soil or LNAPL disposal.
Completion Report	1	EA	$30,000	$ 30,000	
Subtotal				**$ 1,366,076**	
Sales Tax (8.4%)				**$ 94,555**	
Surcharge on Subcontractors (10%)				**$ 7,428**	Assumes contractors except drillers and laboratory contracted to Port.
Capital Cost Subtotal				**$ 1,468,058**	
Contingency (30% Capital)				**$ 440,418**	
Total Project Capital				**$ 1,908,476**	

Monitoring					
Item	**Quantity**	**Unit**	**Unit Cost**	**Cost**	**Assumptions**
YEARS 1 to 5					
System O&M	52	DAY	$750	$ 39,000	Includes labor, repair, and system maint. Costs. 1 day/week by on-site employee. Included monthly PID readings.
Electricity	12	MO	$500	$ 6,000	
Annualized Equipment Replacement Costs	1	YEAR	$4,000	$ 4,000	
Groundwater and Water Level Monitoring Field Labor	4	EVENT	$3,000	$ 12,000	Two staff for one 10-hr day plus equipment, travel, mob/demob.
Groundwater and Water Level Monitoring Field Analytical	4	EVENT	$1,500	$ 6,000	Eight wells sampled for BTEX, TPH-G, and TPH-Dx per event.
Reporting	1	EVENT	$7,000	$ 7,000	One annual data report.
Subtotal				**$ 74,000**	
Sales Tax (8.4%)				**$ 840**	
Surcharge on Subcontractors (10%)				**$ 600**	
Years 1-5 Monitoring Costs				**$ 75,440**	
YEARS 5 to 30					
Groundwater and Water Level Monitoring Field Labor	2	EVENT	$3,000	$ 6,000	Two staff for one 10-hr day plus equipment, travel, mob/demob.
Groundwater and Water Level Monitoring Field Analytical	2	EVENT	$1,500	$ 3,000	Eight wells sampled for BTEX, TPH-G, and TPH-Dx per event.
Reporting	1	EVENT	$5,000	$ 5,000	One annual data report.
Subtotal				**$ 14,000**	
Sales Tax (8.4%)				**$ 252**	
Surcharge on Subcontractors (10%)				**$ 300**	
Years 5-30 Monitoring Costs				**$ 14,552**	
Net Present Value of 30-year O&M Cost				$ 490,000	**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**	

Alternative 2
Chemical Oxidation, Capping, and Institutional Controls

Capital					
Item	**Quantity**	**Unit**	**Unit Cost**	**Cost**	**Assumptions**
EXCAVATION					
Engineering and Permitting					
Design Report	1	LS	$ 25,000	$ 25,000	Assumes design report for excavation and disposal.
Plans and Specs	1	LS	$ 10,000	$ 10,000	
Bidding	1	LS	$ 5,000	$ 5,000	
Institutional Controls					
Legal and Consulting Fees	1	LS	$ 30,000	$ 30,000	
Soil Removal					
Mobilization/Demobilization	1	EA	$ 25,000	$ 25,000	
Stockpile Area Preparation/Site Setup	1	EA	$ 10,000	$ 10,000	Includes set-up and management of stormwater BMPs, bermed clean and dirty stockpile areas.
Concrete Management	1	LS	$ 50,000	$ 50,000	Assumes demolition of two remaining concrete pads, crushing of all demolition concrete including stockpiles from mill demolition, and on-site reuse.
Utility Clearance	8	HR	$ 125	$ 1,000	Assumes standard utility location, mobilization/demobilization included.
Abandonment by Licensed Driller	6	EA	$ 800	$ 4,800	Assumes abandonment by bentonite and concrete plug, by licensed driller, includes materials and mob.
Excavation, Segregation, and Stockpiling of both Contaminated and Overburden Soil	7,300	CY	$ 12	$ 87,600	Estimated volumes are approximate, based on available data indicating extent of soil contamination. Assumes vertical excavation of sidewalls. Excavation of Stack Area (1,200 CY) and Hog Fuel Pile Area (400 CY) are
Vacuum Truck Extraction of LNAPL	24	HR	$ 300	$ 7,200	Assumes open excavation will be vac-ed to remove LNAPL.
Loading of Contaminated Soil	4,000	CY	$ 5	$ 20,000	
Soil Waste Transport and Disposal	6,000	TON	$ 58	$ 348,000	Assumes 1.4 tons/CY for vadose zone soil and 1.6 tons/CY for smear zone soil. Assumes material transported by truck (32 tons/truck to Olympia; 6-hr RT 1-hr load/unload, $85/hr), transfer to rail for non-hazardous disposal. Assumes tipping fee of $40/ton.
Backfill and Compaction (on-site source)	2,100	CY	$ 9	$ 18,900	Re-use of clean overburden and Stack Area soils, compaction in 12-inch lifts.
Backfill and Compaction (off-site source)	5,200	CY	$ 15	$ 78,000	Includes material, haul, and 12-inch layer compaction with roller.
CHEMICAL OXIDATION					
Pilot Study	1	LS	$ 50,000	$ 50,000	Pilot study to determine site-specific conditions for broader application.
PersulfOx	1,080,000	LB	$ 2	$ 1,944,000	Based on quote from vendor. Material cost is $1.80/lb. Does not include shipping or sales tax. Assumes chemical oxidation in areas of soil and groundwater contamination.
Oxygen Release Compound	36,040	LB	$ 8	$ 288,320	ORC Advanced, based on quote from vendor. Material cost is $7.65/lb. Does not include shipping or sales tax. Assumes enhanced bioremediation in areas of only groundwater contamination.
Injection Drilling	292	DAY	$ 3,500	$ 1,022,000	Assumes center-to-center spacing of 12 ft. Assumes eight points per day.
CAPPING					
Paving	22,325	SF	$ 10	$ 223,250	Cost assumes heavy load rating to match paving at Bulkhead. Assumes existing subgrade engineered for travel-lift. 9-inch AC (asphalt) paving ($8/SF), with subgrade preparation, or 8-inch PCC.
MONITORING WELL INSTALLATION					
Well Installation	6	EA	$ 3,000	$ 18,000	Includes site mobilization, oversight, and materials
OVERSIGHT AND CONSTRUCTION MANAGE					
Field Oversight	58	WEEK	$ 7,500	$ 435,000	Assumes 1 FTE for 10-hour days at $135/hr plus travel and per diem.
Construction Management		%	$ 5	$ 54,375	Assumes 5% of construction costs, does not include soil or LNAPL disposal.
Completion Report	1	EA	$ 30,000	$ 30,000	
Subtotal				**$ 4,785,445**	
Sales Tax (8.4%)				**$ 352,470**	
Surcharge on Subcontractors (10%)				**$ 104,480**	Assumes contractors except drillers and laboratory contracted to Port.
Capital Cost Subtotal				**$ 5,242,395**	
Contingency (30% Capital)				**$ 1,572,718**	
Total Project Capital				**$ 6,815,113**	
Monitoring					
Item	**Quantity**	**Unit**	**Unit Cost**	**Cost**	**Assumptions**
YEARS 1 to 5					
Groundwater and Water Level Monitoring Field Labor	4	EVENT	$ 3,000	$ 12,000	Two staff for one 10-hr day plus equipment, travel, mob/demob.
Groundwater and Water Level Monitoring Field Analytical	4	EVENT	$ 1,500	$ 6,000	Eight wells sampled for BTEX, TPH-G, and TPH-Dx per event.
Reporting	1	EVENT	$ 5,000	$ 5,000	One annual data report.
Subtotal				**$ 23,000**	
Sales Tax (8.4%)				**$ 504**	
Surcharge on Subcontractors (10%)				**$ 600**	
Years 1-5 Monitoring Costs				**$ 24,104**	
YEARS 5 to 10					
Groundwater and Water Level Monitoring Field Labor	2	EVENT	$ 3,000	$ 6,000	Two staff for one 10-hr day plus equipment, travel, mob/demob.
Groundwater and Water Level Monitoring Field Analytical	2	EVENT	$ 1,500	$ 3,000	Eight wells sampled for BTEX, TPH-G, and TPH-Dx per event.
Reporting	1	EVENT	$ 5,000	$ 5,000	One annual data report.
Subtotal				**$ 14,000**	
Sales Tax (8.4%)				**$ 252**	
Surcharge on Subcontractors (10%)				**$ 300**	
Years 5-10 Monitoring Costs				**$ 14,552**	
Net Present Value of 10-year O&M Cost				**$ 150,000**	**5% net discount rate implies an 8% rate of return and an inflation rate of 3%, or equivalent.**
Total Present Value Cost for Alternative				**$ 7,000,000**	

Alternative 3
Focused Source Control Excavation, Bioremediation, and Institutional Controls

Capital

Item	Quantity	Unit	Unit Cost	Cost	Assumptions
EXCAVATION					
Engineering and Permitting					
Design Report	1	LS	$ 50,000	$ 50,000	Design for shoring, excavation, and disposal.
Plans and Specs	1	LS	$ 20,000	$ 20,000	
Bidding	1	LS	$ 5,000	$ 5,000	
Institutional Controls					
Legal and Consulting Fees	1	LS	$ 30,000	$ 30,000	
Soil Removal					
Mobilization/Demobilization	1	EA	$ 25,000	$ 25,000	
Stockpile Area Preparation/Site Setup	1	EA	$ 15,000	$ 15,000	Includes set-up and management of stormwater BMPs, bermed clean and dirty stockpile areas.
Concrete Management	1	LS	$ 50,000	$ 50,000	Assumes demolition of two remaining concrete pads, crushing of all demolition concrete including stockpiles from mill demolition, and on-site reuse.
Utility Clearance	8	HR	$ 125	$ 1,000	Assumes standard utility location, mobilization/demobilization included.
Abandonment by Licensed Driller	12	EA	$ 800	$ 9,600	Assumes abandonment by bentonite and concrete plug, by licensed driller, includes materials and mob.
Installation of Temporary Shoring	4,500	SF	$ 45	$ 202,500	Assumes installation of temporary, 30-foot-deep sheetpile structure to reinforce 150 feet of bulkhead. Based on contractor-provided estimate.
Removal of Temporary Shoring	1	LS	$ 10,000	$ 10,000	Based on contractor-provided estimate.
Decontaminate Shoring	4,500	SF	$ 3	$ 14,625	Based on contractor-provided estimate.
Excavation Dewatering	1	LS	$ 45,000	$ 45,000	Assumes dewatering in excavated area during excavation, conveyance to on-site treatment system.
On-site Treatment and Discharge of Contaminated Water	913,000	GAL	$ 0	$ 73,040	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), and disposal of spent materials.
Excavation, Segregation, and Stockpiling of both Contaminated and Overburden Soil	36,100	CY	$ 12	$ 433,200	Estimated volumes are approximate, based on available data indicating extent of soil contamination. Assumes vertical excavation of sidewalls. Excavation of Stack Area (1,200 CY) and Hog Fuel Pile Area (400 CY) are also included.
Vacuum Truck Extraction of LNAPL	24	HR	$ 300	$ 7,200	Assumes open excavation will be vac-ed to remove LNAPL.
Loading of Contaminated Soil	15,700	CY	$ 5	$ 78,500	Includes Hog Fuel Pile Area.
Soil Waste Transport and Disposal	24,100	TON	$ 58	$ 1,397,800	Assumes 1.4 tons/CY for vadose zone soil and 1.6 tons/cubic yard for smear zone soil. Assumes material transported by truck (32 tons/truck to Olympia; 6-hr RT 1-hr load/unload, $85/hr), transfer to rail for non-hazardous disposal. Assumes tipping fee of $40/ton.
Laboratory Analytical Sampling	80	EA	$ 125	$ 10,000	Asssumes field screening to limit sampling. TPD-Dx and TPH-G w/BTEX in soil.
Backfill and Compaction (on-site source)	20,400	CY	$ 9	$ 183,600	Re-use of clean overburden and Stack Area soil, compaction in 12-inch lifts
Backfill and Compaction (off-site source)	15,700	CY	$ 15	$ 235,500	Includes material, haul, and 12-inch layer compaction with roller.
ENHANCED BIOREMEDIATION					
Installation of Injection Galleries	600	LF	$ 30	$ 18,000	Assumes 4-inch perf piping laid in pea gravel trench during backfilling, 200 feet per gallery with at grade manhole.
Oxygen Release Compound	27,800	LB	$ 8	$ 222,400	ORC Advanced, based on quote from vendor. Material cost is $7.65/lb. Does not include shipping or sales tax.
Application Cost (Slurry spray)	14	WEEK	$ 1,500	$ 21,000	Cost for mixing vat, pump, sprayer, and laborer at 4 hrs/day.
ORC for Annual Application Event	3	EVENT	$ 16,000	$ 48,000	Assumes 2,000 lbs per event into the three galleries, at $8/lb.
Labor for Annual Application	3	EVENT	$ 4,500	$ 13,500	
In Situ Injection of off Site Groundwater Plume	3	EVENT	$ 33,333	$ 99,999	Assumes Treatment of benzene plume that is off site and >500 ug/L
MONITORING WELL INSTALLATION					
Well Installation	6	EA	$ 5,000	$ 30,000	Includes site mobilization, oversight, and materials
OVERSIGHT AND CONSTRUCTION MANAGEMENT					
Field Oversight	14	WEEK	$ 7,500	$ 105,000	Assumes 1 FTE for 10.hour days at $135/hr plus travel and per diem.
Construction Management		%	$ 5	$ 71,588	Assumes 5% of construction costs, does not include soil or LNAPL disposal.
Completion Report	1	EA	$ 30,000	$ 30,000	
Subtotal				**$ 3,556,052**	
Sales Tax (8.4%)				**$ 272,535**	
Surcharge on Subcontractors (10%)				**$ 4,960**	Assumes contractors except drillers and laboratory contracted to Port.
Capital Cost Subtotal				**$ 3,833,547**	
Contingency (30% Capital)				**$ 1,150,064**	
Total Project Capital				**$ 5,000,000**	

Monitoring

Item	Quantity	Unit	Unit Cost	Cost	Assumptions
YEARS 1 to 5					
Groundwater and Water Level Monitoring Field Labor	4	EVENT	$ 3,000	$ 12,000	Two staff for one 10-hr day plus equipment, travel, mob/demob.
Groundwater and Water Level Monitoring Field	4	EVENT	$ 1,500	$ 6,000	Eight wells sampled for BTEX, TPH-G, and TPH-Dx per event.
Reporting	1	EVENT	$ 5,000	$ 5,000	One annual data report.
Subtotal				**$ 23,000**	
Sales Tax (8.4%)				**$ 504**	
Surcharge on Subcontractors (10%)				**$ 600**	
Years 1-5 Monitoring Costs				**$ 24,104**	
YEARS 5 to 10					
Groundwater and Water Level Monitoring Field Labor	2	EVENT	$ 3,000	$ 6,000	Two staff for one 10-hr day plus equipment, travel, mob/demob.
Groundwater and Water Level Monitoring Field	2	EVENT	$ 1,500	$ 3,000	Eight wells sampled for BTEX, TPH-G, and TPH-Dx per event.
Reporting	1	EVENT	$ 5,000	$ 5,000	One annual data report.
Subtotal				**$ 14,000**	
Sales Tax (8.4%)				**$ 252**	
Surcharge on Subcontractors (10%)				**$ 300**	
Years 5-10 Monitoring Costs				**$ 14,552**	
Net Present Value of 10-year O&M Cost				**$ 150,000**	**5% net discount rate implies an 8% rate of return and an inflation rate of 3%, or equivalent.**
Total Present Value Cost for Alternative				**$ 5,200,000**	

Alternative 4
Excavation, Bioremediation, and Institutional Controls

Capital					
Item	**Quantity**	**Unit**	**Unit Cost**	**Cost**	**Assumptions**
EXCAVATION					
Engineering and Permitting					
Design Report	1	LS	$ 50,000	$ 50,000	Design for shoring, excavation, and disposal.
Plans and Specs	1	LS	$ 20,000	$ 20,000	
Bidding	1	LS	$ 5,000	$ 5,000	
Institutional Controls					
Legal and Consulting Fees	1	LS	$ 30,000	$ 30,000	
Soil Removal					
Mobilization/Demobilization	1	EA	$ 25,000	$ 25,000	
Stockpile Area Preparation/Site Setup	1	EA	$ 15,000	$ 15,000	Includes set-up and management of stormwater BMPs, bermed clean and dirty stockpile areas.
Concrete Management	1	LS	$ 50,000	$ 50,000	Assumes demolition of two remaining concrete pads, crushing of all demolition concrete including stockpiles from mill demolition, and on-site reuse.
Utility Clearance	8	HR	$ 125	$ 1,000	Assumes standard utility location, mobilization/demobilization included.
Abandonment by Licensed Driller	20	EA	$ 800	$ 16,000	Assumes abandonment by bentonite and concrete plug, by licensed driller, includes materials and mob.
Installation of Temporary Shoring	4,500	SF	$ 45	$ 202,500	Assumes installation of temporary, 30-foot-deep sheetpile structure to reinforce 150 feet of bulkhead. Based on contractor-provided estimate.
Removal of Temporary Shoring	1	LS	$ 10,000	$ 10,000	Based on contractor-provided estimate.
Decontaminate Shoring	4,500	SF	$ 3	$ 14,625	Based on contractor-provided estimate.
Excavation Dewatering	1	LS	$ 60,000	$ 60,000	Assumes dewatering in excavated area during excavation, conveyance to on-site treatment system.
Onsite Treatment and Discharge of Contaminated Water	1,766,000	GAL	$ 0	$ 141,280	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), and disposal of spent materials.
Excavation, Segregation, and Stockpiling of both Contaminated and Overburden Soil	60,300	CY	$ 12	$ 723,600	Estimated volumes are approximate, based on available data indicating extent of soil contamination. Assumes vertical excavation of sidewalls. Excavation of Stack Area (1,200 CY) and Hog Fuel Pile Area (400 CY) are also included.
Vacuum Truck Extraction of LNAPL	24	HR	$ 300	$ 7,200	Assumes open excavation will be vac-ed to remove LNAPL.
Loading of Contaminated Soil	22,400	CY	$ 5	$ 112,000	
Soil Waste Transport and Disposal	34,900	TON	$ 58	$ 2,024,200	Assumes 1.4 tons/CY for vadose zone soil and 1.6 tons/CY for smear zone soil. Assumes material transported by truck (32 tons/truck to Olympia; 6-hr RT 1-hr load/unload, $85/hr), transfer to rail for non-hazardous disposal Assumes tipping fee of $40/ton.
Laboratory Analytical Sampling	100	EA	$ 125	$ 12,500	Assumes field screening to limit sampling. TPD-Dx and TPH-G w/BTEX in soil.
Backfill and Compaction (on-site source)	36,700	CY	$ 9	$ 330,300	Re-use of clean overburden, compaction in 12-inch lifts.
Backfill and Compaction (off-site source)	23,600	CY	$ 15	$ 354,000	Includes material, haul, and 12-inch layer compaction with roller.
ENHANCED BIOREMEDIATION					
Installation of Injection Galleries	600	LF	$ 30	$ 18,000	Assumes 4-inch perf piping laid in pea gravel trench during backfilling, 200 feet per gallery with at grade manhole.
Oxygen Release Compound	58,520	LB	$ 8	$ 468,160	ORC Advanced, based on quote from vendor based on site conditions. Material cost is $7.65/lb. Does not include shipping or sales tax.
Application Cost (Slurry spray)	23	WEEK	$ 1,500	$ 34,500	Cost for mixing vat, pump, sprayer, and laborer at 4 hrs/day.
ORC for Annual Application Event	3	EVENT	$ 16,000	$ 48,000	Assumes 2,000 lbs per event into the three galleries, at $8/lb.
Labor for Annual Application	3	EVENT	$ 4,500	$ 13,500	
In Situ Injection of off Site Groundwater Plume	3	EVENT	$ 33,333	$ 99,999	Assumes Treatment of benzene plume that is off site and >500 ug/L
MONITORING WELL INSTALLATION					
Well Installation	6	EA	$ 5,000	$ 30,000	Includes site mobilization, oversight, and materials.
OVERSIGHT AND CONSTRUCTION MANAGEMENT					
Field Oversight	23	WEEK	$ 7,500	$ 172,500	Assumes 1 FTE for 10-hour days at $135/hr plus travel and per diem.
Construction Management		%	$ 5	$ 105,525	Assumes 5% of construction costs, does not include soil or LNAPL disposal.
Completion Report	1	EA	$ 30,000	$ 30,000	
Subtotal				**$ 5,224,389**	
Sales Tax (8.4%)				**$ 404,155**	
Surcharge on Subcontractors (10%)				**$ 5,850**	Assumes contractors except drillers and laboratory contracted to Port.
Capital Cost Subtotal				**$ 5,634,394**	
Contingency (30% Capital)				**$ 1,690,318**	
Total Project Capital				**$ 7,300,000**	
Monitoring					
Item	**Quantity**	**Unit**	**Unit Cost**	**Cost**	**Assumptions**
YEARS 1 to 5					
Groundwater and Water Level Monitoring Field Labor	4	EVENT	$ 3,000	$ 12,000	Two staff for one 10-hr day plus equipment, travel, mob/demob.
Groundwater and Water Level Monitoring Field Analytical	4	EVENT	$ 1,500	$ 6,000	Eight wells sampled for BTEX, TPH-G, and TPH-Dx per event.
Reporting	1	EVENT	$ 5,000	$ 5,000	One annual data report.
Subtotal				**$ 23,000**	
Sales Tax (8.4%)				**$ 504**	
Surcharge on Subcontractors (10%)				**$ 600**	
Years 1-5 Monitoring Costs				**$ 24,104**	
YEARS 5 to 10					
Groundwater and Water Level Monitoring Field Labor	2	EVENT	$ 3,000	$ 6,000	Two staff for one 10-hr day plus equipment, travel, mob/demob.
Groundwater and Water Level Monitoring Field Analytical	2	EVENT	$ 1,500	$ 3,000	Eight wells sampled for BTEX, TPH-G, and TPH-Dx per event.
Reporting	1	EVENT	$ 5,000	$ 5,000	One annual data report.
Subtotal				**$ 14,000**	
Sales Tax (8.4%)				**$ 252**	
Surcharge on Subcontractors (10%)				**$ 300**	
Years 5-10 Monitoring Costs				**$ 14,552**	
Net Present Value of 10-year O&M Cost				**$ 150,000**	**5% net discount rate implies an 8% rate of return and an inflation rate of 3%, or equivalent.**
Total Present Value Cost for Alternative				**$ 7,500,000**	