FIFTH FIVE-YEAR REVIEW REPORT FOR HARBOR ISLAND SUPERFUND SITE KING COUNTY, WASHINGTON

Prepared by

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List of Abbreviations & Acronyms

AOC	Administrative Order on Consent
ARAR	applicable or relevant and appropriate requirements
bgs	below ground surface
BMPs	best management practices
BP	BP West Coast Products
BTEX	benzene, toluene, ethylbenzene, and xylenes
CAA	Clean Air Act
CAP	Corrective Action Plan
CD	Consent Decree
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CFR	Code of Federal Regulations
COC	contaminants of concern
cPAH	carcinogenic polycyclic aromatic hydrocarbon
CWA	Clean Water Act
EBAP	Elliot Bay Action Program
Ecology	Washington State Department of Ecology
ENR	Enhanced Natural Remediation
EPA	United States Environmental Protection Agency
ESD	Explanation of Significant Differences
EW-OU10	East Waterway Sediments Operable Unit
FS	Feasibility Study
FYR	Five-Year Review
IC	institutional control
IRIS	Integrated Risk Information System
KM	Kinder Morgan Liquid Terminals
LDW	Lower Duwamish Waterway Superfund Site
LNAPL	light non-aqueous phase liquid
LSS-OU7	Lockheed Shipyard Sediments Operable Unit
LU-OU3	Lockheed Upland Operable Unit
µg/kg	micrograms per kilogram
mg/kg	milligrams per kilogram
MLLW	mean lower low water
MNA	monitored natural attenuation
MTCA	Model Toxics Control Act
NAAQS	National Ambient Air Quality Standards
NCP	National Contingency Plan
NPL	National Priorities List
NRWQC	National Recommended Water Quality Criteria
O&M	Operation and Maintenance
OMMP	Operations, Maintenance and Monitoring Plan

ORP	oxidation-reduction potential
OU	operable unit
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
PCE	tetrachloroethylene
ppm	parts per million
PRP	potentially responsible party
PSAPCA	Puget Sound Air Pollution Control Agency
RA	Remedial Action
RAO	Remedial Action Objective
RCW	Revised Code of Washington
RD	Remedial Design
RI	Remedial Investigation
ROD	Record of Decision
RPM	Remedial Project Manager
S&G-OU1	Soil and Groundwater Operable Unit
SCO	Sediment Cleanup Objective
Shell	Shell Oil Products
SMA	Site Management Area
SMS	Sediment Management Standards
SVE	soil vapor extraction
SQS	Sediment Quality Standard
TBC	To Be Considered
TBT	tributyltin
TCE	trichloroethylene
TF-OU2	Tank Farms Operable Unit
TPH	total petroleum hydrocarbons
TSS-OU9	Todd Shipyards Sediments Operable Unit
UECA	Uniform Environmental Covenants Act
USACE	United States Army Corps of Engineers
USC	United States Code
UST	underground storage tank
UU/UE	unlimited use and unrestricted exposure
VISL	Vapor Intrusion Screening Level
WAC	Washington Administrative Code
WPCA	Washington Pollution Control Act
WW-OU8	West Waterway Sediments Operable Unit
WWCA	Water Well Construction Act

Executive Summary

This is the fifth Five-Year Review (FYR) for the Harbor Island Superfund (Site) located in Seattle, King County, Washington. The purpose of this FYR is to review information to determine if the remedies are and will continue to be protective of human health and the environment. The triggering action for this statutory FYR was the signing of the previous FYR on September 23, 2015.

The Site is divided into seven Operable Units (OUs):

OU No.	**Name**
01	Soil and Groundwater OU (S&G-OU1)
02	Tank Farms OU (TF-OU2)
03	Lockheed Upland (LU-OU3)
07	Lockheed Shipyard Sediments OU (LSS-OU7)
08	West Waterway Sediments OU (WW-OU8)
09	Todd Shipyards Sediments OU (TSS-OU9)
10	East Waterway Sediments OU (EW-OU10)

Harbor Island is a 420-acre island located in the Duwamish River delta in Elliott Bay in the City of Seattle, Washington. The man-made island was constructed on the Duwamish River delta with the addition of bulkheads and fill placed in the early 1900s. The Harbor Island Site has evolved from an industrialized upland area into a complex cleanup Site involving both the upland area and the offshore sediment. Contaminated media included soils, sediments, and groundwater.

A summary of the FYR conclusions for each of the OUs is presented below.

S&G-OU1

The Soil and Groundwater Operable Unit 01 (S&G-OU1) consists of the upland portion of Harbor Island except for the Petroleum Tank Farms and the upland area of Lockheed Yard 1. The selected remedy at S&G-OU1 included excavation of hot spot soils and treatment/disposal of these soils off-Site, capping of remaining contaminated soil that exceeds cleanup goals, Institutional Controls (ICs), removal and treatment of floating product at Todd Shipyards, and implementation of long-term groundwater monitoring.

Portions of the remedy are functioning as intended by the decision documents. The light non-aqueous phase liquid (LNAPL) treatment system at the Todd Shipyards portion of OU1 is shut down, as the system is no longer recovering product, and has met the requirements to shut the system down. Groundwater monitoring as required in the Record of Decision (ROD) demonstrates that contaminants are not migrating from the shipyards into the marine environment. Groundwater monitoring across the S&G-OU1 indicates that metals are present at concentrations above ROD cleanup levels in groundwater. Current trends in the groundwater data indicate that migration of metals toward the waterways is not occurring.

Institutional controls in the form of environmental covenants are required for the remedy to remain fully protective. These covenants restrict activities that may otherwise cause damage to the caps that protect

against exposure to contaminated soil. The covenants also prohibit use of groundwater. Environmental covenants have been recorded for five of the seven properties with protective caps. Annual cap inspections are also required to confirm that the cap integrity has not been compromised; however not all the properties consistently submit cap-inspection reports.

Changes to applicable or relevant and appropriate requirements (ARARs) and toxicity data since remedy selection do not affect the current protectiveness of the remedy because the low permeability cap and ICs prevent exposure to soils with contaminant concentrations above the new standards (new standards created since the ROD was created), and contaminants in groundwater have not been detected at concentrations above the new standards, with the exception of lead. There is currently no exposure to contaminants in site groundwater because these contaminants are not reaching the waterways and there is no known extraction or use of the groundwater. There were no changes in exposure pathways.

The remedy at the Soil and Groundwater OU1 currently protects human health and the environment because the cap is in good condition, LNAPL is at low enough amounts to no longer be recovered from the groundwater, and long-term groundwater monitoring indicates that contaminants are not migrating to the waterways. However, in order for the remedy to be protective in the long-term, the following actions need to be taken to ensure protectiveness:

- Complete environmental covenants for all capped properties.
- Complete annual cap inspections consistently.

TF-OU2

The Tank Farms Operable Unit 02 (TF-OU2) is being managed by the Washington State Department of Ecology (Ecology) Toxics Cleanup Program under Model Toxic Control Act (MTCA) Cleanup Action Plans (CAPs). The selected remedy at TF-OU2 included excavation of lead and arsenic contaminated shallow surface soil, and total petroleum hydrocarbons (TPH) contaminated hot spot soils and treatment/disposal of these soils off-Site; construction and operation of *in-situ* remedial systems to treat contaminated groundwater and the remaining contaminated soil, utilization of natural attenuation processes; long-term monitoring; and ICs.

Portions of the remedy are functioning as intended by the decision documents. Active remediation continues at the BP Plant 1 facility. A groundwater/LNAPL recovery system is located along the shoreline. In general, groundwater monitoring data at BP Plants 1 and 2 show that concentrations of contaminants are decreasing or stable, and most detections of contaminants have been below cleanup levels at their points of compliance within the last five years.

The Kinder Morgan (KM) facility has implemented sulfate land application as a remediation system multiple times over the last seven years. The KM and Shell facilities also use passive free-product recovery at select wells on an as-needed basis. Two monitoring wells located along the southwestern edge of the KM property near 13th Ave. S.W. have shown increasing concentrations of contaminants over the last five years, indicating the remedy is not fully functioning as intended in this area, and contaminants may be migrating offsite.

Shell completed construction of a bio-sparging system within the TX-03A area in May 2017 and the system operated until December, 2019, and is currently offline for rebound evaluation. Environmental covenants for BP, KM, and Shell have been recorded to restrict activities at these properties.

Changes to ARARs and toxicity data since remedy selection do not affect the current protectiveness of the remedy because ICs help prevent exposure to soils with contamination levels above the new standards, and contaminants in groundwater detected at concentrations above the new standards are located in remediation areas. There were no changes in exposure pathways.

The remedy at the Tank Farms OU2 currently protects human health and the environment because multiple remediation methods are occurring to treat most contaminants, and restrictive covenants help ensure there is no exposure to site contaminants. However, in order for the remedy to be protective in the long-term, the following actions need to be taken to ensure protectiveness:

- Evaluate alternatives for remediating contaminants near the southwestern area wells of the Kinder Morgan property, and determine if contamination is migrating off site.
- After completion of the planned Washington State Department of Ecology remedial action, an evaluation should be conducted to determine if any CERCLA remedial action is required, and if a decision document should be recorded.

LU-OU3

The selected remedy at Lockheed Upland Operable Unit 03 (LU-OU3) included excavation of contaminated hot spot soils and treatment/disposal of these soils off-site, capping of remaining soil contamination exceeding cleanup goals, ICs, and implementation of groundwater monitoring for 30 years.

Portions of the remedy are functioning as intended by the decision documents. Groundwater monitoring shows exceedances of ROD cleanup levels for copper and tetrachloroethylene (PCE), as well as sporadic or localized detections of metals. PCE concentrations above cleanup levels remain in the northern portion of the LU-OU3 but appear to have a stable trend. ICs in the form of an environmental covenant are required for the remedy to remain protective; however, there is currently no such covenant recorded for the property. Nonetheless, cap inspections undertaken annually show that the integrity of the cap has not been compromised. Changes to ARARs, exposure pathways, and toxicity data since remedy selection do not affect the protectiveness of the remedy.

The remedy at the Lockheed Upland OU3 currently protects human health and the environment because the cap integrity has been maintained and groundwater studies indicate that contaminants are not impacting the waterway. However, in order for the remedy to be protective in the long-term, the following actions need to be taken to ensure protectiveness:

- Complete environmental covenants for capped areas of the property.

LSS-OU7

The selected remedy at the Lockheed Shipyard Sediments Operable Unit 07 (LSS-OU7) included demolition of the existing pier and removal of approximately 6,000 creosote-coated piles, dredging of contaminated sediments in the open channel area and offsite disposal of these sediments, capping of contaminated sediments in the nearshore area, and creation of a riparian buffer and a habitat-friendly substrate on top of the capped sediments.

The remedy is functioning as intended by the decision documents as upland sources are not recontaminating the sediment cap. However, there are off-site sources that are depositing a fine layer of contaminated sediment in the open-channel area. The sediment contaminant concentrations in this area have generally been below cleanup levels. Recent mercury and total polychlorinated biphenyl (PCB)

exceedances in the open channel area may be traced to top-down sources of fine-grained sediments; that is, the contaminant exceedances may be traced to sediment from outside sources deposited from suspension onto the cap. The various areas of the sediment remedy have undergone little to no elevation changes since the implementation of the remedy. Groundwater monitoring data show that concentrations of copper exceeding National Recommended Water Quality Criteria (NRWQC) are present along the shoreline.

Zinc and mercury have been detected in solids collected from the stormwater treatment system that discharges onto the cap within the last five years. Additional actions are required to ensure that contaminated sediments are not being deposited on the cap near the discharge point.

The remedy at the Lockheed Shipyard Sediments OU7 currently protects human health and the environment because the cap integrity has been maintained, and groundwater studies indicate that contaminants are not impacting the waterway. However, in order for the remedy to be protective in the long-term, the following actions need to be taken to ensure protectiveness:

- Evaluate new best management practices (BMPs) or investigate sources and opportunities to ensure that stormwater contaminants are not discharging onto the LSS-OU7 cap.
- EPA will continue to monitor sediment concentrations and trends for these contaminants in the sediment on the open-channel surface area.

WW-OU8

The no action ROD for the WW-OU8 presented the basis for the determination that no Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) action was necessary at this OU to protect human health or the environment. Site conditions allow for unlimited use and unrestricted exposure. The no action ROD did not include any requirements for institutional controls and did not require long-term monitoring. Since Environmental Protection Agency (EPA) made the decision for No Action, the statutory requirements of CERCLA Section 121 for remedial actions are not applicable and no statutory or policy five-year reviews are required to be undertaken.

The no action ROD allowed for a discretionary review to verify that the sediment continues to pose no unacceptable risks to human health and the environment. EPA is not aware of any new sediment data from WW-OU8 that suggests it is necessary to conduct monitoring or remedial action at this OU. The U.S Army Corps of Engineers (USACE) is currently analyzing alternatives for navigation improvements to West Waterway, including potential sediment removal for the purpose of deepening the water column. EPA will re-evaluate sediment PCB concentrations in the WW-OU8 after the EW-OU10 ROD is signed. Therefore, this OU was not evaluated in this FYR.

TSS-OU9

The selected remedy at the Todd Shipyards Sediments Operable Unit 09 (TSS-OU9) included dredging of contaminated sediments in the open channel area and offsite disposal of these sediments, demolition of certain piers, capping contaminated sediments under the existing piers, and creation of a habitat bench on the surface of a capped nearshore area.

Results from the latest annual monitoring event indicate that the remedy is functioning as intended by the decision documents for both the dredged and capped areas. At the TSS-OU9, contaminated sediments were either dredged to native clean sediments or capped. The remedial action prevents exposure to fish and shellfish and absent recontamination, should be fully protective. Sediment samples were taken in

2018 to characterize capped sediment remaining underneath the piers that has not been previously characterized. Remedial action (RA) is planned for sediment under piers found to have concentrations exceeding the cleanup goals in 2021. Because the cap remains in place and stable, contaminant exposure to marine organisms is expected to be minimal or non-existent

The remedy at the Todd Shipyard Sediments OU9 is protective of human health and the environment. The Remedial Action Objective (RAO) is being met by the sediment cap integrity being maintained, and dredging and capping is planned as intended by the ROD for remaining contaminated sediments.

EW-OU10

No ROD has been prepared for this OU. A supplemental Remedial Investigation and Feasibility Study was completed in 2019. Therefore, this OU was not evaluated in this FYR.

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1. Introduction

The purpose of a FYR is to evaluate the implementation and performance of a remedy in order to determine if the remedy is and will continue to be protective of human health and the environment. The methods, findings, and conclusions of reviews are documented in five-year review reports such as this one. In addition, FYR reports identify issues found during the review, if any, and document recommendations to address them.

EPA is preparing this FYR pursuant to Section 121(c) of CERCLA, 42 U.S.C. § 9621(c), and section 300.430(f)(4)(ii) of the National Oil and Hazardous Substances Pollution Contingency Plan (NCP), 40 C.F.R. § 300.430(f)(4)(ii)), and consistent with EPA policy.

This is the fifth FYR for the Harbor Island Superfund Site. The triggering action for this statutory review is the September 23, 2015, completion of the previous FYR. The FYR is required due to the fact that hazardous substances, pollutants, or contaminants remaining at the Site above levels that allow for unlimited use and unrestricted exposure (UU/UE).

The Site consists of seven OUs, and 5 OUs are addressed in this FYR. The West Waterway and East Waterway OUs are not addressed in this FYR because "No Action" was selected in the West Waterway ROD, and the ROD for East Waterway has not been issued by EPA. The following list identifies the seven OUs:

OU No.	**Name**
01	Soil and Groundwater OU (S&G-OU1)
02	Tank Farms OU (TF-OU2)
03	Lockheed Upland OU (LU-OU3)
07	Lockheed Shipyard Sediments OU (LSS-OU7)
08	West Waterway Sediments OU (WW-OU8)
09	Todd Shipyards Sediments OU (TSS-OU9)
10	East Waterway Sediments OU (EW-OU10)

The FYR process was led by Ravi Sanga (EPA Remedial Project Manager [RPM]). Participants included Amy Baker (US Army Corps of Engineers [USACE] project manager), Jacob Williams (USACE chemist), and Jeff Weiss (USACE geologist). The review began on October 1, 2019.

1.1. Background

Harbor Island was historically used for commercial and industrial activities including ocean and rail transport operations, bulk fuel storage and transfer, secondary lead smelting, lead fabrication, shipbuilding, and metal plating. Warehouses, laboratories, and offices also existed on the Island. The land use on the Island is changing from a variety of smaller businesses to large operations: Port of Seattle

(Port) shipping container handling and storage, bulk fuel storage, and shipbuilding and repair. Marine activities occur around the entire Island, and dredging has allowed deep draft (40-foot) vessels to berth along piers on the eastern side of the site. The groundwater has never been used as a domestic water source, and was deemed as not a suitable source for drinking water by EPA and Ecology in the 1993 Soil and Groundwater (OU-1) ROD.

The Site has been investigated on numerous occasions beginning in 1980. Based on these studies, Harbor Island was listed on the National Priorities List (NPL) on September 8, 1983, due to elevated concentrations of lead in soil associated with the former lead smelter operations, as well as elevated concentrations of other inorganic and organic substances. The soil on Harbor Island had lead, arsenic, and TPH concentrations well above acceptable human health risk levels, which were identified and quantified in the remedial investigation and feasibility studies that have been completed. In addition, spills and leaks of product at the petroleum tank farms have created several areas of localized soil contamination in both TF-OU2 and in S&G-OU1.

General sources of potential contamination to the sediments surrounding Harbor Island were identified as direct discharge of waste, spills, historical disposal practices, atmospheric deposition, groundwater seepage, storm drains, combined sewer overflow systems, and other nonpoint discharges. Sediment contamination of the estuarine environment surrounding Harbor Island may also have resulted from upstream sources.

Five-Year Review Summary Form

SITE IDENTIFICATION		
Site Name: Harbor Island		
EPA ID: WAD980722839		
Region: 10	**State:** WA	**City/County:** Seattle/King

SITE STATUS	
NPL Status: Final	
Multiple OUs? Yes	**Has the site achieved construction completion?** No

REVIEW STATUS
Lead agency: EPA
Author name (Federal or State Project Manager): Ravi Sanga
Author affiliation: EPA Remedial Project Manager
Review period: October 1, 2019 – September 23, 2020
Date of site inspection: none
Type of review: Statutory
Review number: 5
Triggering action date: September 23, 2015
Due date *(five years after triggering action date)*: September 23, 2020

1.2. Physical Characteristics

Harbor Island is among the largest man-made islands in the United States and is located approximately one mile southwest of downtown Seattle in King County, Washington (Figure 1). The Island lies at the mouth of the Duwamish River on the southern edge of Elliott Bay in Puget Sound. The 420-acre Island was created during the dredging of the lower Duwamish River and the creation of the East and West Waterways between 1903 and 1905. The dredge spoils were deposited across the Island. Subsequent bulkhead construction and filling has brought the Island into its current configuration (Figure 2). The former Duwamish River channel and surrounding floodplains were filled and graded to form the present-day topography. The present urban and developed shoreline is primarily composed of piers, riprap bank lines, and constructed bulkheads for industrial and commercial use.

The Island upland is divided into three OUs; Soil and Groundwater OU01 (S&G-OU1), Tank Farms OU02 (TF-OU2), and Lockheed Upland OU03 (LU-OU3). The Island is over 90 percent covered with impervious surfaces. The Island is within the Seattle City limits. The closest residential properties to Harbor Island are approximately one-half mile away.

The waterway sediment operable units include the Lockheed and Todd Shipyards sediments and the East and West Waterways. The Lockheed Shipyard Sediment OU 07 (LSS-OU7) consists of contaminated nearshore sediments within and adjacent to the former Lockheed Shipyard property on Harbor Island out to the edge of the steep slope of the West Waterway, which occurs at approximately the -36 foot mean lower low water (MLLW) contour. The Todd Shipyards Sediments Operable Unit 09 (TSS-OU9) consists of contaminated nearshore sediments within and adjacent to the Todd Shipyards property on Harbor Island. Todd Shipyards is located at the northwest corner of Harbor Island and faces Elliott Bay to the north and the West Waterway of the Duwamish River to the west.

The West Waterway Sediments OU 08 (WW-OU8) includes approximately 70 acres of estuarine sediments located in the West Waterway on the western side of Harbor Island. The West Waterway is a dredged navigable channel used extensively for industrial and Port purposes. The West Waterway consists primarily of subtidal sediments, which remain underwater even at low tides. The shoreline of the West Waterway is predominantly pilings, bulkhead, and riprap. Areas of intertidal sediments along the shorelines adjacent to the WW-OU8 are generally nonexistent. No shoreline public access areas exist in the WW-OU8.

The East Waterway Sediments OU 10 (EW-OU10) consists of the East Waterway adjacent to the east side of Harbor Island and its associated contamination. The bed of the East Waterway is owned by the State of Washington (State) and managed by the Washington State Department of Natural Resources. The East Waterway is channelized, has a south-to-north orientation, and is approximately 5,800 feet long and 800 feet wide. The southern 1,500-foot section of the EW-OU10 varies in width from 225 feet to approximately 130 feet near the West Seattle Bridge. The depth of the East Waterway ranges from 7.2 to 51 feet MLLW. The minimum depth of 7.2 feet MLLW is at the southern end, in the vicinity of the West Seattle Bridge, and limits large vessel traffic.

The Harbor Island waterways are located within the boundaries of the federally adjudicated Usual and Accustomed Fishing Area for the Muckleshoot Indian Tribe and Suquamish Indian Tribe.

1.3. Hydrology

The soils beneath Harbor Island consist of 3 to 18 feet of mechanically and hydraulically placed fill underlain by native alluvium deposited in a fluvial deltaic environment (mudflats) of the Duwamish River delta. The physical characteristics of the fill and the upper portion of the underlying deltaic sediments are often indistinguishable from each other. The native material consists of unconsolidated silty to clean, fine-to-medium sand with discontinuous interbeds of silt and clay. The native material has increasing amounts of the finer grained material with depth. The overlying fill material consists primarily of loose fine-to-coarse sand and ranges in thickness from about 3 to 18 feet. Shallow, unconfined groundwater is first encountered at depths of 2.5 to 11 feet below ground surface (bgs) in the fill unit. The remedial investigation (RI) identified two hydrostratigraphic units: a freshwater lens floating on a second basal saline water unit. The thickness of the freshwater lens exceeds 85 feet in the center of the Island and thins to about 35 to 40 feet near the shoreline. The thickness of the freshwater/saltwater interface at the base of the freshwater lens is generally less than 10 feet at the perimeter of the Island and possibly somewhat thicker near the center. The freshwater/saltwater interface is assumed to be a boundary for the groundwater flow because of density differences between freshwater and saltwater.

The RI found that groundwater mostly flows from the interior of the Island toward the shoreline; typical of an island setting. Groundwater gradients are steepest along the shoreline and flatten toward the interior of the Island. However, a localized groundwater low was present in the south-central interior portion of the Island. It is unknown if this groundwater low still exists, since most of the wells used in the RI have been destroyed as part of Island redevelopment activities. The RI indicated that the groundwater low was likely associated with the sanitary sewers.

Since the RI, several studies on groundwater flow patterns have been completed at the S&G-OU1 and LU-OU3. A summary of the resulting modifications to the original conceptual model of groundwater flow in the RI is presented in Table 1.

Table 1. Groundwater Flow Conceptual Model Modifications

Original Conceptual Model (1990s)	Modifications
Groundwater behaves as a single hydrostratigraphic unit of freshwater floating on a base of saline water.	A shallow saline water interval has been identified at the margins of the island where bulkheads are not present (or fail to significantly impede flow). Freshwater from the interior of the island discharges below this shallow saline interface. Where bulkheads are present, groundwater may discharge below the barrier.
Recharge occurs primarily through precipitation and infiltration from utility lines.	Recharge has likely decreased substantially due to the increase in impervious surface at Terminal 18 (figure 4).
Groundwater flows mainly outward from the interior of the Island in a radial pattern and discharges to the waterways.	The center of the island appears to be drained by a major sewer line, which has caused a groundwater low.
A groundwater low was identified in the southern portion of the Island.	The groundwater low (mentioned previously) covered an extensive area along the island's center into the region under the Tank Farms. Due to the removal of most of the monitoring locations in the island center, the extent of the area contributing to this sewer line is unknown.
Groundwater levels are tidally influenced. In general, monitoring wells near the shoreline show a larger influence than interior wells.	Tidal studies by Lockheed indicated that in some areas with bulkheads, the net shallow groundwater flow direction may be toward the interior of the Island.

2. Response Action Summary

2.1. Basis for Taking Action

A summary of the major contaminants found at Harbor Island that have been released to the different media in the environment are presented in Table 2.

Table 2. Summary of Contaminants by Media

Soil	Sediments	Groundwater
Lead	PCBs	PAH
Arsenic	PAHs	PCBs
PCBs	Arsenic	Copper
TPH	Copper	TCE
Trichloroethylene (TCE)	Lead	Tetrachloroethylene (PCE)

	Mercury TBT Zinc	TPH (TPH-G, TPH-D, TPH-O, BTEX, cPAHs) Arsenic Lead

Notes:

- total petroleum hydrocarbons = TPH
- total petroleum hydrocarbons, gasoline range organics = TPH-G
- total petroleum hydrocarbons, diesel range organics = TPH-D
- total petroleum hydrocarbons, oil range organics = TPH-O
- benzene, toluene, ethylbenzene, and xylene = BTEX
- carcinogenic polycyclic aromatic hydrocarbons = cPAHs

An assessment of the human health risks at Harbor Island identified people who may incidentally ingest soil or have dermal contact with soil as the population most at risk. Inhalation was not identified as a significant pathway of exposure to contaminants on the upland of Harbor Island. For the Shipyard Sediments, human health risks resulted from consumption of seafood. The most significant risk was elevated cancer risk from PCBs in fish captured in the Elliott Bay/Duwamish River area.

2.2. Soil and Groundwater OU1

2.2.1. Remedy Selection

The ROD for the S&G-OU1 was signed on September 30, 1993, and amended in August 1995 and January 1996. Explanation of Significant Differences (ESDs) were signed in July 1994 and September 2001. The RAOs are as follows:

- Protect human health from exposure to contaminants in surface soil that pose a combined risk of greater than $1x10^{-5}$.
- Protect human health from infrequent exposure to contaminants in the subsurface soil that pose a risk greater than $1x10^{-5}$ for each contaminant.
- Prevent release of contaminants into the groundwater where they can be transported to the shoreline where marine organisms could be exposed.
- Prevent migration of contaminants to the shoreline where marine organisms could be exposed.
- Protect human health from consuming contaminated marine organisms which pose a risk greater than $1x10^{-6}$.

The components of the selected remedial action identified in the ROD (including amendments) to be completed for S&G-OU1 are listed below:

- Excavate hot spot soils and treat or dispose off-site. Hot spots are defined as soils with TPH concentrations greater than 10,000 milligrams per kilogram (mg/kg); PCBs greater than 50 mg/kg; and mixed carcinogens with a total risk greater than $1x10^{-4}$. TPH hot spot soil, which was determined to be non-dangerous waste, would be disposed of at Roosevelt Regional Landfill in

Klickitat County, Washington. PCB and hot spot soil with greater than 10^{-4} risk would be sent off-site for treatment (incineration) or disposed in a hazardous waste landfill.

- Cap exposed contaminated soil exceeding cleanup goals. The cap would consist of low permeability material such as asphalt or concrete. New pavement was required to have a minimum thickness of 3 inches and a maximum permeability of 1 x 10^{-5} cm/s. Existing asphalt and concrete surfaces that were damaged and located in areas where soils exceed cleanup levels were to be replaced or repaired to prevent infiltration of rainwater.
- Invoke Institutional Controls (ICs). These ICs would include a requirement for long-term maintenance of new and existing caps, warn future property owners of remaining contamination under capped areas on their properties, and specify procedures for handling and disposal of excavated contaminated soil from beneath capped areas if future excavation is necessary.
- Remove and treat floating petroleum product and associated contaminated groundwater at Todd Shipyards.
- Implement groundwater monitoring for 30 years, with review of groundwater trends every 5 years to assess the effectiveness of the selected remedy.

Table 3. Cleanup Levels for Soil and Groundwater OU1

Chemical of Concern	Soil-Surface Cleanup Level (mg/kg)	Soil–Subsurface Cleanup Level (mg/kg)	Groundwater Cleanup Level(µg/L)
lead	1000[a]	1000[a]	5.8
arsenic	3.6 to 32.6[b]	200[a]	36
antimony	180 to 677[b]	-	-
carcinogenic PAHs	0.1 to 36.5[b]	20[a]	-
PCBs	0.18 to 2.99[b]	-	0.03
TPH (diesel)	-	6002[a]	-
TPH (gas)	-	400[c]	-
cadmium	-	10[a]	8.0
chromium	-	5800[a]	-
mercury	-	1.02[a]	0.025
benzene	-	1.0[c]	71
Ethylbenzene	-	200[c]	-
toluene	-	100[c]	-
xylenes	-	150[c]	-
carbon tetrachloride	-	-	4.48
trichloroethane	-	-	42
tetrachloroethylene	-	-	8.8
copper	-	-	2.9
nickel	-	-	7.9
silver	-	-	1.2
thallium	-	-	6.3
zinc	-	-	76.6
cyanide	-	-	1

Notes: cleanup goals were determined at various locations over the Site and vary based on the number and type of contaminants present. All groundwater levels are based on protection of marine organisms or human health from consumption of organisms.
Surface soil defined as soil within the top 6 inches below ground surface. Subsurface soil defined as greater than 6 inches below ground surface.
[a] Goals are based on MTCA Method A for soil industrial sites.
[b] Based upon achieving a 1 x 10^{-5} excess cancer risk or Hazard Index equal to 1.
[c] Based on the State of Washington Petroleum-Contaminated Soil Matrix Rating method.

2.2.2. Remedy Implementation

Hot Spot Soils Removal and Capping

All of the hot spot soils that had chemicals of concern (COCs) above acceptable on-site contaminant concentrations have been removed and disposed of off-site. In 2003, the Port finished expanding its cargo container facility (T18) by acquiring approximately 90 acres within the interior of Harbor Island. Contaminated soils exceeding cleanup criteria on the expansion properties were capped. The remaining soil hot spot at Todd Shipyards (in the uplands area) was remediated in 2011.

Table 4. Institutional Controls for S&G OU-1

Media, engineered controls, and areas that do not support UU/UE based on current conditions	ICs Needed	ICs Called for in the Decision Documents	Impacted Parcel(s)	IC Objective	Title of IC Instrument Implemented and Date (or planned)
Soil	Yes	Yes	Port of Seattle	Require long term maintenance of caps; warn future property owners of remaining contamination; specify procedures for handling and disposal of excavated contaminated soil	EPA Covenant, 2017
			Dutchman LLC		Ecology Covenant, 2002
			King County		UECA Covenant, 2013

			Harbor Island Machine Works		None
			Duwamish Properties LLC		EPA Covenant, 1999
			UPRR		UECA Covenant, 1999
			Todd Shipyards (Vigor)		In progress

Todd Shipyards LNAPL Recovery (uplands)
Todd Shipyards has been operating a LNAPL recovery system within the S&G-OU1 boundaries since 1998. Several system modifications have been completed since start-up including a vacuum-enhancement system installed in 2001 and installation of additional recovery wells in 2005 and 2009. The recovery system is planned to be shut down in the summer of 2020, as chemical product is no longer being recovered.

Long-Term Groundwater Monitoring
The ROD required semi-annual long-term groundwater monitoring at selected wells across Harbor Island for a period of 30 years. Long-term monitoring began in 2005.

2.2.3. System Operation/Operation and Maintenance

As part of the ICs, property owners are required to perform annual cap inspections and maintenance to ensure protection of site workers from dermal contact and reduce infiltration from rainwater.

A cap inspection was performed annually for all properties, and each year numerous areas with cracking and plant growth in the pavement were observed, and damaged pavement was repaired/replaced in needed

areas.

2.3. Tank Farms OU2

2.3.1. Remedy Selection

TF-OU2 is comprised of three facilities (Figure 3):

- BP West Coast Products (formerly ARCO Bulk Fuel Storage Facility Harbor Island). Comprised of Plant 1 and Plant 2.
- KM Liquids Terminal, Harbor Island (formerly GATX Terminals). Comprised of Yards A through E.
- Shell Oil Products Seattle Terminal, Harbor Island (formerly Equilon Enterprises). Comprised of the Shell Main Terminal and Tank Farm, Shell's North Tank Farm area (located 300 feet north of Shell's Main Tank Farm) and Shell's Shoreline Manifold area (located 1,200 feet north of Shell's Main Tank Farm).

Consent Decrees and Cleanup Action Plans (CAPs), which Ecology issues that are similar to EPA RODs, were established with property owners during 1999 and 2000. Indicator hazardous substances identified within the TF-OU2 included:

- Soil: TPH (shallow and subsurface soil), arsenic (shallow soil), and lead (shallow soil).
- Groundwater: Free product/sheen; TPH gasoline, diesel, and oil range; benzene, toluene, ethylbenzene, xylenes, carcinogenic PAHs, and lead.

Cleanup levels for these substances were established in the CAPs for each property within TF-OU2 and were mostly identical to cleanup levels established in the EPA RODs for S&G-OU1 and LU-OU3. The cleanup levels for soil were considered protective of industrial worker exposure. The cleanup levels in groundwater were considered protective of surface water (aquatic organisms in Elliott Bay). The specific cleanup levels for each property within TF-OU2 and the associated constituents are listed in Table 5 below.

Table 5. Cleanup Levels for Tank Farms OU (µg/L (groundwater) & µg/kg (soil))

		Kinder Morgan	**BP**	**Shell**	**Source**
Medium	**Substance**	**Cleanup level**			
Surface Soil	Arsenic	32,600			ROD – OU1
	Lead	1,000,000			ROD – OU1
	Total TPH	10,000,000			MTCA A
Subsurface Soil	Total TPH	20,000,000			MTCA A
Groundwater	Product	No sheen			MTCA &

			Ambient Water Quality
	Benzene	71	WAC 173-201A
	cPAHs	0.031	Clean Water Act Section 304
	Copper	2.9	Clean Water Act Section 304
	Ethylbenzene	29	Clean Water Act Section 304
	Lead	5.8	Clean Water Act Section 304
	Toluene	200	Clean Water Act Section 304
	TPH-gas	10	MTCA A
	TPH-diesel	10	MTCA A
	TPH-oil	10	MTCA A

The objectives of the remedial actions were to remove all accessible contaminated soil and to achieve groundwater cleanup levels at the shoreline areas and inland property boundaries.

The selected remedial components included:

- Excavate and remove shallow surface soil (6 inches) in areas exceeding 1,000 parts per million (ppm) lead and/or 32 ppm arsenic.
- Excavate and remove accessible surface and subsurface soil in areas exceeding 10,000 ppm total TPH at identified areas adjacent to the shoreline and inland where a large release occurred in 1996. Excavate and remove soil exceeding 20,000 ppm total TPH throughout all other inland

areas. An overriding consideration regarding excavation of contaminated soils was to avoid any risk to the petroleum storage tanks and pipelines.

- Construct and/or operate *in-situ* remedial systems to treat contaminated soil and groundwater. The systems include free product/groundwater recovery, air sparging, and soil vapor extraction (SVE) components and supplemental active free-product recovery by passive methods in specific wells as needed.
- Utilize natural attenuation processes to reduce contaminant levels in soil and groundwater. This was an inherent part of the remedy for inaccessible contaminated soils left in place to avoid risk to infrastructure.
- Perform long-term groundwater monitoring, examine wells for free product, measure groundwater elevations at wells, and construct seasonal groundwater flow maps. Analyze groundwater samples for contaminants of concern (TPH-G, TPH-D, TPH-O, BTEX, cPAHs, arsenic, lead). Also analyze for natural attenuation parameters (dissolved oxygen [DO], oxidation reduction potential [ORP], carbon dioxide, methane, ferrous iron, nitrate, sulfate, alkalinity) to evaluate natural attenuation processes.
- Institute Restrictive Covenants. The restrictive covenants identified the contamination that existed at each property, provided for the continued industrial use of the property, prohibited groundwater taken from the property, provided for the safety and notification of on-site workers, prohibited activities that would release or cause exposure to contamination, provided for continuance of remedial actions given property transference, and provided for Ecology access.

2.3.2. Remedy Implementation

Removal of Lead-Arsenic Contaminated Surface Soil

Excavation of near-surface lead-arsenic contaminated soil in areas throughout the main tank farm at the Shell facility was completed December 2003 through February 2004. Approximately 2,929 tons of impacted soil were removed and disposed of at the Roosevelt Regional Landfill in Klickitat County, Washington. Soil cleanup standards for lead (1,000 ppm) and arsenic (32 ppm) were achieved throughout this area. A small area of lead-contaminated soil near an oil-water separator at the Shell facility was excavated during October 2001, and approximately 75 tons of impacted soil was removed. Due to structural constraints, lead levels in some subsurface soil remains above the lead standard in this area and it was capped with 3 inches of low-permeability asphalt.

Excavation of near-surface lead-arsenic contaminated soil throughout large areas in B and C Yards at the KM facility was completed April through May 2002. Approximately 11,094 tons of impacted soil was removed and disposed of at the Waste Management Columbia Ridge Landfill and Recycling Facility in Arlington, Oregon. Soil cleanup standards for lead (1,000 ppm) and arsenic (32 ppm) were achieved throughout these areas.

No removal of lead/arsenic contaminated surface soil was required at the BP facility.

Removal of TPH Contaminated Surface and Subsurface Soil

All TPH “hot spots” identified in the original RI work and CAPs have been addressed. A description of the removals is presented below.

Numerous discrete areas of TPH-contaminated soil above established cleanup standards were identified throughout all three tank farms. Impacted soil with concentrations above applicable standards was removed in areas and transported to appropriate facilities off-site for treatment or disposal. Some subsurface soil with concentrations above applicable standards remains in most of these areas because of the safety constraints imposed on excavating by existing structures (primarily the aboveground tanks).

A waterfront probing investigation was completed in 2020 at the BP site. The results of the investigation showed that remedial actions along the Plant 1 waterfront have reduced or removed most of the preexisting soil impacts in the unsaturated zone and that no free LNAPL was detected in the groundwater. The results indicate that the current remedial system may have recovered LNAPL to the extent practicable and further operation of the existing groundwater pump and treatment system is may be unlikely to provide additional environmental benefit (TechSolve, 2020).

A new seawall was installed in 2018 on the border of the OU which now extends down to about -66 feet. This is a deeper subsurface barrier to groundwater discharged to the surface of west waterway than before. Ecology is evaluating continued operation of the LNAPL recovery system in conjunction with a hydraulic evaluation of the new seawall.

Construction and Operation of In-Situ Remedial Systems

A summary of the remediation systems that have operated or are currently operating at TF-OU2 is as follows:

- A free product recovery and vapor extraction system operated at the shoreline in the Shoreline Manifold area of the Shell facility prior to the Consent Decree until 2005 when product was no longer observed and hydrocarbon recovery through vapor extraction declined.
- A point-source free product recovery at the KM facility A and B Yards operated from October 2002 through 2004 when product was no longer observed.
- An air sparge system consisting of 16 sparge wells at the KM facility C Yard operated from October 2002 through August 2004 when groundwater cleanup standards had been achieved and maintained.
- An SVE/air sparge system at the KM facility A Yard started up in 2006 and operated until 2010.
- A free product recovery and vapor extraction system at the bulkhead area of BP Plant 1 has been operating since 1992. The system was expanded in 2003 as a requirement of the CAP to include greater capacity for free product/groundwater recovery and add vapor extraction and air sparging components and continues to operate at present.
- An SVE system at BP Plant 1's southern boundary operated from 2008-2014. In 2018, a partial decommissioning of the SVE System occurred.
- Passive free product recovery is occurring at the KM and Shell facilities.
- Sulfate Land Application continues with application of Epsom salt at KM in 2016, 2018 and 2019, which was also implemented in 2013 and 2015, at Yards B, C, and D to enhance biodegradation of petroleum products.
- A bio-sparging system installed in the Shell terminal, within the TX-03A area.

Natural Attenuation

Monitored Natural Attenuation (MNA) has occurred at 13th Ave SW right of way at the SH-04 area by the KM and Shell facilities. Select wells are analyzed for indicator parameters to evaluate natural attenuation processes. These included dissolved oxygen, ferrous iron, methane, sulfate, sulfide, carbon dioxide. Declining contaminant levels in some wells near remaining areas of subsurface TPH contamination provide evidence that natural attenuation is occurring in these areas.

Groundwater Monitoring
Numerous monitoring wells at the tank farms were in place prior to the Consent Decrees and additional wells were installed afterwards. Monitoring wells throughout the tank farms were regularly examined for free product and/or sampled for the contaminants of concern and natural attenuation parameters. Wells designated for particular monitoring activities are specified in the Groundwater Compliance Monitoring Plan for each facility. Two compliance monitoring wells in the Shoreline Manifold area at the Shell facility and five compliance monitoring wells in Plant 1 at the BP facility are screened in groundwater at depths below the bottom of each bulkhead to monitor possible discharge of contaminants to surface water. Other monitoring wells are screened at the water table.

Institutional Controls
Institutional Controls were required in the form of Restrictive Covenants (now called Environmental Covenants) for each facility and were required to be written and recorded 10 days after the signing of each Consent Decree. The restrictive covenants for BP, KM, and Shell were filed with King County on August 15, 2000, August 30, 2000, and October 5, 2000, respectively.

2.3.3. System Operation/Operation and Maintenance

The Operation and Maintenance (O&M) procedures specific to each system are presented in O&M manuals prepared for each system. General system operations and maintenance activities along with the operating and performance parameters for each system are presented in required quarterly reports.

BP
Recovery wells have experienced pumping rate reductions in recent years, attributed to biological fouling in the shallow aquifer due to high concentrations of iron and sulfate present in the brackish water along the waterfront. During the previous five years annual average flow rates ranged from 1.9 gpm in 2016 to 1.2 gpm in 2018. The system operated at a maximum annual average flow rate of 11.2 gpm in 2005. Maintenance is performed on the wells and pumps to maintain and improve groundwater capture and to ensure that adequate drawdown is achieved.

Kinder Morgan
Passive free product recovery using absorbent socks continues, and is currently performed at select wells periodically when sheen or product is observed.

Shell
There are currently no active recovery systems at Shell. Passive free-product recovery continues in the Shoreline Manifold area on an as needed basis.

2.4. Lockheed Upland OU3

2.4.1. Remedy Selection

During the site-wide Remedial Investigation/Feasibility Study (RI/FS), LU-OU3 was established to allow the Lockheed Martin Corporation to proceed with the cleanup of its property on a different schedule from the rest of the Site. The ROD for LU-OU3 was signed by EPA in 1994. The objectives, selected remedial actions, and cleanup goals are the same as the S&G-OU1 ROD. The LU-OU3 remedial action objectives were to:

- Protect human health from exposure to contaminants in surface soil that pose a combined risk of greater than $1x10^{-5}$.
- Protect human health from infrequent exposure to contaminants in the subsurface that pose a risk greater than $1x10^{-5}$ for each contaminant.
- Prevent release of contaminants into the groundwater where they can be transported to the shoreline, where marine organisms could be exposed.
- Prevent migration of contaminants to the shoreline where marine organisms could be exposed.
- Protect human health from consuming contaminated marine organisms that pose a risk greater than $1x10^{-6}$.

The components of the selected remedial actions outlined in the ROD are:

- Excavate and treat hot spot soils. Hot spots are defined as soils with TPH concentrations greater than 10,000 mg/kg. The TPH hot spot soil will be treated on-site by a thermal desorption system with an afterburner.
- Contain exposed contaminated soil with contaminant levels exceeding inorganic and organic cleanup goals.
- Invoke ICs that will warn future property owners of the remaining contamination contained under capped areas on this property, require future owners and operators to maintain these caps, and specify procedures for handling and disposal of excavated contaminated soil from beneath capped areas if future excavation is necessary.
- Monitor groundwater quality semi-annually for 30 years, or until it has been demonstrated that groundwater contaminants will not reach the shoreline in concentrations exceeding cleanup goals. The groundwater data will be reviewed every 5 years to assess the effectiveness of the selected remedy.

2.4.2. Remedy Implementation

A Consent Decree for LU-OU3 was signed on December 8, 1994 and the remedial actions were completed on December 27, 1995. The LU-OU3 soils portion was deleted from the NPL on November 7, 1996.

Hot Spot Soils Removal and Capping
All of the hot spot soils have been removed and areas with organics and inorganics exceeding soil cleanup

goals have been capped.

Institutional Controls
To warn future property owners of the remaining contamination, the Consent Decree for this OU requires that a certified copy of the Consent Decree be recorded in the appropriate King County office. Thereafter, each deed, title, or other instrument conveying an interest in a property included in the LU-OU3 is required to contain a recorded notice that the property is subjected to the Consent Decree (and any lien retained by the United States) and to reference the recorded location of the Consent Decree and any restrictions applicable to the property.

Long-Term Groundwater Monitoring
Semi-annual groundwater monitoring has been conducted since 2005, and still continues. The objective of the program is to monitor contaminants at and down-gradient of source areas.

2.4.3. System Operation/Operation and Maintenance

Cap Inspection
As part of the ICs, annual cap inspections and cap maintenance are required to ensure protection of on-site workers from dermal contact and reduce infiltration from rainwater. The integrity of the capped areas is inspected by examining them for cracks, breaches, and the presence of vegetation.

There are five capped areas at LU-OU3 that require annual inspections. Maintenance items have been completed as necessary to maintain cap integrity. A summary of the annual inspections is presented in Table 6 below.

Table 6. Summary of Annual Cap Inspections, LU-OU3

Year	Cap Area 1	Cap Area 2	Cap Area 4	Cap Area 5	Cap Area 6
2015	Excellent condition	Excellent condition	Very good condition	Very good condition	Good condition. Shallow-rooted weeds (non cap penetrating) and moss were observed on the cap.
2016	Excellent condition	Excellent condition	Good condition	Very good condition	Cracks in which plants were starting to become established. Rooted weeds observed on the cap.

Year	Cap Area 1	Cap Area 2	Cap Area 4	Cap Area 5	Cap Area 6
2017	Excellent condition	Excellent condition	Good condition. Minor weeds were observed; however, total cap thickness is over 3 feet (significantly greater than ROD requirement).	Good condition	Good condition
2018	Excellent condition	Excellent condition	Good condition. Minor weeds were observed; however, total cap thickness is over 3 feet (significantly greater than ROD requirement).	Good condition. 2-inch deep hole was observed; however, total cap thickness is over 3 feet (significantly greater than ROD requirement).	Good condition
2019	Excellent condition	Good condition. A few small divots (1/4 inch deep) located throughout.	Good condition. Minor weeds were observed; however, total cap thickness is over 3 feet (significantly greater than ROD requirement).	Good condition. 2-inch deep hole was observed; however, total cap thickness is over 3 feet (significantly greater than ROD requirement	Good condition

2.5. Lockheed Shipyard Sediment OU7

2.5.1. Remedy Selection

The Shipyard Sediment ROD was signed by EPA on November 30, 1996. This ROD divided the Sediment OUs into separate OUs for Lockheed and Todd shipyards. The RAO for the LSS-OU7 is to reduce concentrations of hazardous substances to levels that will have no adverse effect on marine organisms.

The major components of the remedy selected in the ROD include the following:

- All sediment exceeding the State of Washington sediment management standards (SMS) Cleanup Screening Levels (CSLs) and all shipyard waste will be dredged and disposed of in an appropriate in-water or upland disposal facility. CSLs are the level above which minor adverse effects occur in marine organisms.
- All sediments exceeding the Sediment Quality Standards (SQS) of the SMS will be capped with a minimum of 2 feet of clean sediment. SQS corresponds to a level which has no acute or chronic adverse effects on marine organisms.
- Specification of design criteria for acceptable habitat and to prevent future recontamination.
- Institution of long-term monitoring and maintenance of the remedy.
- The extent of dredging of contaminated sediments and waste under piers at the LSS-OU7 will be determined during remedial design (RD) based on cost, benefit, and technical feasibility.

Subsequent to the ROD, pre-remedial design studies for the LSS-OU7 better defined the nature and extent of contamination within the OU. The results of these studies indicated that certain elements of the ROD needed to be modified. The February 12, 2002, ESD summarized the sediment characterization data, specified details regarding the dredge and cap remedy, and defined abrasive grit blast. The March 7, 2003, ESD established confirmation sampling values for contaminants to be used in distinguishing contaminants characteristic of the West Waterway from contamination associated with the LSS-OU7; summarized the long-term monitoring, maintenance, and operational parameters; and identified the disposal option for contaminated sediments dredged from the LSS-OU7 identified as requiring upland disposal.

2.5.2. Remedy Implementation

In an Administrative Order on Consent (AOC) issued by EPA on July 16, 1997, Lockheed Martin agreed to perform the RD for implementing the remedy in conformance with the ROD as modified by the two ESDs. Three RDs for various dredging seasons were approved by EPA between 2003-2004.

A Consent Decree between EPA and Lockheed was court-approved on July 23, 2003, under which Lockheed would perform the Remedial Action (RA) and pay past costs for cleaning up the site.

The major components of the RA were the following, which were all completed:

- Replace the existing deteriorated bulkhead wall so the upland soils will remain stable during and after remedial activities. This included pier and timber bulkhead removal and dredging adjacent to the bulkhead.
- Remove all existing pier structures including timber piling and portions of the existing shipway structures from aquatic areas of the OU while maintaining the stability of the OU.
- Dredge contaminated sediments from the channel and slope areas of the LSS-OU7 while maintaining stable slopes and critical habitat elevations.
- Design the dredge prisms and constructed slopes such that they will be constructible.

- In the Channel Area, remove the depth of sediment that has contaminant levels exceeding SQS criteria and construct a berm to support the Slope Area and maintain critical habitat elevation.
- Perform post-dredge sediment verification sampling and analysis to confirm achievement of SQS in the Channel Area.
- In the Slope Area, limit post-remediation changes of critical habitat elevations (i.e., between -4 to 8 feet MLLW) from that of the existing condition while accommodating a 5-foot-thick cap.
- Construct an on-site mitigation area.
- Create intertidal habitat with clean soil in the vicinity of Pier 10 to mitigate habitat losses resulting from the partial filling of the South Shipway.
- Cap the Slope Area such that the cap will provide: chemical and physical isolation of the underlying contaminated sediments; protection of the chemical isolation portion of the cap from bioturbation and erosional forces; and a final cap surface that is compatible with marine organisms.
- Limited dredging and a sand cover boundary line along the offshore perimeter of the OU (as a placeholder concept pending the results of further characterization in this area) to provide partial removal, coverage, and enhanced natural remediation (ENR) of contaminated off-site sediments located adjacent to the OU; and a final substrate surface that is habitat compatible for marine organisms.

The LSS-OU7 was subdivided into eight Site Management Areas (SMAs) for the purposes of remedial design and action.

The RA was conducted in two phases. Phase 1 was completed on March 10, 2004, and Phase 2 was completed on February 4, 2005. The first phase of remedial construction efforts was focused on pier demolition and dredging of contaminated sediments. The second phase consisted of dredging, capping, and habitat enhancement. During this remedial action, 119,064 tons of contaminated sediments were dredged and transported to an approved upland facility for disposal.

Capping was implemented using approximately 100,000 cubic yards of capping material including the cap layer, toe buttress riprap, armor riprap, filter layer, armor layer, and fish mix.

Following remedial action dredging, eight sediment samples were collected from the post-dredge surface of the channel area (SMAs 1 through 7) to evaluate compliance with the design criteria. All analytical results were compared to the SQS chemical criteria to evaluate compliance. Three samples exceeded the SQS for PCBs only. Three other samples exceeded the SQS for a combination of COCs.

The remedial action for portions of the channel area, represented by four sediment samples, failed to meet the cleanup levels for several COCs. In these areas 6 inches of sand was added to the sediment surface, i.e., enhanced natural remediation. At location SED-200 where there was an exceedance of PCBs only, no actions were taken because the exceedances were minor and were below the 90th percentile for PCBs present in the West Waterway based on bioassays.

Remedial activities were conducted as planned, and cleanup goals were obtained for the first phase of the remedial action (TRC Solutions, 2005). EPA conducted a final inspection on March 7, 2005.

2.5.3. System Operation/Operation and Maintenance

Remedial action at the LSS-OU7 was completed on February 4, 2005. The Operation, Maintenance and Monitoring Plan (OMMP) was implemented immediately after the completion of the remedial action to gather monitoring data that would serve as a baseline against which future monitoring results would be compared. The final topographic and hydrographic surveys of the remedy were taken on February 28, 2005. These surveys demonstrate that the cap met design specifications and are used as a baseline against comparison to future OMMP surveys.

The OMMP was approved on September 28, 2006, for LSS-OU7. The goals of the OMMP are to ensure that the remedial actions continue to be protective of the environment. The specific goals are to ensure that:

- The sediment cap continues to isolate toxic concentrations of previously identified COCs in the underlying sediments from marine biota and other biological receptors.
- The sediment cap and the previously dredged open channel area do not become re-contaminated with COCs from the underlying sediments or from the uplands adjacent to the LSS-OU7.

The LSS-OU7 is now divided into the following five areas based on characteristics or function:

- Slope Area.
- Open Channel Area.
- Beach Area.
- Mitigation Area.
- Riparian Area.

The OMMP requires visual inspections, hydrographic and topographic surveys, and sediment and groundwater monitoring for COCs. Monitoring results will be used to assess cap integrity, sediments quality, and source control. Detailed tasks and procedures are described in the OMMP.

Visual inspections of the riparian buffer, Mitigation Area, and the Beach Area are conducted at a very low point in the tidal cycle, approximately -3 feet MLLW.

Hydrographic surveys are evaluated to assess the stability of the Slope Area and Open Channel Area. Each survey involves creation of a bathymetric map. Isopachs are produced by comparing results from previous and current bathymetric maps. The isopach illustrates changes in the bathymetry from one year to the next. Topographic surveys, also used to evaluate stability, involve the creation of a topographic contour map of the Beach Area of the sediment cap and the Mitigation Area. Hydrographic surveys of the slope area and the open-channel area and topographic surveys of the beach area and mitigation area were last conducted in 2015. Visual and photographic surveys of the beach area, mitigation area, and riparian area are conducted annually and documented in the annual operation, monitoring, and maintenance reports.

Since August 2006, five surface (0-10 cm) sediment samples each have been collected annually (excluding 2011 and 2013) from the open-channel area and the beach area. Sediment samples are taken and analyzed for COCs to assess the potential toxicity of surface sediments. Sediments remaining in the LSS-OU7 must be protective of the environment. Sediment grab samples are taken to evaluate sediment toxicity in the Open Channel Area, Slope Area, and Beach Area. Sediment traps were placed to evaluate deposition of contamination from the West Waterway. Therefore, if sediment contaminant levels were found to exceed the SQS, EPA could determine whether the contamination was from cap failure or deposition of sediment from the waterway.

Zinc and mercury have been detected above SCO criteria in solids in stormwater treatment effluent that discharges to the LSS-OU7 cap within the last five years. The most recent stormwater discharge sampling in 2019 showed zinc with a concentration of 3,100 mg/kg dw, which exceeds the LSSOU CSL of 960 mg/kg dw. In this sampling event, mercury was detected at 0.24 mg/kg dw, which is below the LSSOU CSL of 0.59. However, other sampling events within the last five years showed concentrations of mercury above its LSSOU CSL. The Port started implementing actions to address this issue, and more information is explained in section 3.

Monitoring wells were installed along the bulkhead on the land side. Results from analyzing groundwater are used to assess the quality of the groundwater entering the West Waterway from Harbor Island.

2.6. West Waterway Sediments OU8

2.6.1. Remedy Selection

The No Action ROD for the WW-OU8 (September 11, 2003) presented the basis for the determination that no CERCLA action was necessary at this OU to protect human health or the environment. Site conditions allow for unlimited use and unrestricted exposure. The no action ROD did not include any requirements for institutional controls and did not require long-term monitoring.

2.6.2. Remedy Implementation

EPA is not aware of any new sediment data from the sediments of the WW-OU8 that suggest it is necessary to conduct monitoring at the site to verify that sediment continues to pose no unacceptable risks to human health and the environment.

In 2014, USACE issued a Notice of Preparation (November 7, 2014), which documented that USACE is analyzing “alternatives for navigation improvements to the East and West Waterways of Seattle Harbor, including potential deepening of these waterways. Initial alternatives include deepening the East and West Waterways up to -55 feet mean lower low water.” There is the potential for sediment sampling and/or dredging to occur in the future.

2.7. Todd Shipyards Sediments OU9

2.7.1. Remedy Selection

The Shipyard Sediment ROD, which includes the Todd Shipyards Sediment area, was signed on

November 30, 1996. The single RAO for the TSS-OU9 is to reduce concentrations of hazardous substances to levels that will have no adverse effect on marine organisms.

The major components of the remedy selected in the ROD include the following:

- All sediment exceeding the chemical contaminant screening level of the State of Washington SMS and shipyard waste will be dredged and disposed of in an appropriate in-water or upland disposal facility.
- All sediments exceeding the SQS of the SMS will be capped with a minimum of 2 feet of clean sediment.
- Specification of design criteria for acceptable habitat and to prevent future recontamination.
- Institution of long-term monitoring and maintenance of the remedy.
- The extent of dredging of contaminated sediments and waste under piers at the TSS-OU9 will be determined during remedial design based on cost, benefit, and technical feasibility.

Subsequent to the ROD, pre-remedial design studies for the TSS-OU9 better defined the nature and extent of contamination within the OU. The results of these studies indicated that certain elements of the ROD needed to be modified. EPA issued an ESD on December 27, 1999. The purpose of the ESD is to designate the Todd Shipyards Site as an independent operable unit identified as the TSS-OU9 and to redefine the boundary of the OU identified in the November 1996 ROD based on additional information gathered during two remedial design investigations associated with this OU.

On April 7, 2003, EPA issued a second ESD. The primary changes documented in this ESD were to:

- Further define the selected remedial action for the under-pier areas.
- Establish confirmation numbers characteristic of contamination present in the West Waterway for the purpose of defining the TSS-OU9 boundary.
- Adjust the TSS-OU9 boundary based on the use of confirmation numbers.
- Summarize the long-term monitoring, maintenance and operational requirements for TSS-OU9.
- Define “predominantly abrasive grit blast”.
- Identify the disposal option.

2.7.2. Remedy Implementation

In an AOC signed with EPA on April 25, 2000, Todd Shipyards agreed to perform the RD for implementing the remedy in conformance with the ROD as modified by the 1999 ESD. The RD was approved by EPA on May 25, 2004. A consent decree (CD) between EPA and Todd was court-approved on July 21, 2003, under which Todd Shipyards would perform the RA.

The RA was conducted in two phases. Phase 1 was completed at the end of February 2005, and Phase 2 was completed in February 2007 (Floyd Snider, 2007). The first phase of remedial construction efforts was focused along the north end of the TSS-OU9 and included pier demolition, dredging, and disposal of contaminated sediments and capping. The major components of this phase of the RA were the following

(which are different from the SMAs in Lockheed Shipyard OU-7):

- Completed demolition and disposal of side-launch shipways located along the Northeast Shoreline of SMA 1 and Pier 2 located in SMA 8.
- Completed dredging and disposal of contaminated sediment and shipyard debris in SMAs 1, 2, 3, 4, and 5, located on the north side of the Todd Shipyards property.
- Completed placement of in-water fill, including reconstruction of the Northeast Shoreline slope in SMAs 1 and 2; filling of subtidal depressions in SMAs 3, 5, and 7; and placement of boundary sand in SMAs 1 and 5.
- Completed placement of under-pier cap material at Pier 4 North, Pier 5, Pier 6, and Pier 6 Platform.
- Initiated, but did not complete, dredging and disposal of contaminated sediment in SMAs 7, 8, and 9.

During this period, 166,192 cubic yards of contaminated sediments were dredged and transported to an approved upland facility for disposal.

Under-pier capping was implemented at Piers 4N, 5, 6 and 6P using special equipment consisting of a throwing conveyor mounted on a series of modular floats, a barge-mounted derrick crane, and a series of flat-decked material barges. A total of about 150,000 square feet were capped.

A total of 45 sediment samples were collected from the post-dredge surface of SMAs 1-7 to evaluate compliance with the design criteria. Two of these samples were submitted for bioassay testing and evaluated for compliance using the SMS biological criteria. One of the bioassay locations did not pass the SMS biological criteria; this area has been addressed by placement of a permanent sediment cap. The remaining 43 samples were compared to the SQS chemical criteria to evaluate compliance. Six of these samples exceeded the SQS for mercury only, and in these areas EPA determined that ENR would be a sufficient remediation alternative.

Remedial activities were conducted as planned, and cleanup goals were obtained for the first phase of the remedial action. EPA conducted a pre-final inspection on March 7, 2005. The pre-final inspection concluded that construction had been completed in accordance with the remedial design plans and specifications.

The second phase of remedial construction, completed in 2006, was focused along the west side of the OU, and included pier demolition, dredging and disposal of contaminated sediments, and capping.

The major components of Phase 2 RA were the following:

- Dredging in SMA 6, SMA 8 (where the initial overburden dredging was conducted in 2004), and SMA 9.
- Demolition of Pier 4S.
- Construction of habitat bench in SMA 6.

- Capping below Piers 1, 2P, 3, and outer reaches of building ways (completed as an interim remedy until the piers would be demolished, and dredging of contaminated sediments could commence).

Based on information provided to the EPA by Vigor Shipyards Inc. (Vigor), the successor in interest to Todd Shipyards, the shipways and Pier 1 are going to be demolished by Vigor in 2021-2022 for construction of a habitat restoration project. Following demolition, Vigor will dredge the sediments with concentrations exceeding the CSL from the shipways and install an engineered cap which protects against exposure to contamination remaining in sediments that exceed the SQS, but are still below the CSL, in the Pier 1 area.

2.7.3. System Operation/Operation and Maintenance

An OMMP for the TSS-OU9 was approved by EPA on October 22, 2007 after the completion of the remedial action. The goals of the OMMP are to ensure that the remedial actions continue to be protective of human health and the environment. The specific goals are to ensure that:

- The sediment cap continues to isolate toxic concentrations of previously identified COCs in the underlying sediments from marine biota and other biological receptors.
- The sediment cap and the previously dredged open channel area do not become re-contaminated with COCs from the underlying sediments or from the uplands adjacent to the TSS-OU9.

For the OMMP, the TSS-OU9 was divided into four areas based on characteristics or function (Figure 13). They are the:

- Under-Pier Capped Area.
- Northeast Shoreline Sediment Cap.
- Western Shoreline Habitat Bench.
- Open Water Dredged Area.

Monitoring (physical integrity monitoring) occurred at the Under-Pier Capped Areas, the Northeast Shoreline Sediment Cap, and the Western Shoreline Habitat Bench in Year 1, 2, 4, and 9 after construction of the remedy to compare to the Year 0 monitoring observations. Visual surveys were conducted to assess:

- Physical integrity monitoring of under-pier cap areas, with contingencies for maintenance of the caps and potential sampling for COCs in areas adjacent to the piers if erosion of cap material has occurred.
- Physical integrity monitoring of the riprap along the Northeast Shoreline in SMA 2 to ensure stability of the sediment cap, with contingencies for maintenance of the cap if erosion of cap material has occurred.

Early warning standards were developed to signal potential cap failure. Observations of complete erosion of the sand cap along a transect would trigger additional action to assess the extent of erosion and if necessary additional remedial actions. Detailed tasks and procedures are described in the OMMP.

The TSS-OU9 Year 9 monitoring occurred in 2016. Based on diver observations and video footage of the sediment, the sand cap material has appeared to remain in place and there was no indication that complete erosion of the sand cap material had occurred at any of the observation locations either under the piers or at the building berth. In accordance with the OMMP, because cap material continues to be stable after Year 9 monitoring, long-term monitoring of the under-pier capped areas can be considered complete and no further monitoring is required.

The most recent upland Vigor Shipyards Cap Inspection took place in August 2020. The pavement and observable surface water collection system components were inspected. No significant issues were identified except for four relatively small areas of pavement that needs repair because of cracking in the pavement.

2.8. East Waterway Sediments OU10

A ROD has not been completed for the East Waterway Sediments. The current schedule calls for the signature of this ROD in 2021.

In 2004–2005, the Port of Seattle conducted a non-time-critical removal action for highly contaminated sediments in the East Waterway. The removal action was implemented under the authority of an Action Memorandum (2003). The following actions were completed under the Action Memorandum:

- Dredging 180,000 cubic yards of contaminated sediment unsuitable for open-water disposal and 67,000 cubic yards of sediment suitable for open-water disposal.
- Dewatering sediments not suitable for open-water disposal at an upland staging area and disposing of the dewatered sediments at an upland landfill.

In 2005, it was determined that the dredging did not reach SQS sediment standards after sediment removal so a 6-inch layer of clean sand was placed over the surface to protect benthic organisms from residual contaminants. Recontamination monitoring in 2006, 2007, and 2008 revealed the presence of PCBs and mercury above sediment management standards SQS, at 65% and 21% respectively, of the sample locations. The Supplemental Remedial Investigation was completed in 2014, and the Feasibility Study was completed in 2019. A ROD for the East Waterway is expected in 2021.

Since there is not selected remedial actions, there will be no further evaluation of this OU in the FYR.

3. Progress Since the Last Review

Table 7. Protectiveness Determinations/Statements from the 2015 FYR

OU #	Protectiveness Determination	Protectiveness Statement
1	Short-term Protective	*The remedy at the Soil and Groundwater OU1 currently protects human health and the environment because the LNAPL extraction system is actively removing the remaining product and long-term groundwater monitoring indicates that contaminants are not*

		migrating to the waterways. However, in order for the remedy to be protective in the long-term, the following actions need to be taken to ensure protectiveness: *• Complete Restrictive Covenants for all capped properties.* *• Complete annual cap inspections consistently.* *• Develop a groundwater monitoring program at Todd Shipyards to determine whether or not contamination is migrating to the waterway.*
2	Short-term Protective	*The remedy at the Tank Farms OU2 currently protects human health and the environment because active remediation or MNA is treating contaminants. However, in order for the remedy to be protective in the long-term, the following actions need to be taken to ensure protectiveness:* *• Evaluate full-scale active remediation at the area near well TX-03A and implement additional remediation if determined appropriate by Ecology in coordination with EPA.*
3	Short-term Protective	*The remedy at the Lockheed Upland OU3 currently protects human health and the environment because the cap integrity has been maintained and groundwater studies indicate that contaminants are not impacting the waterway. However, in order for the remedy to be protective in the long-term, the following actions need to be taken to ensure protectiveness:* *• Complete Restrictive Covenants for capped areas of the property.*
7	Short-term Protective	*The remedy at the Lockheed Shipyard Sediments OU7 currently protects human health and the environment because the cap integrity has been maintained and groundwater studies indicate that contaminants are not impacting the waterway. However, in order for the remedy to be protective in the long-term, the following actions need to be taken to ensure protectiveness:* *• Evaluate the new BMPs or investigate sources and opportunities to ensure that stormwater contaminants are not discharging onto the LSS-OU7 cap.* *• In future monitoring events, confirm whether or not the recent contamination can be traced to sediment from outside sources deposited from suspension. If sources such as this exist, EPA will*

		work with the PRP for additional investigations to ensure protectiveness.
9	Short-term Protective	*The remedy at the Todd Shipyard Sediments OU9 currently protects human health and the environment because the cap integrity has been maintained. However, in order for the remedy to be protective in the long-term, the following actions need to be taken to ensure protectiveness:* *• Collect sediment samples to determine whether recontamination is occurring.* *• Conduct an IC study to evaluate the need for ICs. If warranted, include ICs in a decision document and implement the ICs.*

Table 8. Status of Recommendations from the 2015 FYR

OU #	Issue	Recommendations	Current Status	Current Implementation Status Description	Completion Date (if applicable)
1	Cap Inspection and maintenance reporting is inconsistent.	Submit reports for all cap areas on a consistent basis.	Ongoing	EPA continues to remind property owners to submit cap inspection reports.	
1	Appropriate Restrictive covenants are not in place for all required properties.	Record restrictive covenants on required properties and negotiate UECA covenants.	Ongoing	EPA is working to ensure appropriate restrictive covenants are recorded.	
1	The LNAPL system at Todd Shipyards has been partially shut down, but long-term groundwater monitoring has not started.	Develop a groundwater monitoring program at Todd Shipyards to determine whether or not contamination is migrating to the waterway.	Completed	Complete	September 1, 2016

2	Elevated COC concentrations and a lack of decreasing trends indicate that MNA may not be able to reach cleanup levels in the TX-03A area	Evaluate full-scale active remediation at the area near well TX-03A and implement additional remediation if determined appropriate by Ecology in coordination with EPA.	Completed	A bio-sparging system within the TX-03A area was completed and has started operation.	May 25, 2017
3	Appropriate Restrictive covenants are not in place for all required properties.	Record restrictive covenants on required properties and negotiate UECA covenants.	Ongoing	EPA is working to ensure appropriate restrictive covenants are recorded.	
7	Zinc and mercury have been detected above sediment cleanup objective (SCO) criteria in solids in stormwater treatment effluent that discharges to the LLS-OU7 cap	Evaluate the new BMPs or investigate sources and opportunities to ensure that stormwater contaminants are not discharging onto the LSS-OU7 cap.	Ongoing	[1]POS is in the process of implementing new BMPs to try to reduce discharge concentrations of these metals.	
7	Fine-grained sediments collected during the most recent sampling event in the open-channel area have mercury and total PCB concentrations greater than their respective SCOs. A general increase in total fines has been observed over the last five years. It is possible that there is a fine top layer of	In future monitoring events, confirm whether or not the recent contamination can be traced to sediment from outside sources deposited from suspension. If that occurs before the next FYR, EPA will work with the PRPs for future investigations.	Completed	An evaluation in 2018 determined that there is a fine top layer of sediment that has deposited on the open-channel surface that is indicative of coming from sources outside the LSS-OU7, which is contributing to recontamination of the cap from	August 28, 2018

	sediment that has deposited on the open channel surface from sources outside the LSSOU7, which may be indicative of sediment from outside sources deposited from suspension onto the cover.			top-down sources.	
9	Institutional Controls Study needs to be completed.	Conduct IC Study to evaluate the need for ICs. If warranted, include ICs in a decision document and implement the ICs.	Complete	An IC study was completed by the PRP.	August 1, 2007 (the last FYR listed this as an issue, but it had already been completed)
9	An evaluation of sediment chemistry has not been completed since the RA in 2007.	Collect sediment samples to ensure that recontamination is not occurring.	Completed	The current PRP, Vigor, completed sediment sampling throughout the OU in May 2019	May 2019

[1] The Port of Seattle started implementing the following actions in response to the previous FYR issue/recommendation of zinc and mercury being detected at concentrations above SCO criteria:

- Increased sweeping of the upland grounds to 2 times a month (increase from 1 time per month)
- System jetting/cleanout to remove solids from the stormwater treatment system
- Treatment vault modifications to increase retention time of stormwater within the vault, and reduce the frequency of system bypasses during high flow events
- Site inspections of leased area operations to identify and stop any potential sources of contaminants to the stormwater system from tenant operations.

However, recent sampling shows that zinc and mercury continue to be detected above SCO criteria in solids in stormwater treatment effluent that discharges to the LLS-OU7 cap, so the Port is still continuing to evaluate BMPs to mitigate this issue.

4. Five-Year Review Process

4.1. Community Notification and Involvement

A public notice was made available by posting a solicitation for comments (Appendix F) on The West Seattle Blog, on May 12, 2020, stating that there was a five-year review and inviting the public to submit any comments to the U.S. EPA. The results of the review and the report will be made available at the Site information repository located at: https://semspub.epa.gov/src/search.

4.2. Data Review

4.2.1. Soil and Groundwater OU1 Data Review

NAPL recovery from the Todd Shipyards has significantly declined during the past five years. The monthly recovery declined from 378 gallons in August 2015 to no measureable recovery in June 2017. The west shed recovery wells FW-17, FW-18 and FW-19 were shut down during the second quarter of 2018 due to no product being recovered. When the wells were turned off, the only well with measurable product was FW-18 with 0.25 ft. An absorbent sock was installed in FW-18 and is checked biweekly for accumulation and replaced as needed. As of April 2020, FW-18 had 0.2 feet of product and none of the other wells had measureable product. The limited extent of free product and inefficiency of the NAPL recovery system demonstrate the NAPL recovery system has achieved the purpose it was installed for and cleanup should focus on dissolved phase cleanup.

Groundwater sampling for the S&G-OU1 is conducted annually according to the modified groundwater monitoring plan (see Figure 4 for well locations). Analyses include total metals (copper, lead, and zinc), available cyanide, and benzene at well TD-06A. The maximum concentrations and number of exceedances by well for each constituent analyzed are presented in Appendix D (Table 17). Exceedances of ROD cleanup goals over the last five years (2015 – 2019) include nickel, cadmium, arsenic, copper, lead, zinc and available cyanide. The greatest exceedances were at HI-17 and included zinc, nickel, lead, cadmium, copper and arsenic. The greatest exceedance was cooper with a concentration of 1,110 µg/L and a cleanup level of 2.9 µg/L. HI-17 is located in the center of the site near an old smelter where metals would have been deposited at high concentrations. The concentrations have remained elevated at only HI-17, indicating the contaminants are not migrating, likely due to soil properties and groundwater flow.

Those wells with a detection of a ROD COC concentration above the cleanup goal in the last five years for the constituents sampled annually were evaluated for trends using the Mann-Kendall nonparametric test for trend (Table 9). Only wells with more than four detections during the last five years were evaluated. All of the Mann Kendall results were stable or no trend.

Table 9. Mann-Kendall Trend Analysis (2015-2019), S&G-OU1

Well	Constituent	Number of Data Points	Trend Test Result	Confidence Factor
HI-12	Copper	5	Stable	59.2%
MW-213	Copper	4	Stable	37.5%
HI-1	Lead	4	No Trend	83.3%
HI-12	Lead	5	Stable	88.3%
HI-16	Lead	4	Stable	83.3%
HI-18	Lead	5	No Trend	59.2%
HI-2	Lead	5	No Trend	40.8%
MW-01	Lead	4	No Trend	37.5%
MW-213	Lead	5	Stable	40.5%
HI-12	Zinc	5	Stable	75.8%

As part of the remedy, all monitoring wells were analyzed for the full list of COCs identified in the ROD. In addition, volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), and antimony were analyzed at the point of compliance wells to determine if the remedy is functioning as intended. Detected concentrations of constituents without ROD cleanup levels were compared to the lower of the NRWQC for marine acute and chronic exposures and for human consumption of organisms. A brief summary of the comprehensive sampling results from November 2019 follows:

- No VOCs or PCBs were detected at concentrations above cleanup levels.
- Cyanide slightly exceeded cleanup levels at HI-6A, HI-7 and HI-13. The concentrations ranged from 1.3 to 2.3 µg/L and the ROD cleanup goal is 1 µg/L.
- Copper exceeded cleanup levels at HI-7, HI-12 and HI-17. Detections ranged from 3.19 µg/L at HI-7 to 155 µg/L at H-17 and the ROD cleanup goal is 2.9 µg/L.
- Monitoring well HI-17 had concentrations well above cleanup levels for arsenic, cadmium, copper, lead, nickel and zinc. This is consistent with historic data and is due to the well location being near a former smelter. The high concentrations of metals appear to be isolated to the area near HI-17, and not migrating to surrounding wells.

The results of all the Mann-Kendall analyses were categorized as “stable” or “no trend”, and exceedances were similar to historic values at the same wells indicating groundwater contamination within OU1 remained stable over the previous five years.

4.2.2. Tank Farms OU2 Data Review

BP

Performance monitoring at Plant 1 includes groundwater monitoring for TPH-G, TPH-D, TPH-O, benzene, cPAHs, groundwater elevations, and the presence of LNAPL. The groundwater monitoring program at Plant 1 includes 15 wells sampled at varying frequencies (Figure 5). Groundwater monitoring at Plant 2 consists of one well sampled semi-annually (Figure 6). In addition to the annual monitoring a

soil and groundwater study (Waterfront Probing Study) was completed in 2019 at Plant 1 to evaluate the extent of contamination remaining from an LNAPL plume.

At Plant 1 contamination is below cleanup levels at the compliance wells (AMW-01 through AMW-05) and there were no wells with increasing contaminant trends indicating contamination at the site is stable and not migrating off site. Table 10 has a summary of the trend analysis results and maximum and minimum concentrations of contaminants during the previous five years. The most common contaminant above cleanup levels was TPH with four of the fifteen wells exceeding the cleanup level of 1,000 µg/L during the previous five years.

At BP Plant 2, TPH-G concentrations at GM-19S have been below cleanup levels since 2007 and declining during the previous five years based on a Mann-Kendall trend analysis. During the previous five years benzene concentrations at GM-19S were also below the cleanup level however there were not enough detections of benzene from the previous five years to complete a trend analysis.

In general, groundwater monitoring data at BP Plants 1 and 2 show that concentrations of TPH-G and benzene are decreasing or stable.

Table 10. Mann-Kendall Trend Analysis (2015-2019), TF-OU2, BP

Well	Constituent	# Data Points	Min-Max Concentration (µg/L)	Trend Test Result	Confidence Factor
AMW-01	Benzene[1]	12	1 to 68	Decreasing	>99.9%
AMW-02	Benzene[1]	17	0.9 to 69.7	No Trend	59.6%
MW-3-T9	Benzene[1]	13	0.5 to 2.5	No Trend	70.5%
AR-03	TPH-G[2]	10	66 to 780	No Trend	50%
GM-19S	TPH-G[2]	5	140 to 1,000	Decreasing	99.2%
GM-15S	TPH-G[2]	10	72 to 430	No Trend	53.5%
GM-16S	TPH-G[2]	10	91 to 400	Stable	83.2%
GM-14S	TPH-G[2]	20	150 to 2,700	No Trend	58.9%
GM-24S	TPH-G[2]	20	170 to 1,800	No Trend	60.1%
MW-1-T9	TPH-G[2]	16	140 to 490	No Trend	58.8%
MW-2-T9	TPH-G[2]	16	410 to 770	Stable	78.8%
MW-3-T9	TPH-G[2]	16	560 to 1,000	Stable	77.5%

[1]Benzene cleanup level = 71 µg/L

[2]TPH-G cleanup level = 1,000 µg/L

The Waterfront Probing study was completed in an area where a product recovery system has operated from 1992 to 2019. The recovery system had minimal recovery of product during the previous five years and is no longer an effective method of free product remediation. During the previous five years the system has recovered between 7.5 and 2 gallons of gas, diesel and oil per year. The study evaluated the extent and concentration of contamination remaining near the product recovery system to determine future remedial actions. The study included 41 direct push borings to 10 ft below water. One soil sample was collected from each boring at the depth with the highest evidence of contamination based on visual

and PID readings. Eleven of the probes had temporary wells installed to sample groundwater and check for LNAPL. The soil was tested for total hydrocarbons (NWTPH) and the water was tested for total hydrocarbons and volatile organics. Table 11 provides a summary of the results and Figure 7 shows the sample locations.

The probing study provided evidence that contamination still exists above cleanup levels, however no product or evidence of product was observed, indicating the product recovery system is no longer effective. Out of the 41 soil samples, 13 were above the cleanup level of 10,000 mg/kg for total TPH - with the highest concentration being 34,800 mg/kg at B-02. Four out of the eleven groundwater samples had concentrations above cleanup levels - two concentrations exceeded TPH-G and two concentrations exceeded TPH-D. The water sample with the greatest exceedance was B-42 with 6,300 µg/L of TPH-G and the cleanup level is 1,000 µg/L. A hydraulic evaluation of the new seawall is being planned which will assist in evaluating the changes in subsurface hydrology caused by the new seawall, plume fate and transport around or beneath the seawall sheet pile, bulkheads, and building foundations, and recovery system performance in remediating shallow dissolved contamination and residual NAPL at Plant 1.

Table 11. Waterfront Probing Study, BP Plant 1

Boring ID/Well ID	Sample Depth (ft bgs)	Soil Results	Groundwater Results			
		Total TPH Gasoline + Diesel + Oil Result (µg/kg)	Gasoline NWTPH-Gx Results (µg/L)	Diesel NWTPH-Dx Results (µg/L)	Oil NWTPH-DX Result (µg/L)	Benzene EPA-8260 (µg/L)
B-01/MW-01	10	**16,000**	115	460	<750	<0.5
B-03/MW-02	14	3,663	530	**13,000**	<1500	<0.5
B-05/MW-03	10	1,559	<50	**13,000**	2200	<0.5
B-07/MW-04	12	5,110	150	2,500	<750	<0.5
B-09/MW-05	10	690	<50	3,400	860	<0.5
B-11/MW-06	13	8,050	52	380	<750	<0.5
B-25/MW-07	12	3,450	240	5,600	<750	<0.5
B-33/MW-08	9	3,760	180	<250	<750	<0.5
B-35/MW-09	9	524.7	530	1,800	<750	<0.5
B-41/MW-10	8	4,200	**2,200**	6,000	<750	68
B-42/MW-11	7	5,030	**6,300**	3,400	<750	63
B-02	12	**34,080**				
B-20	15	**25,220**				
B-19	13	**20,400**				
B-14	13	**17,250**				
B-43	7	**16,640**				
B-32	12	**12,920**				
B-15	11	**12,100**				

B-06	13	**12,050**				
B-24	13	**12,040**				
B-21	12	**11,430**				
B-13	9	**11,130**				
B-44	13	**10,760**				
B-08	10	9,630				
B-31	12	8,480				
B-18	12	7,990				
B-38	8	7,700				
B-10	13	6,800				
B-22	14	6,610				
B-17	17	6,420				
B-36	8	6,160				
B-30	12	5,820				
B-40	7	5,670				
Cleanup Level		**10,000 µg/Kg**	**1,000 µg/L**	**10,000 µg/L**	**10,000 µg/L**	**71 µg/L**

Bold = exceedance of cleanup level

Kinder Morgan

Groundwater contamination at the KM site has not significantly changed in the past five years. The most common contaminants are benzene and gasoline range organics (GRO). GRO was detected above the cleanup level (1000 µg/L) in 15 of the 40 wells with a maximum of 11,600 µg/L at TMW-6. The data review included reviewing annual groundwater monitoring reports from the previous five years and evaluating contaminant trends using the Mann-Kendall trend analysis. The groundwater compliance monitoring program consists of 40 wells sampled annually (Figure 8). Nineteen of the wells are sampled twice a year and all 40 of the wells are sampled once a year. The Mann-Kendall trend analysis was completed for constituents with more than four detections during the previous five years. Table 12 has the results of the Mann-Kendall analysis. Most of the contaminant trends were stable or had no trend.

There were increasing or probably increasing benzene and GRO concentrations at three wells (A-28R, MW-19 and MW-23) and increasing GRO concentrations in TMW-6. The increasing trends at MW-19 and TMW-6 were likely due to the ongoing remedial application near the wells (Figure 9) which includes irrigating the ground during sulfate land applications. The irrigation likely mobilizes contaminants causing an increase in concentrations at some wells. Monitoring wells TMW-B1, TMW-4 and A-27 are located within or near the remedial application and results of the Mann-Kendall trend analysis using groundwater data from the previous five years was decreasing, indicating the remediation is effective.

As discussed in the above paragraph, elevated contaminant concentrations have been observed in both A-28R and MW-23. As displayed in Figure 8, these two monitoring wells are located along the southwestern edge of the property near 13th Ave. S.W., providing evidence for potential offsite migration. In addition, the proximal monitoring well, MW-24, also demonstrated concentrations of GRO and

benzene in exceedance of the cleanup levels throughout the five-year monitoring period. Natural attenuation parameters collected from these wells, including DO, methane and ferrous iron indicate conditions for natural attenuation are present. The dissolved petroleum hydrocarbon contamination along 13th Ave. S.W. is located inland and limited in extent. Further to the east, along the local downgradient direction of groundwater flow, monitoring wells such as A-23R, A-21, and A-14R (Kinder Morgan wells) and MW-111 (Shell wells, SH-04 area) are either non-detect or below cleanup levels for these contaminants, indicating that there is no expanding plume and no migration of groundwater contaminants to receptors such as surface water. However, the contaminant concentrations remain above cleanup levels, and the results of the Mann-Kendall analysis show increasing trends at these wells near 13th Ave. S.W. Additional data is needed to determine if the increasing trends over the previous five years are fluctuations or consistently increasing contaminant concentrations. Kinder Morgan and Shell Oil Harbor Island will continue to monitor their portions of this area of contamination.

Table 12. Mann-Kendall Trend Analysis (2015-2019), TF-OU2, Kinder Morgan

Well	Constituent	# Data Point	Min-Max Concentration (µg/L)	Trend Test Result	Confidence Factor
MW-19	Benzene[1]	5	1 to 5	Stable	75.8%
TMW-B	Benzene[1]	5	23 to 83	No Trend	75.8%
TMW-4	Benzene[1]	9	3 to 210	Decreasing	100%
TMW-5	Benzene[1]	6	8 to 46	Stable	86.4%
MW-23	Benzene[1]	10	2 to 36	Probably Increasing	94.6%
MW-24	Benzene[1]	10	106 to 1,400	No Trend	56.9%
A-27	Benzene[1]	10	9 to 144	Decreasing	99.4%
A-28R	Benzene[1]	10	20 to 850	Increasing	97.7%
12	Benzene[1]	9	2 to 43	No Trend	76.2%
MW-7	Benzene[1]	8	1 to 8	Stable	80.1%
A-5	TPH-G[2]	10	277 to 1,040	No Trend	85.4%
A-8	TPH-G[2]	4	143 to 382	Stable	83.3%
A-27	TPH-G[2]	10	869 to 2,810	Decreasing	97.7%
A-28R	TPH-G[2]	10	1,850 to 8,860	Increasing	99.9%
12	TPH-G[2]	9	725 to 3,320	Stable	46%
MW-6	TPH-G[2]	5	249 to 389	No Trend	59.2%
MW-7	TPH-G[2]	9	451 to 1,870	Stable	69.4%
MW-14	TPH-G[2]	5	299 to 1,110	No Trend	59.2%
MW-19	TPH-G[2]	9	810 to 4,300	Probably Increasing	94%
MW-23	TPH-G[2]	10	433 to 3,170	Probably Increasing	92.2%
MW-24	TPH-G[2]	10	3,440 to 28,000	Stable	60.3%
TMW-B1	TPH-G[2]	5	5,680 to 7,220	Decreasing	99.2%
TMW-3	TPH-G[2]	10	170 to 1,150	No Trend	75.8%
TMW-4	TPH-G[2]	10	2,230 to 7,500	No Trend	70%
TMW-5	TPH-G[2]	8	865 to 3,000	Stable	82.1%
TMW-6	TPH-G[2]	10	2,000 to 11,600	Increasing	96.4%

[1]Benzene site specific cleanup level = 71 µg/L
[2]TPH-G site specific cleanup level = 1000 µg/L

Shell

Compliance groundwater monitoring is completed semi-annually at about 30 wells (Figure 10). Samples are analyzed for BTEX, TPH and natural attenuation parameters. Results above detection limits for the site COCs were evaluated using the Mann-Kendall trend analysis. The result of the Mann-Kendall and the maximum and minimum concentrations are presented in Table 13.

At the Shoreline Manifold Area, BTEX and PAH concentrations at the two deep compliance monitoring wells (MW-213 and MW-214) have remained below cleanup levels during the previous five years. There was a fuel spill near the Shoreline Manifold Area that occurred after the groundwater remedy was implemented and is not part of the cleanup for the Superfund site. The spill is being mitigated by placing absorbent socks in shallow monitoring wells MW-210 and MW-211. Washington State Department of Ecology is overseeing the cleanup.

Near 13th Ave S.W. along the south western portion of the site contamination remains below cleanup levels. Monitoring well MW-05 contained no sample detections of benzene, and one sample was detected for TPH-G below the cleanup level during the previous five years of sampling. There was one anomalously high TPH-G result of 70,000 µg/L at MW-05 in May 2015 which is considered an error in sampling or reporting since TPH-G was only detected two other times in the previous five years and both were below the cleanup level of 1000 µg/L. Both TPH-G and benzene were detected below cleanup levels in SH-04 and Mann-Kendall trend analysis indicates benzene concentrations are declining and TPH-G is stable.

Contamination near monitoring well TX-03A has declined over the previous five years due to an air sparging system. Eleven monitoring wells: MW-301 through MW-304, MW-307 through MW-315, and TX-03A were used to monitor the contamination near TX-03A. Eight of the monitoring wells had decreasing trends for benzene and nine had decreasing trends for TPH-G. Two of the wells, MW-312 and MW-315, had increasing trends for TPH-G and benzene above cleanup levels. MW-312 and MW-315 are located down gradient of TX-03A and concentrations will likely decline as the remediated groundwater from the air sparging system migrates down gradient.

The stormwater system at the site was upgraded to prevent contaminated groundwater from entering the stormwater system by lining 440 feet of the pipes. Samples collected in August 2019 from the stormwater system indicated BTEX and petroleum hydrocarbons were significantly reduced.

Table 13. Mann-Kendall Trend Analysis (2015-2019), TF-OU2, Shell

Well	Constituent	# Data Points	Min-Max Concentration (µg/L)	Trend Test Result	Confidence Factor
MW-111	Benzene[1]	9	0.3 to 386	Decreasing	99.4%
MW-112A	Benzene[1]	9	11 to 42.6	Stable	87.0%
MW-202	Benzene[1]	5	1 to 6	Stable	59.2%
MW-301	Benzene[1]	18	0.1 to 28	Decreasing	99.9%
MW-302	Benzene[1]	15	1.21 to 759	Decreasing	99.9%
MW-303	Benzene[1]	14	0.6 to 1,190	Decreasing	99.9%
MW-304	Benzene[1]	12	2.1 to 775	Decreasing	99.9%
MW-307	Benzene[1]	19	5 to 699	Decreasing	99.9%
MW-308	Benzene[1]	18	0.3 to 383	Decreasing	95.9%
MW-310	Benzene[1]	17	0.1 to 980	Decreasing	100.0%
MW-311	Benzene[1]	4	0.1 to 0.7	Stable	62.5%
MW-312	Benzene[1]	19	72 to 414	Decreasing	99.8%
MW-314	Benzene[1]	4	0.1 to 7	No Trend	37.5%
MW-315	Benzene[1]	14	3 to 97	Probably Decreasing	92.1%
SH-04	Benzene[1]	10	0.4 to 16	Decreasing	56.9%
TX-03A	Benzene[1]	19	2 to 1,860	No Trend	99.9%
MW-104	TPH-G[2]	9	530 to 7,450	Probably Decreasing	91%
MW-111	TPH-G[2]	8	84 to 944	Stable	80.1%
MW-112A	TPH-G[2]	9	728 to 2,390	No Trend	54%
MW-202	TPH-G[2]	10	1,490 to 5,670	No Trend	63.6%
MW-203	TPH-G[2]	9	90 to 1,740	No Trend	61.9%
MW-301	TPH-G[2]	18	455 to 3,650	Decreasing	99.9%
MW-302	TPH-G[2]	15	232 to 5,080	Decreasing	100%
MW-303	TPH-G[2]	13	371 to 8,600	Decreasing	99.9%
MW-304	TPH-G[2]	10	105 to 5,750	Decreasing	99.8%
MW-307	TPH-G[2]	20	280 to 6,330	Decreasing	99.9%
MW-308	TPH-G[2]	17	62 to 1,770	Decreasing	98.6%
MW-310	TPH-G[2]	19	74 to 5,920	Decreasing	99.9%
MW-311	TPH-G[2]	5	26 to 751	Increasing	95.8%
MW-312	TPH-G[2]	20	1,260 to 2,500	No Trend	52.6%
MW-314	TPH-G[2]	11	0.089 to 0.298	No Trend	82.1%
MW-315	TPH-G[2]	14	453 to 2,160	Increasing	97.3%
SH-04	TPH-G[2]	10	80 to 1,350	Stable	70%
TX-03A	TPH-G[2]	20	446 to 7,160	Decreasing	99.9%

[1]Benzene site specific cleanup level = 71 µg/L

[2]TPH-G site specific cleanup level = 1000 µg/L

4.2.3. Lockheed Uplands OU3 Data Review

Groundwater sampling is conducted semi-annually at eight wells (see Figure 11 for well locations). Monitoring constituents are determined on a well-by-well basis. Currently, wells are analyzed for a combination of benzene, PCE, copper, lead, and zinc; although not all wells are analyzed for all constituents. Table 14 includes the minimum and maximum concentration for constituents that exceeded cleanup goals during the previous five years. Exceedances of ROD cleanup goals over the last five years (2015 -2019) include PCE, copper, and zinc.

Those wells with a detection of a ROD COC above the cleanup goal in the last five years were evaluated using the Mann-Kendall nonparametric test for trend (Table 14). All of the trends were either stable or had no trend.

Table 14. Mann-Kendall Trend Analysis (2015-2020), LU-OU3

Well	Constituent	# Data Points	Min and Max (µg/L)	Trend Test Result	Confidence Factor
LMW12	PCE[2]	10	2.6 to 22	Stable	60.3%
LMW26[1]	PCE[2]	10	4.9 to 15	Stable	53.5
LMW27	PCE[2]	10	1.1 to 21	Stable	85.4%
LMW18[1]	Copper[3]	5	0.261 to 2.93	Stable	59.2%
LMW26[1]	Copper[3]	5	2.76 to 18.3	No Trend	59.2%
LMW12	Copper[3]	4	3.3 to 11.7	Stable	62.5%
LMW27	Copper[3]	4	2.21 to 3.76	Stable	37.5%
LMW18[1]	Zinc[4]	5	9.8 to 24.2	No Trend	67.5%
LMW26[1]	Zinc[4]	5	15.3 to 28.7	Stable	59.2%
LMW12	Zinc[4]	4	60.7 to 113	Stable	37.5%
LMW27	Zinc[4]	4	62.5 to 89.2	Stable	37.5%

[1]LMW18 and LMW26 are sampled as part of both the Uplands OU and the LSSOU groundwater monitoring program
[2]PCE ROD cleanup goal = 8.8 µg/L
[3]Copper ROD cleanup goal = 2.9 µg/L
[4]Zinc ROD cleanup goal = 76.6 µg/L

4.2.4. Lockheed Shipyard Sediments OU7 Data Review

Monitoring of the Lockheed shipyard sediments include cap inspection, sediment sampling and groundwater monitoring. The cap inspection includes an annual visual inspection and topographic inspection every five years for the on-land portion and hydrographic survey every five years for the in-water portion of the cap. The sediment sampling is completed every two years for metals, PCBs and PAHs.

Groundwater sampling is conducted semi-annually at eleven wells, eight shoreline compliance wells and three background wells (Figure 11). Wells are currently analyzed for metals, cyanide, VOCs, and total petroleum hydrocarbons (TPH). Where LU-OU3 ROD cleanup levels are not available, concentrations at the shoreline compliance wells are compared to the lower of the NRWQC for marine acute and chronic exposures and for human consumption of organisms. Exceedances of ROD cleanup goals over the

last five years included PCE, Copper and Zinc. The Mann-Kendall trend analysis was completed for constituents that exceeded cleanup goals during the previous five years (Table 15). None of the trends were increasing, and most are stable or no trend.

Table 15. Mann-Kendall Trend Analysis (2015-2020), Groundwater, LU-OU7

Well	Constituent	# Data Points	Min and Max (µg/L)	Trend Test Result	Confidence Factor
LMW26[1]	PCE[2]	10	4.9 to 15	Stable	53.5
LMW34	PCE[2]	5	2.6 to 13	Stable	75.8%
BG-02	Copper[3]	5	0.48 to 2.07	Decreasing	95.8%
LMW18[1]	Copper[3]	5	0.261 to 2.93	Stable	59.2%
LMW26[1]	Copper[3]	5	2.76 to 18.3	No Trend	59.2%
LMW30	Copper[3]	4	0.1 to 2.85	No Trend	83.3%
LMW31	Copper[3]	5	8.19 to 12.4	No Trend	88.3%
LMW32D	Copper[3]	5	0.126 to 2.79	No Trend	40.8%
LMW32S	Copper[3]	5	1.44 to 4.7	Stable	75.8%
LMW33	Copper[3]	5	1.21 to 2.97	Stable	75.8%
LMW34	Copper[3]	5	1.35 to 2.4	Decreasing	99.2%
BG-02	Zinc[4]	4	24.7 to 68.5	Stable	83.3
LMW18[1]	Zinc[4]	5	9.8 to 24.2	No Trend	67.5%
LMW26[1]	Zinc[4]	5	15.3 to 28.7	Stable	59.2%
LMW31	Zinc[4]	5	28.9 to 50.1	No Trend	75.8%
LMW32S	Zinc[4]	5	46.3 to 58.2	Stable	88.3%
LMW33	Zinc[4]	5	16.4 to 27.8	Stable	50%
LMW34	Zinc[4]	5	5.3 to 33.7	No Trend	83.3%

[1]LMW18 and LMW26 are sampled as part of both the Uplands OU and the LSSOU groundwater monitoring program
[2]PCE ROD cleanup goal = 8.8 µg/L
[3]Copper ROD cleanup goal = 2.9 µg/L
[4]Zinc ROD cleanup goal = 76.6 µg/L

The cap inspections indicate the on-land portion of the cap remains intact and is functioning as expected. The in-water portion of the cap has erosion within the channel, however the cap thickness remains sufficient to prevent breakthrough contamination into the waterway. The sediment sampling had PCB exceedances at three of the five locations, and mercury at one location during the previous five years (Figure 12). The highest concentration of PCBs and the only exceedance of mercury in the sediment sampling was in the sediment accumulating on top of the cap. This indicates contamination is from sediment being deposited on top of the cap.

The Lockheed Shipyard sediments continue to have low levels of contamination consistent with historical concentrations. No new contamination or increasing concentrations have been recorded indicating the sediment remedy is functioning as intended.

4.2.5. Todd Shipyard Sediments OU9 Data Review

Sediment data collected during the previous five years at the Todd Shipyard were physical integrity monitoring of the in-water sediment cap and pre-design investigation for an intertidal and riparian habitat restoration project referred to as the Southwest Yard Habitat Project.

The TSS-OU9 Year 9 physical integrity monitoring survey was conducted from October 24 – 28, 2016. The physical integrity monitoring was performed by divers at the under-pier capped areas, the Northeast Shoreline Sediment Cap, and the Western Shoreline Habitat Bench to determine if the integrity of the capped material or habitat mix placed during the remedial action has been maintained, and to document conditions following the remedial action and the baseline (2007), Year 1 (2008), Year 2 (2009) and Year 4 (2011) monitoring surveys. Divers completed visual observations at all 21 transects shown in Figure 13. Detailed diver observations and comments (documented on audio and video recordings) were made at 10-foot increments along each transect.

For the under-pier capped areas, diver observations and video footage indicate that the sand cap material has appeared to remain in place and there was no evidence that complete erosion of the sand cap material had occurred at any of the observation locations, either under the piers or at the building berth. The OMMP early action warning level for the under-pier capped areas is any observation of complete erosion of the sand cap. Since there were no exceedances of this early action warning level, no contingency actions for the under-pier areas are warranted at this time. Silt and shell debris are continuing to accumulate on the surface of the sand cap material.

Based on diver observations in the Northeast Shoreline Sediment Cap, it was confirmed that the riprap slope and the habitat mix placed on top of the riprap during the remedial action remains in place and no erosion of the riprap was noted. In some of the locations, the habitat mix completely covers the riprap slope. This area is well colonized by substantial marine flora and fauna. The OMMP early action warning level for the Northeast Shoreline Sediment Cap is an observation that erosion of the riprap is occurring. Because there were no exceedances of this early action warning level, no contingency actions for this area are warranted at this time.

For the Western Shoreline Habitat Bench, diver observations and video footage confirmed that the habitat mix remains in place and there are no areas of complete erosion. The area is well colonized by marine life and plants, which will continue to assist with material stability over time. The OMMP early action warning level for the Western Shoreline Habitat Bench is any observation of complete erosion of the habitat mix. No contingency actions are required on the habitat bench because the early action warning level was not exceeded.

The Southwest Yard Habitat Project is being completed to meet the requirements of a Natural Resource Damage Settlement. The project will also meet the remedy requirements for the under portion area of the piers being removed at the Todd Shipyard. The 2003 ESD for the Todd Shipyards defines the remedial action for the under-pier areas, which included delineating the boundary of the Todd Shipyard Sediments OU based on additional sampling and dredging and capping the impacted area. The pre-design investigation for the restoration project included collecting soil samples, subgrade sediments for the

proposed final depth of excavation, capped sediments and groundwater. The investigation included five locations where sediment and water samples were collected and seven locations where just soil was collected (Figure 14). An evaluation of the exceedances of cleanup criteria in the samples was completed (Table 16). The results of the sampling indicate contaminants are prevalent throughout the area tested with metals, PAHs, HPAHs, PCBs and SVOCs detected above cleanup levels. The on-land soil had exceedances of metals, PCBs, SVOCs and TPH-D within the area that will be removed. There were no soil exceedances within the subgrade material remaining on-site. The groundwater had concentrations of PAHs slightly above the National Recommended Water Quality Criteria for surface water and when mixed with surface water will be below the criteria. The in-water sediment samples had exceedances of metals, PCBs and HPAHs which will need to be addressed in future remedial actions.

Table 16. Summary of Exceedances from Pre-Design Investigation for Vigor Ship Yard OU9

Boring	Depth	Chemical	Value	Cleanup Level	Unit	Cleanup Criteria
On-Land Soil Samples						
SB-02	0 to 5	Arsenic	100	57	mg/kg	[2]TSS-OU9 Sediment Compliance Criteria
		Mercury	0.42	0.41	mg/kg	
		Zinc	600	410	mg/kg	
		PCBs (total aroclors)	71	12	[1]mg/kg OC	
SB-03	0 to 5	Zinc	600	410	mg/kg	[2]TSS-OU9 Sediment Compliance Criteria
		Copper	1,200	390	mg/kg	
		SVOC - Phenol	850	420	ug/kg	[3]SMS Marine Criteria
		TPH-D	860	600	mg/kg	[4]Soil Compliance Criteria
SB-04	0 to 5	SVOC - Phenol	1,400	420	ug/kg	[3]SMS Marine Criteria
SB-04	5 to 10	SVOC - Phenol	1,300	420	ug/kg	[3]SMS Marine Criteria
SB-05	0 to 5	SVOC - Pentachlororphenal	430	360	ug/kg	[3]SMS Marine Criteria
Groundwater Sample						
SB-04	18.3 to 23.3	PAH - Benzo(a)anthracene	0.002	0.0013	ug/kg	[5]NRWQC
SB-05	12.7 to 17.6	PAH - Benzo(a)anthracene	0.005	0.0013	ug/kg	[5]NRWQC
		PAH - Benzo(b)fluoranthene	0.004	0.0013	ug/kg	
In-Water Sediment Samples						
SC-01	1.2 to 3.7	Arsenic	380	57	[6]mg/kg dw	[2]TSS-OU9 Sediment Compliance Criteria
		Mercury	0.69	0.41	[6]mg/kg dw	
		Zinc	3,100	410	[6]mg/kg dw	

		Copper	460	390	[6]mg/kg dw	
		PCBs (total aroclors)	66	12	[1]OC mg/kg	
		Total HPAH	1,700	960	[1]OC mg/kg	
SC-03	0.8 to 4	Total HPAH	1,300	960	[1]OC mg/kg	[2]TSS-OU9 Sediment Compliance Criteria
SC-05	1.2 to 2.6	Mercury	0.56	0.41	[6]mg/kg dw	[2]TSS-OU9 Sediment Compliance Criteria

TPH-D – Diesel Range Organics

[1]mg/kg OC; for samples with percent OC between 0.5 and 3.5 percent, the data have been normalized for carbon

[2]TSS-OU9 compliance criteria based on the SMS sediment quality standards presented in the Remedial Action Completion Report

[3]SMS criteria presented in Washington Department of Ecology Sediment Cleanup User's Manual II

[4]S&G-OU1 compliance criteria presented in the Record of Decision (USEPA 1993).

[5]National Recommended Water Quality Criteria

[6]mg/kg dw, milligram per kilogram dry weight

4.3. Site Inspection

No site inspection occurred during this review period. The review period for this FYR occurred during the COVID-19 outbreak and site access was not permitted during this time. Therefore no site inspection was able to be completed. In lieu of the site inspection not occurring during the review period for this FYR, it is EPAs intent to conduct a site inspection within one year after signing of this FYR to evaluate site conditions.

5. Technical Assessment

5.1. Question A. Is the remedy functioning as intended by the decision documents?

5.1.1. Soil and Groundwater OU1

Yes, the remedy is functioning as intended by the decision documents.

The requirements of the 1993 ROD (Design Set #3) have been met.

Groundwater monitoring is conducted semi-annually. The semi-annual and comprehensive sampling data indicated that exceedances of ROD cleanup goals over the last five years (2015 – 2019) include copper, lead, zinc, and available cyanide. Over the last 5 years, all of these wells with these detections have shown either no trend or a stable trend for these exceedances. These trends indicate that contaminant concentrations have largely met asymptotic levels throughout most of the OU, and contaminants are not currently migrating out of the site boundary.

The LNAPL system has ceased operations, and is planned to be formally approved by EPA in 2020. The

system is no longer recovering LNAPL product. Recent LNAPL thickness measurements in the west shed wells do not appear to be showing significant declines; however, oil/water emulsions in the recovery wells frequently bias measurements high. Groundwater monitoring has demonstrated that contaminants are not migrating into the marine environment.

The ROD states that ICs are required for seven properties containing environmental caps to provide long-term maintenance of the caps, warn future property owners of remaining contamination, and specify procedures for handling and disposal of excavated contaminated soil. Appropriate ICs are in place for all properties except for Harbor Island Machine Works and Todd Shipyards (Vigor). A restrictive covenant is currently in progress for Vigor and is expected to be completed in 2020. EPA is currently working to notify the property owner and ensure a restrictive covenant is filed for Harbor Island Machine Works.

As part of the ICs, annual cap inspections are required for seven properties. Not all properties have submitted reports, but EPA has reviewed the reports that have been submitted. Of those reviewed, the capped areas are being appropriately maintained.

5.1.2. Tank Farms - OU2

No, the remedy is not fully functioning as intended. Active and passive remediation is occurring at the facilities and contaminant concentrations appear to be generally decreasing, however, contaminant concentrations at KM along the western edge of the property indicate MNA may not be functioning in this area of the site, and contamination above cleanup levels may be migrating off site. However, the remedy is functioning as intended at the Shell and BP areas of this OU.

Remedial Action Performance
BP

A groundwater/LNAPL recovery system is located along the shoreline and was designed to pump shallow groundwater with drawdown extending to the bottom of the LNAPL smear zone, approximately 4 feet in total. Results of operation show that desired drawdown and hydraulic capture/control are being achieved along the waterfront despite reduction in pumping rates from some wells.

At BP Plant 1, groundwater compliance monitoring wells AMW-01 through AMW-05, located along the waterfront, have had concentrations below cleanup levels for TPH-G, TPH-D, and TPH-O for all quarterly groundwater monitoring events since installation. With the exception of wells AMW-01 and AMW-02, these wells have also been below cleanup levels for benzene. AMW-01 and AMW-02 are currently in compliance; and benzene concentrations have been below its cleanup level since June 2014 and September 2012, respectively. Trend evaluations indicate that benzene concentrations at these wells are decreasing.

At Plant 2, THP-G concentrations at GM-19S have been below cleanup levels since 2007. Also, benzene concentrations at GM-19S were consistently below the cleanup level during the last five years.

Kinder Morgan

Most of the contaminant trends in this area of the Site were stable or had no trend. TPH-G was detected above the cleanup level (1 mg/l) in 15 of the 40 wells.

The KM facility has implemented sulfate land application as a remediation system to increase biodegradation with applications in 2013, 2015, 2016, 2018 and 2019. Passive free-product recovery using absorbent socks is also performed at select wells.

There were increasing benzene and TPH-G concentrations at four wells. The increasing trends at MW-19 and TMW-6 were likely due to the ongoing remedial application near the wells (Figure 9) which includes irrigating the ground during sulfate land application. The irrigation likely mobilizes contaminants causing an increase in concentrations at some wells. Monitoring wells TMW-B1, TMW-4 and A-27 are located within or near the remedial application and had decreasing trends indicating the remediation is effective with likely short term increases at some wells.

Contaminant increases at A-28R and MW-23 are located along the western edge of the property near 13th Ave S.W. indicate contamination is not fully attenuating and may be migrating off site. However, downgradient wells show non-detect concentrations, indicating the contamination is inland and limited in extent. Monitoring well MW-24 also located near 13th Ave S.W. had TPH-G and benzene concentrations above cleanup levels during all of the monitoring events during the past five years. Groundwater parameters collected from wells near 13th Ave S.W. including DO, methane and ferrous iron indicate natural attenuation is occurring, however the concentrations above cleanup levels and increasing trends indicate the MNA is not sufficient at reducing concentrations of contaminants to below cleanup levels.

Shell

At the Shoreline Manifold Area, BTEX and PAH concentrations at the two deep compliance monitoring wells have remained below cleanup levels during the previous five years. Near 13th Ave S.W. along the south eastern portion of the site, contamination mostly remains below cleanup levels.

Contamination near monitoring well TX-03A has declined over the previous five years due to an air sparging system. Two of the wells, MW-312 and MW-315, had increasing trends for TPH-G and benzene above cleanup levels. These wells are located down gradient of TX-03A and concentrations will likely decline as the remediated groundwater from the air sparging system migrates down gradient.

Implementation of Institutional Controls and Other Measures
Restrictive covenants for BP, KM, and Shell were recorded by these parties in accordance with the Consent Decree in 2000. The following limitations were imposed by the restrictive covenant: industrial zoning, groundwater shall not be used for any purpose inconsistent with the remedial action, existing structures shall not be modified to expose contamination, and site workers will be instructed to take precautionary actions to avoid direct contact with contamination.

5.1.3. Lockheed Upland - OU3

Yes, the remedy is functioning as intended. Cap integrity has been maintained and groundwater studies

indicate that contaminants are not impacting the waterway.

Most of the contamination detected at the OU are below cleanup levels and none of the wells have increasing trends. Most of the trend results were stable or no trend, except copper concentrations at BG-02 and LMW34 which were decreasing.

The Port redeveloped the Lockheed Uplands property for use as a container cargo marshalling area in 2011. As part of this project, the utility infrastructure was upgraded to protect the LSS OU cap area and eliminate ponding on the upland cap.

The 1994 Lockheed Uplands ROD required ICs for the capped areas of the OU. A review of the ICs indicates that the Consent Decree was recorded; however, there were no restrictive covenants in place mandating the necessary activities and limitations for protection of the caps. Annual cap inspections are completed consistently. Maintenance items are completed as necessary to maintain cap integrity. There have been no reported ponding issues in Cap Area 2 since the completion of the T10 infrastructure project in 2011.

5.1.4. Lockheed Shipyard Sediments - OU7

Yes. The sediment cap is in place. Upland sources do not appear to be a source to cap recontamination. However, there may be off-site sources that are depositing a fine layer of contaminated sediment in the open-channel area.

The sediment sampling had PCB exceedances at three of the five locations and mercury at one location during the previous five years (Figure 12). The highest concentration of PCBs and the only exceedance of mercury in the sediment sampling was in the sediment accumulating on top of the cap indicating contamination is occurring from an upstream source and depositing on the cap. An evaluation of equilibrium partitioning indicates that the cap will not be re-contaminated due to the observed levels of contamination in groundwater at the uplands (OU-3). The Lockheed Shipyard sediments continue to have low levels of contamination consistent with historical concentrations. No new contamination or increasing concentrations have been recorded, indicating the sediment remedy is functioning as intended.

As part of the T10 Utility Infrastructure Upgrade Project, a stormwater treatment system was constructed which discharges onto the LSS-OU7 cap. Zinc and mercury have been detected at concentrations above SCO criteria in solids sampled from the treatment system. The Port implemented BMPs to help mitigate the problem, such as increased sweeping frequency, inspection of tenants properties, and cleanup of the treatment system. However, the most recent stormwater discharge sampling in 2019 still showed zinc with a concentration of 2,600 mg/kg dw, which exceeds the LSSOU CSL of 960 mg/kg dw.

Fine-grained sediments collected during the most recent sampling event in 2020 in the open-channel area contained concentrations of mercury and total PCBs greater than their respective SCOs. Additionally, an increase in total fines has been observed over the last five years. An evaluation in 2018 determined that there is a fine top layer of sediment that has deposited on the open-channel surface that is indicative of coming from sources outside the LSS-OU7, which is contributing to recontamination of the cap from top-

down sources.

ICs were not specified in the 1996 ROD, but the OMMP requires the PRP to maintain OU access and required ICs including establishing a United States Coast Guard Restricted Navigation Area. This was established on April 10, 2012 as documented in the Federal Register.

5.1.5. Todd Shipyards Sediments (OU9)

Yes. Results from the latest annual monitoring event indicates that the remedy is functioning as intended by the decision documents for both the dredged and capped areas. Annual monitoring indicates that the capped areas are intact and do not appear to be subject to erosion. Evidence of fines and shell debris has settled on the surface of the caps indicating that erosion has not taken place.

Vigor completed a Pre-Design Investigation Data Report and Remedial Action Work Plan in 2018, and 2019 respectively, to present the results of sampling activities to support the characterization of upland soil and capped sediment as part of Vigor's Southwest Yard Habitat Project. The Southwest Yard Habitat Project will cover an industrial area at Vigor to intertidal and riparian habitat that is designed to maximize aquatic habitat benefits for the purposes of settling Natural Resource Damage claims.

The 2018 Pre-Design Investigation Data Report revealed concentration exceedances of cleanup levels in the existing OU sediment, however it is currently planned to be remediated. Based on information provided to EPA by Vigor, the Shipway's in-water structures are going to be demolished by Vigor in 2021-2022. Following demolition, Vigor will dredge the sediments with concentrations exceeding the CSL from the shipway and install an engineered cap which protects against exposure to contamination remaining in sediments that exceed the SQS, but are still below the CSL, in the Pier 1 area.

Physical integrity monitoring was conducted once in the last five years. Results indicated that capping materials have stayed in place and the cap is not significantly eroding. Sediment chemistry monitoring was completed in 2018.

An institutional controls study was conducted and approved by EPA as part of the Final OMMP approval. All institutional controls required per the OMMP have been implemented for this OU.

5.2. Question B. Are the exposure assumptions, toxicity data, cleanup levels, and remedial action objectives (RAOs) used at the time of the remedy selection still valid?

5.2.1. Soil and Groundwater OU1

Yes. ARARs that cleanup levels and toxicity data were based on at the time of remedy selection have changed, however, the changes do not affect the protectiveness of the remedy because the asphalt cap helps ensure there is no exposure to contamination.

Changes in Standards and TBCs

ARARs cited in the ROD were reviewed to evaluate changes since the ROD was signed in 1993. In addition, requirements promulgated after the 1993 ROD were also evaluated to determine if there were ARARs or To Be Considereds (TBCs) necessary to ensure that the remedy is protective of human health and the environment. A summary of the evaluation of each ARAR is presented in Appendix C. The table does not include those ARARs that are no longer pertinent.

Cleanup goals specified in the ROD, along with changes in the standards, are shown in Appendix C. Cleanup goals for soil were primarily based on criteria contained in the State of Washington MTCA. Goals for surface (depth less than 0.5 feet) and subsurface soil (depth greater than 0.5 feet) were primarily based on MTCA Method A, which specifies cleanup goals based on a risk of 10^{-6} for individual carcinogens or a hazard quotient of 1.0 for non-carcinogens. In 2001, MTCA amendments reduced the MTCA Method A soil criteria for TPH-G, cadmium, PAHs, arsenic, benzene, ethylbenzene, toluene, and xylenes. However, the selected remedy limits the exposure to these soils through a low permeability cap and ICs.

Additionally, the current EPA lead policy has been reviewed for this site. Because there is no current or expected exposure to the site groundwater based on the non-potable determination of the groundwater, the site remedy still remains valid with respect to the EPA lead policy.

Groundwater cleanup goals were based on the protection of marine organisms or human health from consumption of organisms. Since the 1993 ROD, there have been revisions to the NRWQC for marine waters that have decreased groundwater standards for cadmium, thallium, lead, benzene, and trichloroethane. Trichloroethane was not detected during the first year of groundwater monitoring and was subsequently dropped from the sampling requirements. Detected concentrations of these chemicals that have changed have been below their respective current cleanup goals, except lead. Lead has been detected above this respective cleanup goal, however there are ICs in place to help limit exposure to groundwater in all areas where lead is present at concentrations above this cleanup goal. Therefore, the reduction in NRWQC criteria does not call into question the validity of the remedy.

Changes in Toxicity and Other Contaminant Characteristics

EPA's Integrated Risk Information System (IRIS) has a program to update toxicity values used by EPA in risk assessment when newer scientific information becomes available. Risk-based values were used as the basis for cleanup levels for antimony, arsenic, carcinogenic PAHs, and PCBs in surface soil. In the past five years, based on IRIS information, there have not been any changes to the toxicity values for these COCs. The oral slope factors for arsenic, carcinogenic PAHs, and PCBs have all changed since the ROD, but only carcinogenic PAHs has become more stringent (Appendix C). The change was relatively small, and the selected remedy limits the exposure to soils through a low permeability cap and ICs.

Changes in Exposure Pathways

The exposure assumptions used to develop the Human Health Risk Assessment remain valid. Assumptions included industrial worker incidental ingestion and dermal contact with contaminated soil. Inhalation was not identified as a significant pathway of exposure. Human health exposure to contaminants in groundwater was not evaluated because there was no current or foreseeable use of groundwater for drinking water. Capping of the site has reduced exposure to the remaining contaminated

soils and ICs were required to document the location of remaining soil contamination at each property and procedures for handling and disposal of excavated soil from beneath the capped areas. Land use at the OU remains industrial and there are no expected land use changes in the future.

Expected Progress Toward Meeting RAOs
The selected remedy limits the exposure to these soils through a low permeability cap and ICs. Additionally, there is no indication that groundwater with contaminant concentrations above cleanup levels are migrating to the shoreline.

5.2.2. Tank Farms - OU2

Yes. ARARs that cleanup levels were based on at the time of the remedy selection have changed, however, changes do not affect the protectiveness of the remedy because there is no exposure to groundwater at concentrations above the revised criteria. Additionally, groundwater at this OU was declared non-potable in the EPA ROD and in the Ecology CAPs.

Changes in Standards and TBCs
ARARs cited in the CAPs were reviewed to evaluate changes since they were completed in 1999 and 2000. A summary of the evaluation of each ARAR is presented in Appendix C. The table does not include those ARARs that are no longer pertinent because of completion of the associated work.

Cleanup levels listed in the CAPs along with changes in standards are presented in Appendix C. Soil cleanup levels for the TF-OU2 are similar to those in the EPA cleanup goals for the S&G-OU1 and LU-OU3, which were established unique to Harbor Island. Since the 1993 ROD, the source of the standard (MTCA A) for lead has decreased, and the cleanup goal is now above the standard. Concentrations of lead in groundwater have remained below this updated standard, so therefore this change does not affect protectiveness.

Groundwater cleanup levels were for “the chronic criteria for protection of aquatic organisms (WAC 173-201A) and Section 304 of the Clean Water Act” and were similar to the EPA cleanup goals for the S&G-OU1 and LU-OU3. Since the CAPs have been completed, NRWQC for benzene, ethylbenzene, toluene, cPAHs, and lead have decreased. Ethylbenzene and toluene concentrations at TF-OU2 are below the revised standards. Remaining elevated concentrations of benzene and cPAHs are in areas of active and passive remediation. Therefore, based on the reduction in NRWQC criteria and recent sampling results, the remedy still remains valid.

Surface water standards are not available for TPH. The CAPs selected groundwater cleanup levels for TPH-G, TPH-D, and TPH-O to be protective of surface water. In 2001, MTCA revisions lowered the MTCA Method A groundwater cleanup levels for TPH-G, TPH-D, and TPH-O. However, these standards do not affect protectiveness, as the selected remedy limits the exposure to these soils through a low permeability cap and ICs.

Changes in Exposure Pathways
Exposure assumptions used in the CAPs remain valid. Assumptions included industrial zoning of the OU

and the determination that there is no planned future use of the groundwater for drinking purposes.

Expected Progress Toward Meeting RAOs
Groundwater COC concentrations in the BP area are generally below cleanup levels or showing stable or decreasing trends. The data review done in this FYR shows that MNA may not be functioning as intended in groundwater contamination in the KM site area, and contamination may be extending off-site. COC concentrations remain above the cleanup level only in areas of active and passive remediation at the Shell site area. Contaminants in one well in the Shell area are above cleanup levels, however active remediation has started in this area.

5.2.3. Lockheed Upland - OU3

Yes. ARARs that cleanup levels and toxicity data were based on at the time of the remedy selection have changed. However, changes do not affect the protectiveness of the remedy because there is no exposure.

Changes in Standards and TBCs
ARARs cited in the ROD were reviewed to evaluate changes since the ROD was signed in 1994. In addition, requirements promulgated after the 1994 ROD were also evaluated to determine if there were ARARs or TBCs necessary to ensure that the remedy is protective of human health and the environment. A summary of the evaluation of each ARAR is presented in Appendix C. The table does not include those ARARs that are no longer pertinent because of completion of the associated work.

Cleanup goals specified in the ROD along with changes in the standards are presented in Appendix C. Cleanup goals for soil are similar to the S&G-OU1: MTCA Method C for industrial soil was applied to the surface soil (depth less than 0.5 foot) and MTCA Method A for subsurface soil (depth greater than 0.5 foot). In 2001, MTCA amendments reduced the MTCA Method A soil criteria for lead, cPAHs, arsenic, benzene, ethylbenzene, toluene, and xylenes. However, the selected remedy limits the exposure to these soils through a low permeability cap and institutional controls.

Groundwater cleanup goals were based on the protection of marine organisms or human health from consumption of organisms. Since the 1994 ROD, there have been revisions to the NRWQC for marine waters that have decreased groundwater standards for benzene and lead. Detected concentrations of benzene and lead have been below the revised standard; therefore, this revision does not call into question the validity of the remedy.

Human Health exposure to contaminants in groundwater was not evaluated because there was no current or foreseeable use of groundwater for drinking water. Groundwater cleanup levels in the ROD have been based on the protection of marine organisms and human ingestion of marine organisms.

Changes in Exposure Pathways
The exposure assumptions used to develop the Human Health Risk Assessment remain valid. Assumptions included industrial worker incidental ingestion and dermal contact with contaminated soil. Capping of the OU has reduced the exposure to the remaining contaminated soils and ICs were required to document the location of remaining soil contamination and procedures for handling and disposal of excavated soil from beneath the capped areas. Land use at the OU remains industrial and there are no

expected land use changes in the future.

The potential for groundwater containing VOCs to act as a source of contamination to soil gas that may impact indoor air was not fully evaluated at the time the original risk evaluation was prepared. Low concentrations of VOCs have been detected in groundwater at the northern portion of the OU near the gas station. For a commercial exposure scenario, a groundwater PCE concentration of 65 µg/L corresponds to a vapor intrusion target risk for carcinogens of 10^{-6} (based on EPA's Vapor Intrusion Screening Level [VISL] Calculator version 3.3.1). PCE concentrations continue to remain below 65 µg/L. Therefore, vapor intrusion risk for the current commercial scenario is below 10^{-6}.

Expected Progress Towards Meeting RAOs
The selected remedy limits the exposure to these soils through a low permeability cap. Additionally, there is no indication that groundwater with contaminant concentrations above cleanup levels is discharging from the shoreline.

5.2.4. Lockheed Shipyard Sediments - OU7

Yes. The exposure assumptions and toxicity data used at the time of the remedy selection have changed, however, no change to remedy protectiveness is expected because the sediment cap is in place and preventing exposure.

Changes in Standards and TBCs
A summary of the ARARs evaluation for LSS-OU7 is presented in Appendix C. The table does not include those ARARs that are no longer pertinent because of completion of the associated work. The remedial action required for the LSS-OU7 was based on the presence of unacceptable risks to benthic organisms. Cleanup levels for the protection of benthic organisms were derived from Ecology regulations for sediment cleanups. These Ecology regulations for sediment cleanups are also presented in Appendix C and have not changed since the ROD.

Changes in Exposure Pathways
Land use at the site remains industrial and there are no expected land use changes in the future. The ecological exposure assumptions and toxicity data have not changed.

Expected Progress Towards Meeting RAOs
RAOs in the ROD and the subsequent ESDs were to reduce concentrations of hazardous substances to levels that will have no adverse effect on marine organisms.

At the LSS-OU7, contaminated sediments were either dredged to native clean sediments or capped. Both remedial actions prevent exposure to humans, fish, shellfish, etc., either by removing the contaminated sediments or capping contaminated sediments remaining in place, and absent deposition of contaminated sediments from outside the remedial action area, should be meeting its RAO to reduce concentrations of hazardous substances for the protection of marine organisms. Based on post-cleanup sediment sampling of the cap and dredged area, all COCs, except mercury and PCBs, were undetected. Recent sediment concentrations of mercury and PCBs were above the SCO in a few locations, likely due to deposition

from other sources. The top-down trend needs be confirmed in future annual sampling events.

5.2.5. Todd Shipyards Sediments (OU - 9)

Yes. The exposure assumptions and toxicity data used at the time of the remedy selection have changed. However, no change to remedy protectiveness is expected because the sediment cap is in place and preventing exposure.

Changes in Standards and TBCs
A summary of the ARARs evaluation for TSS-OU9 is presented in Appendix C. The table does not include those ARARs that are no longer pertinent because of completion of the associated work. The remedial action required for the TSS-OU9 was based on the presence of unacceptable risks to benthic organisms. Cleanup levels for the protection of benthic organisms were derived from Ecology regulations for sediment cleanups. These Ecology regulations for sediment cleanups are also presented in Appendix C and have not changed since the ROD.

Changes in Exposure Pathways
Land use at the OU remains industrial and there are no expected land use changes in the future. The ecological exposure assumptions and toxicity data have not changed.

Expected Progress Towards Meeting RAOs
RAOs in the ROD and the subsequent ESDs were to reduce concentrations of hazardous substances to levels that will have no adverse effect on marine organisms.

At the TSS-OU9, contaminated sediments were either dredged to native clean sediments or capped. Both remedial actions prevent exposure to fish and shellfish either by removing the contaminated sediments or capping contaminated sediments remaining in place and absent recontamination should be fully protective over its lateral extent. Because the cap remains in place and stable, contaminant exposure to marine organisms is expected to be minimal or non-existent. Applicable areas of the TSS-OU9 have been well-colonized by marine life.

5.3. Question C. Has any other information come to light that could call into question the protectiveness of the remedy?

No other information has come to light that could call into question the protectiveness of the remedy.

6. Issues/Recommendations

Issues and Recommendations Identified in the Five-Year Review:	
OU(s): 1 & 3	**Issue Category: Institutional Controls**
	Issue: Appropriate restrictive covenants are not in place for all required properties.

	Recommendation: Record completed UECA covenants on required properties.			
Affect Current Protectiveness	**Affect Future Protectiveness**	**Party Responsible**	**Oversight Party**	**Milestone Date**
No	Yes	EPA	EPA	September 2022
OU(s): 1	**Issue Category: Operations and Maintenance**			
	Issue: Cap inspection and maintenance reporting is inconsistent.			
	Recommendation: Submit reports for all cap areas to EPA on a consistent basis.			
Affect Current Protectiveness	**Affect Future Protectiveness**	**Party Responsible**	**Oversight Party**	**Milestone Date**
No	Yes	Steering Committee	EPA	September 2021
OU(s): 2	**Issue Category: Remedy Performance**			
	Issue: Groundwater concentrations of site contaminants exceed cleanup levels in western area wells, indicating MNA may not be functioning as intended, and contamination may be migrating off site.			
	Recommendation: Evaluate alternatives for remediating contaminants in western area wells, and determine if contamination is migrating off site.			
Affect Current Protectiveness	**Affect Future Protectiveness**	**Party Responsible**	**Oversight Party**	**Milestone Date**
No	Yes	State	EPA	September 2021
OU(s): 2	**Issue Category: Operations and Maintenance**			
	Issue: Current remedial action work is conducted solely by Washington State Department of Ecology. There is currently no CERCLA remedial action decision document recorded for this OU.			
	Recommendation: After completion of the planned Washington State Department of Ecology remedial action, an evaluation should be conducted to determine if any CERCLA remedial action is required, and if a decision document should be recorded.			
Affect Current Protectiveness	**Affect Future Protectiveness**	**Party Responsible**	**Oversight Party**	**Milestone Date**
No	Yes	EPA	EPA	December 2027
OU(s): 7	**Issue Category: Operations and Maintenance**			
	Issue: Zinc and mercury continue to be detected above SCO criteria in solids in			

	stormwater treatment effluent that discharges to the LSS-OU7 cap.			
	Recommendation: Evaluate new BMPs or investigate sources and opportunities to ensure that stormwater contaminants are not discharging onto the LSS-OU7 cap.			
Affect Current Protectiveness	**Affect Future Protectiveness**	**Party Responsible**	**Oversight Party**	**Milestone Date**
No	Yes	Port of Seattle	EPA	September 2021
OU(s): 7	**Issue Category: Remedy Performance**			
	Issue: Fine-grained sediments collected during the most recent sampling event in the open-channel area have mercury and total PCB concentrations greater than their respective SCOs. A general increase in total fines has been observed over the last five years. Evaluations have determined that sediment has deposited on the open-channel surface from sources outside the LSS-OU7.			
	Recommendation: EPA will continue to monitor sediment concentrations and trends for these contaminants in the sediment on the open-channel surface area.			
Affect Current Protectiveness	**Affect Future Protectiveness**	**Party Responsible**	**Oversight Party**	**Milestone Date**
No	Yes	EPA	EPA	September 2022
OU(s): 1, 2, 3, 7, 9	**Issue Category: Operations and Maintenance**			
	Issue: No site visit was conducted during the 2020 FYR review period due to COVID-19 travel restrictions.			
	Recommendation: Conduct a site visit to evaluate current site conditions as soon as possible.			
Affect Current Protectiveness	**Affect Future Protectiveness**	**Party Responsible**	**Oversight Party**	**Milestone Date**
No	Yes	EPA	EPA	September 2021

6.1. Other Findings

Soil & Groundwater - OU1

A determination for when groundwater monitoring may stop, if before 30 years, should be made. Additionally, a formal memo stating that the groundwater throughout Harbor Island is non-potable should be filed.

Lockheed Shipyard Sediments – OU7

The property owner at LSS-OU7 has implemented institutional controls in the form of establishing a U.S

Coast Guard Restricted Navigation Area, however institutional controls were not required in the original ROD. EPA should consider documenting this change to the remedy in the form of a ROD Amendment or ESD.

7. Protectiveness Statement

Protectiveness Statement(s)	
Operable Unit: S&G-OU1	*Protectiveness Determination:* Short-Term Protective

Protectiveness Statement:

The remedy at the Soil and Groundwater OU1 currently protects human health and the environment because the cap is in good condition, LNAPL is at low enough amounts to no longer be recovered from the groundwater, and long-term groundwater monitoring indicates that contaminants are not migrating to the waterways. However, in order for the remedy to be protective in the long-term, the following actions need to be taken to ensure protectiveness:

- Complete environmental covenants for all capped properties.
- Complete annual cap inspections consistently.

Protectiveness Statement(s)	
Operable Unit: TF-OU2	*Protectiveness Determination:* Short-Term Protective

Protectiveness Statement:

The remedy at the Tank Farms OU2 currently protects human health and the environment because multiple remediation methods are occurring to treat most contaminants, and restrictive covenants help ensure there is no exposure to site contaminants. However, in order for the remedy to be protective in the long-term, the following actions need to be taken to ensure protectiveness:

- Evaluate alternatives for remediating contaminants near the southwestern area wells of the Kinder Morgan property, and determine if contamination is migrating off site.
- After completion of the planned Washington State Department of Ecology remedial action, an evaluation should be conducted to determine if any CERCLA remedial action is required, and if a decision document should be recorded.

Protectiveness Statement(s)	
Operable Unit: LU-OU3	*Protectiveness Determination:* Short-Term Protective

Protectiveness Statement:

The remedy at the Lockheed Upland OU3 currently protects human health and the environment because the cap integrity has been maintained and groundwater studies indicate that contaminants are not impacting the waterway. However, in order for the remedy to be protective in the long-term, the following action need to be taken to ensure protectiveness:

- Complete environmental covenants for capped areas of the property.

Protectiveness Statement(s)	
Operable Unit:	*Protectiveness Determination:*
LSS-OU7	Short-Term Protective

Protectiveness Statement:

The remedy at the Lockheed Shipyard Sediments OU7 currently protects human health and the environment because the cap integrity has been maintained, and groundwater studies indicate that contaminants are not impacting the waterway. However, in order for the remedy to be protective in the long-term, the following actions need to be taken to ensure protectiveness:

- Evaluate new BMPs or investigate sources and opportunities to ensure that stormwater contaminants are not discharging onto the LSS-OU7 cap.
- EPA will continue to monitor sediment concentrations and trends for these contaminants in the sediment on the open-channel surface area.

Protectiveness Statement(s)	
Operable Unit:	*Protectiveness Determination:*
TSS-OU9	Protective

Protectiveness Statement:

The remedy at the Todd Shipyard Sediments OU9 is protective of human health and the environment. The RAO to reduce concentrations of hazardous substances to levels that will have no adverse effect on marine organisms is being met by the sediment cap integrity being maintained, and dredging and capping is planned as intended by the ROD for remaining contaminated sediments underneath portions of the sediment cap.

8. Next Review

The next Five-Year Review is due five years from the signature date of this review.

Appendix A: Figures

Figure 1. Harbor Island Site Vicinity Map

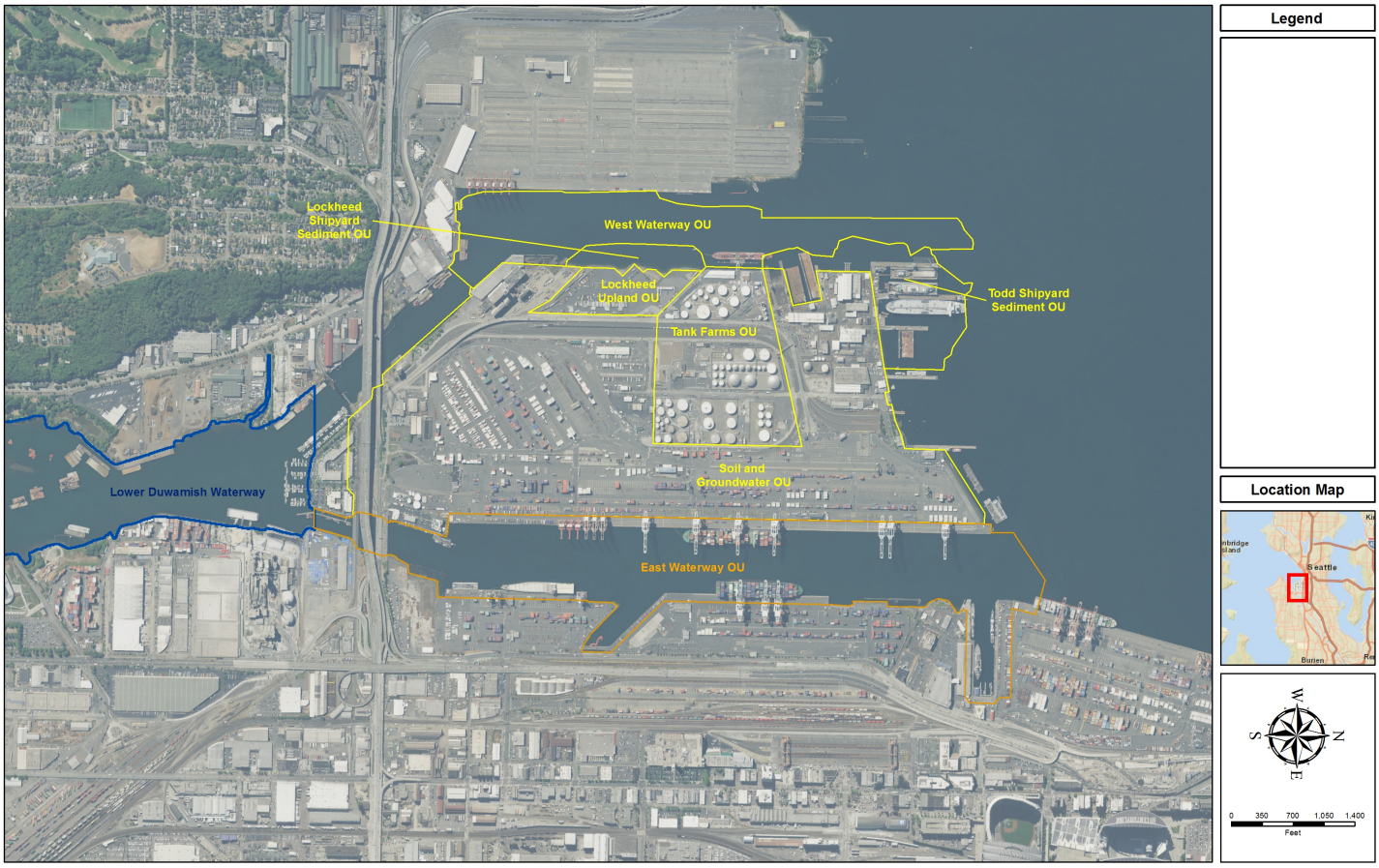

Figure 2. Harbor Island Operable Units

Figure 3. TF-OU2 - Tank Farm Facilities

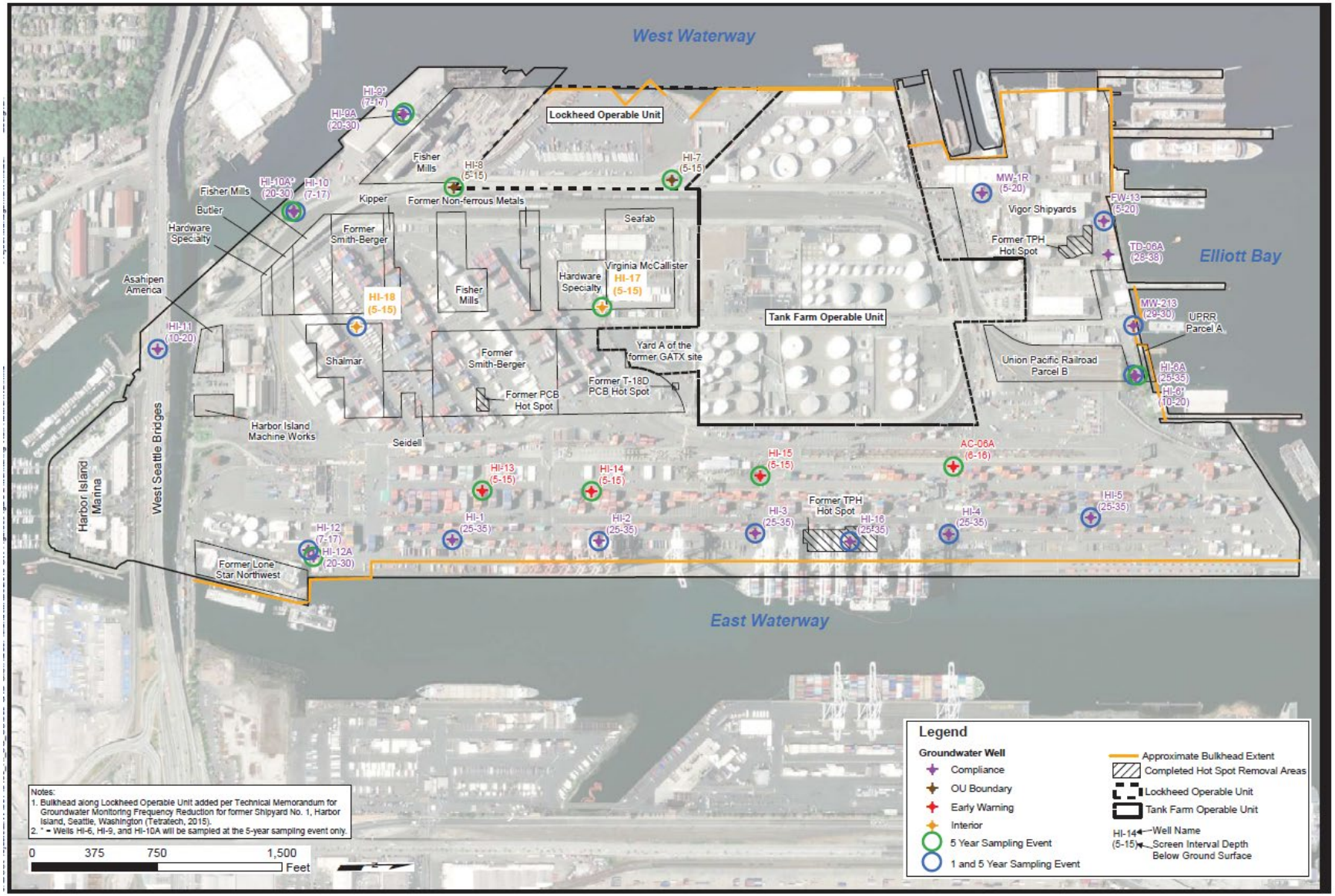

Figure 4. S&G Operable Unit 1 Groundwater Monitoring Locations

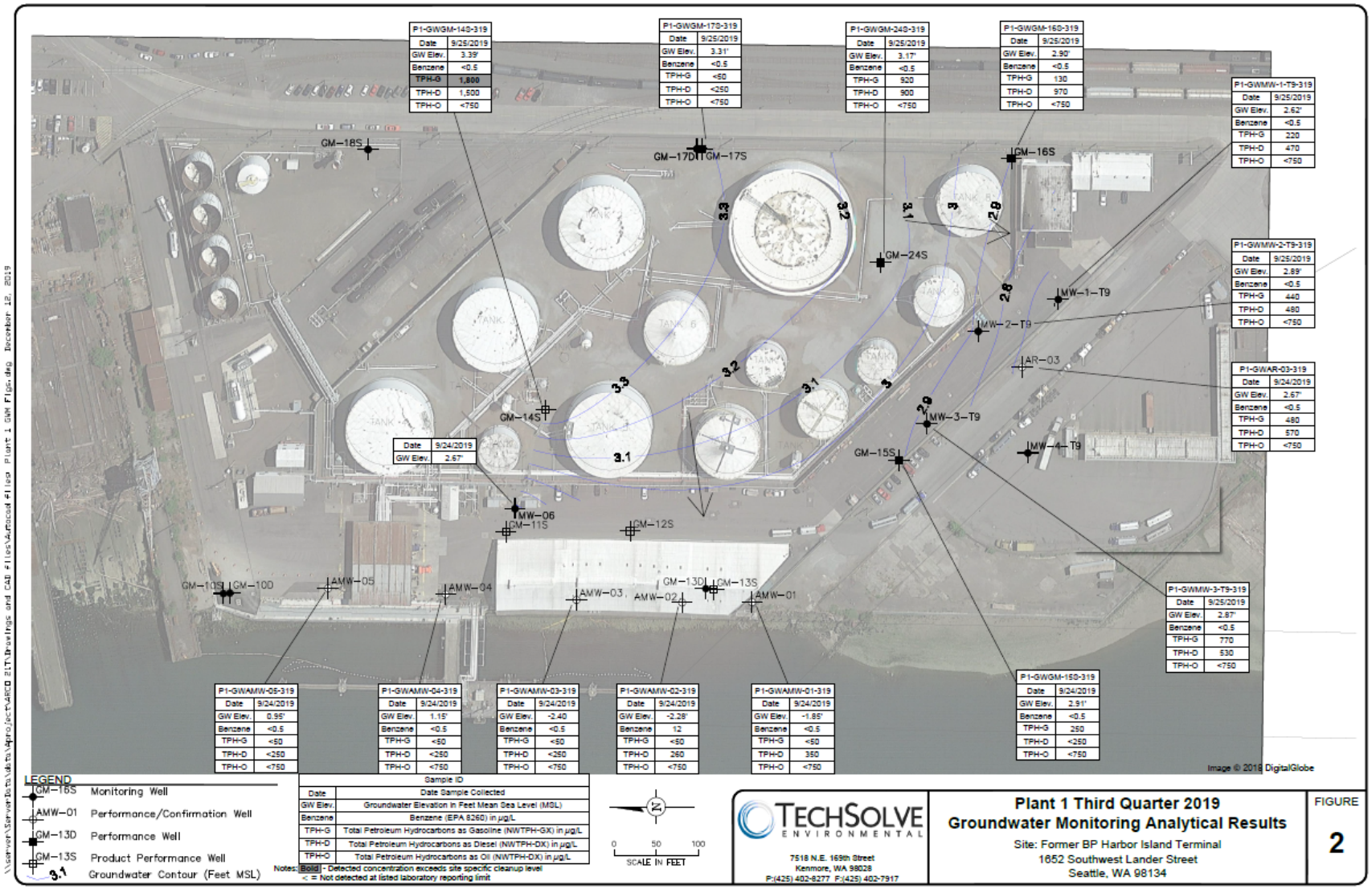

Figure 5. Tanks Farms Operable Unit 2, BP Plant 1 Well Locations

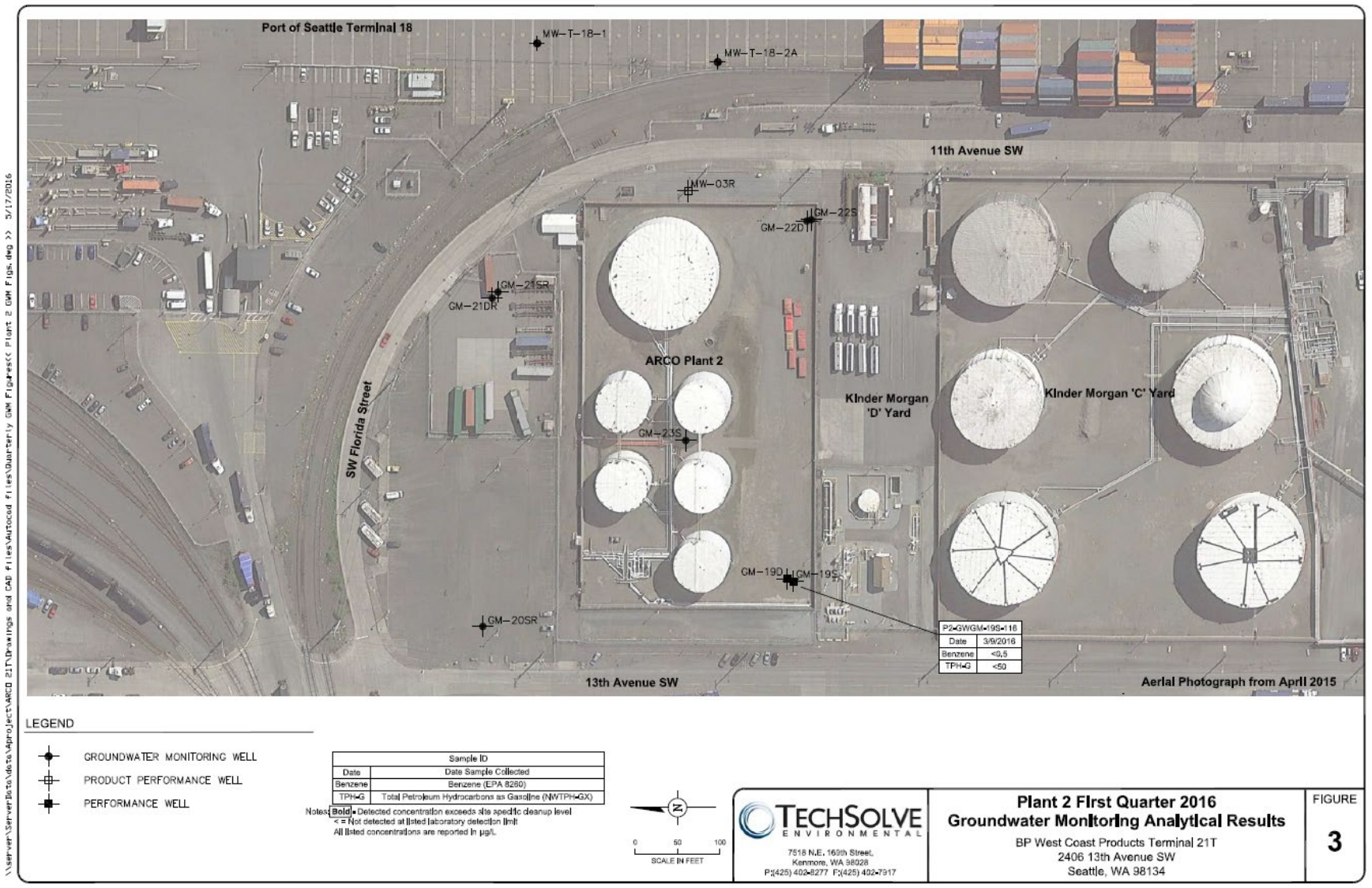

Figure 6. Tank Farm Operable Unit 2, BP Plant 2 Well Locations

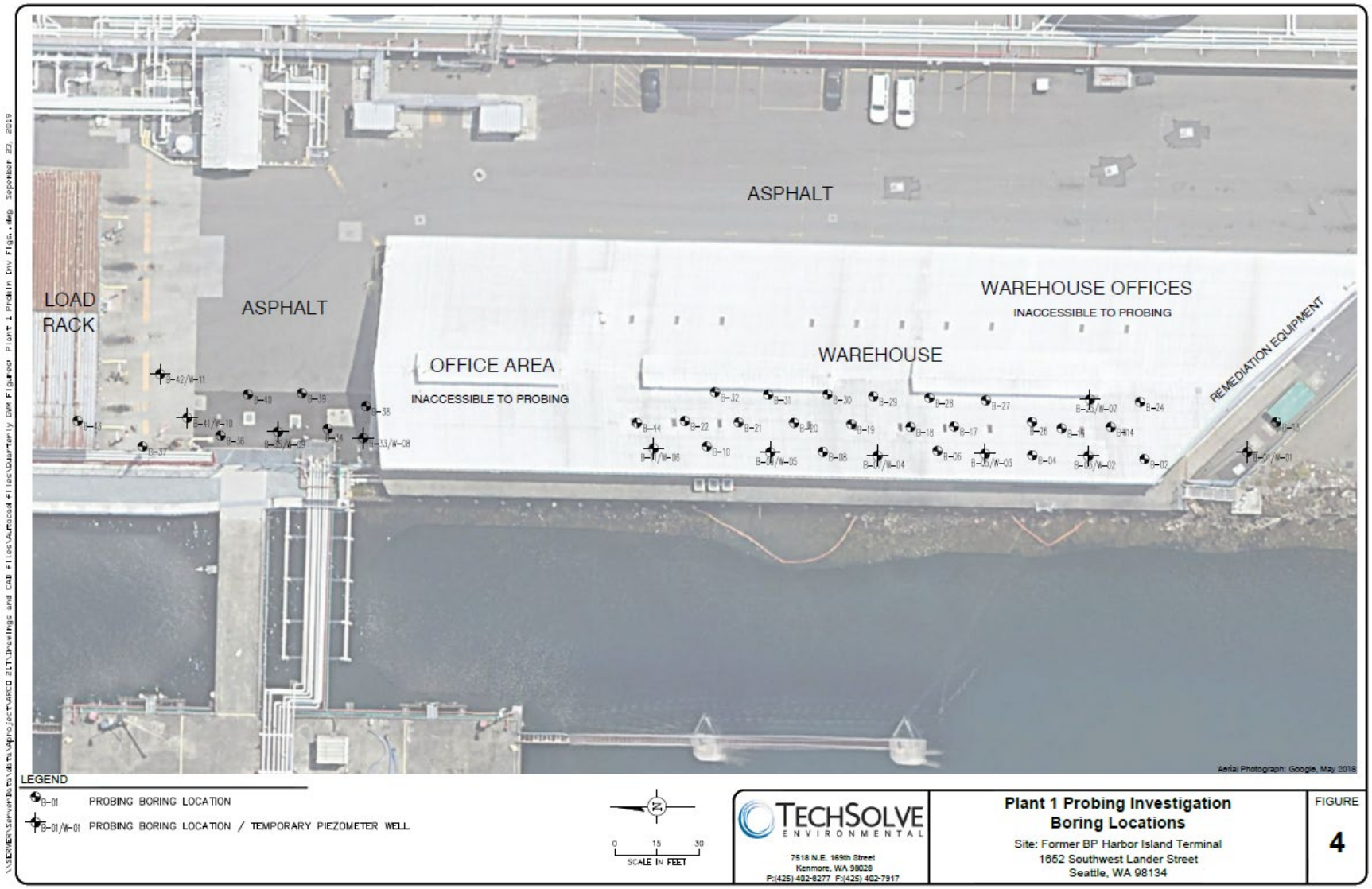

Figure 7. Tank Farm Operable Unit 2, BP Plant 1 Geoprobe Study

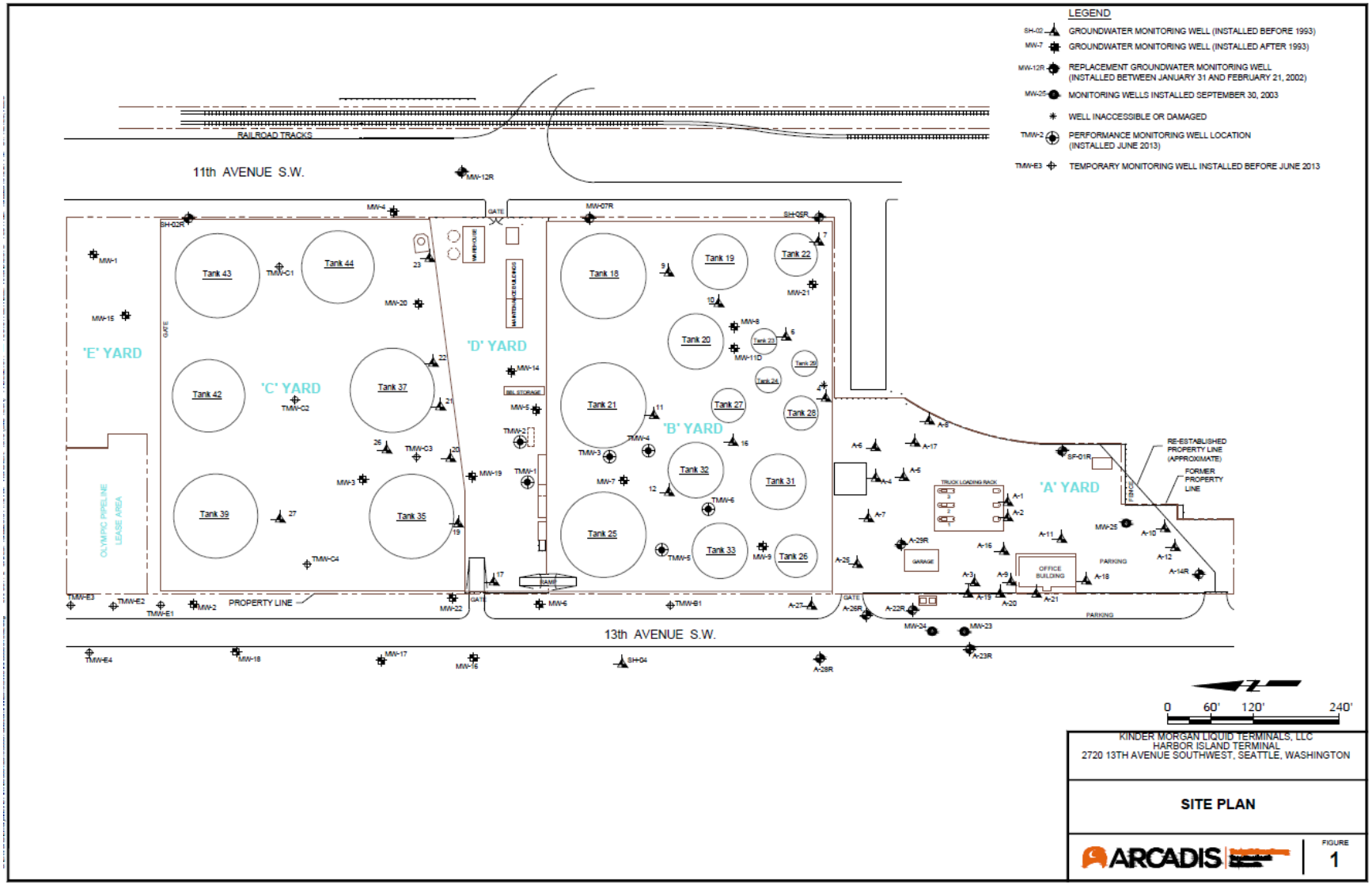

Figure 8. Tank Farm Operable Unit 2, Kinder Morgan Monitoring Well Locations

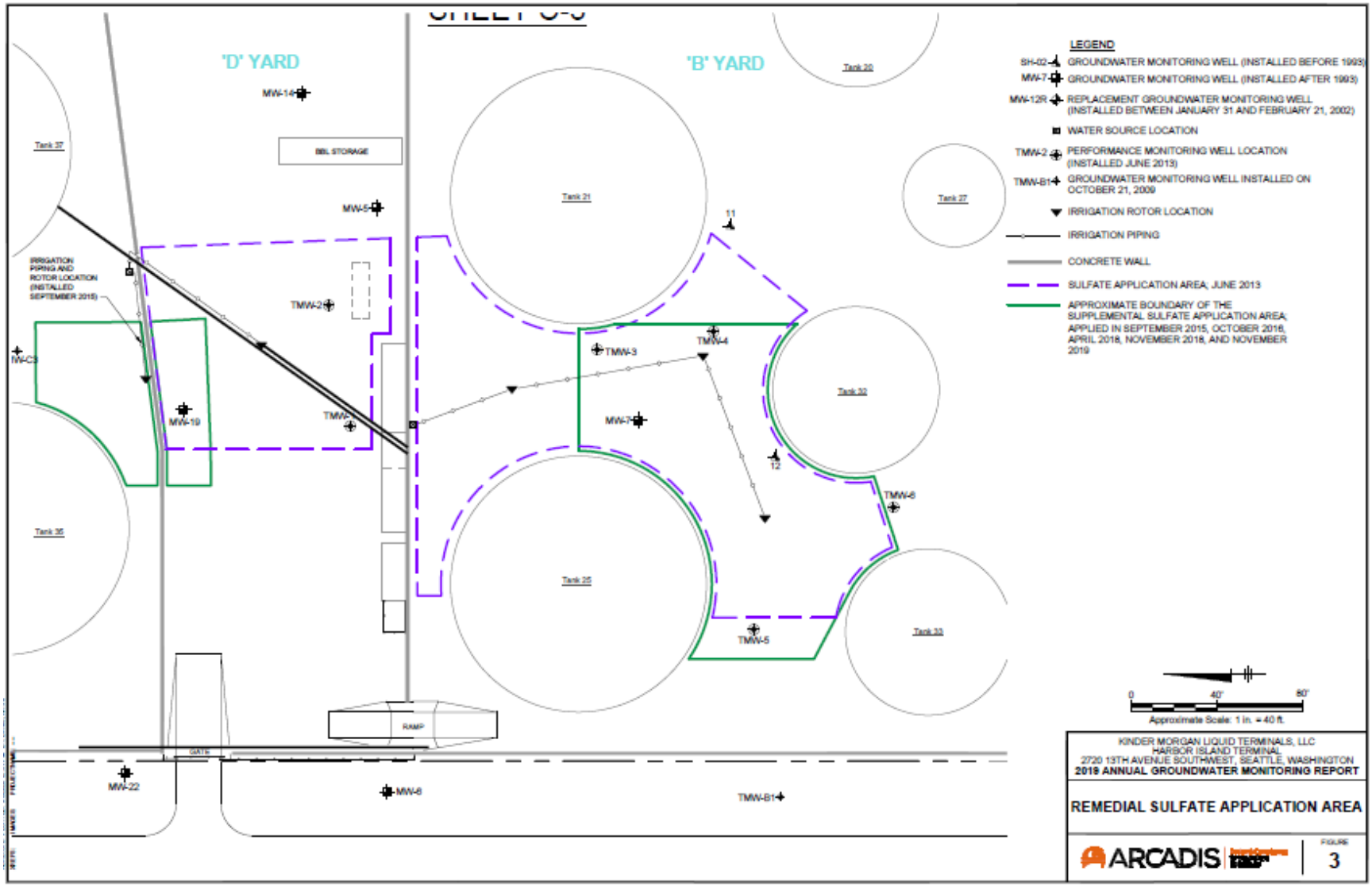

Figure 9 Tank Farm Operable Unit 2, Kinder Morgan Remediation Area

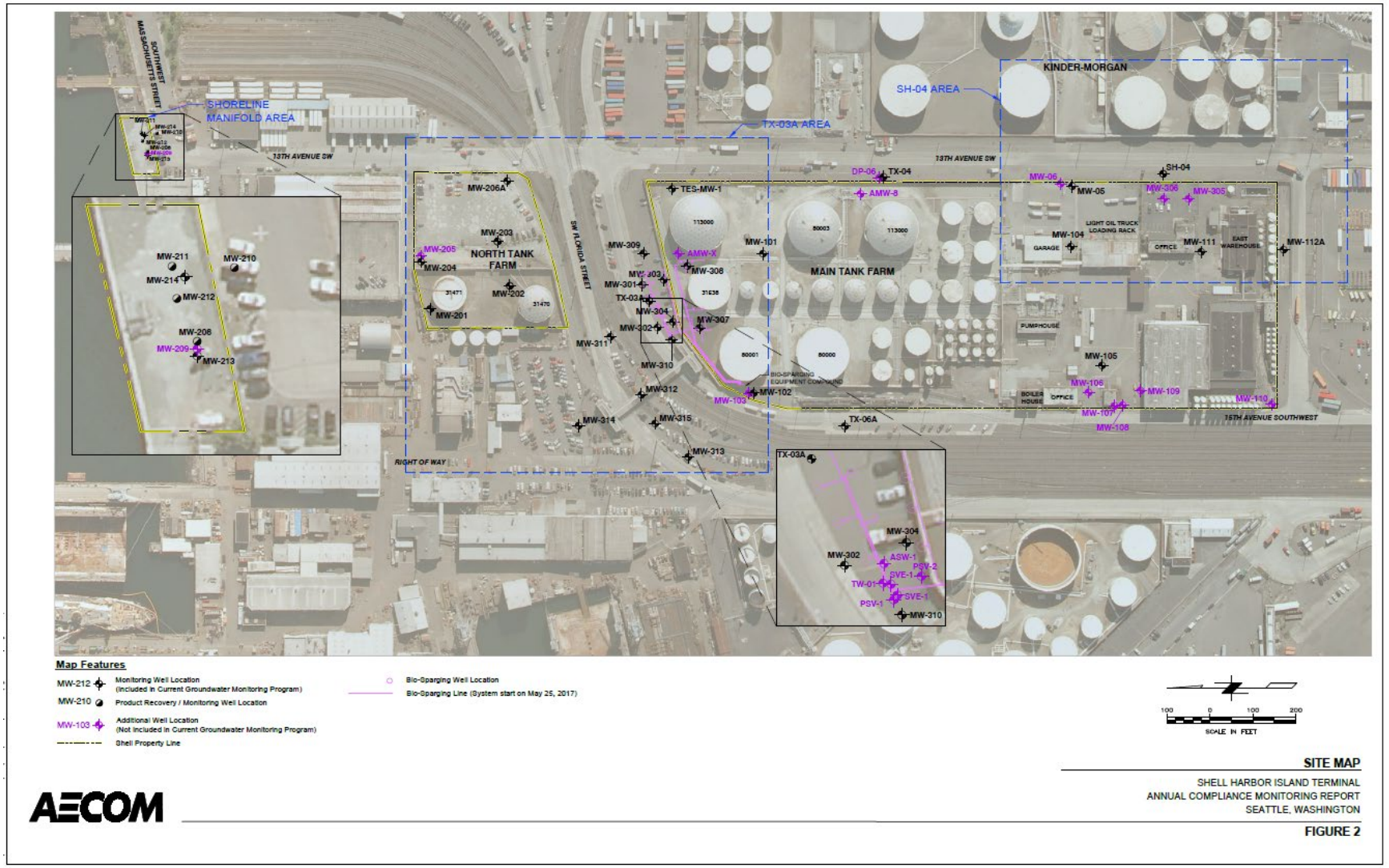

Figure 10. Tank Farm Operable Unit 2, Shell Monitoring Well Locations

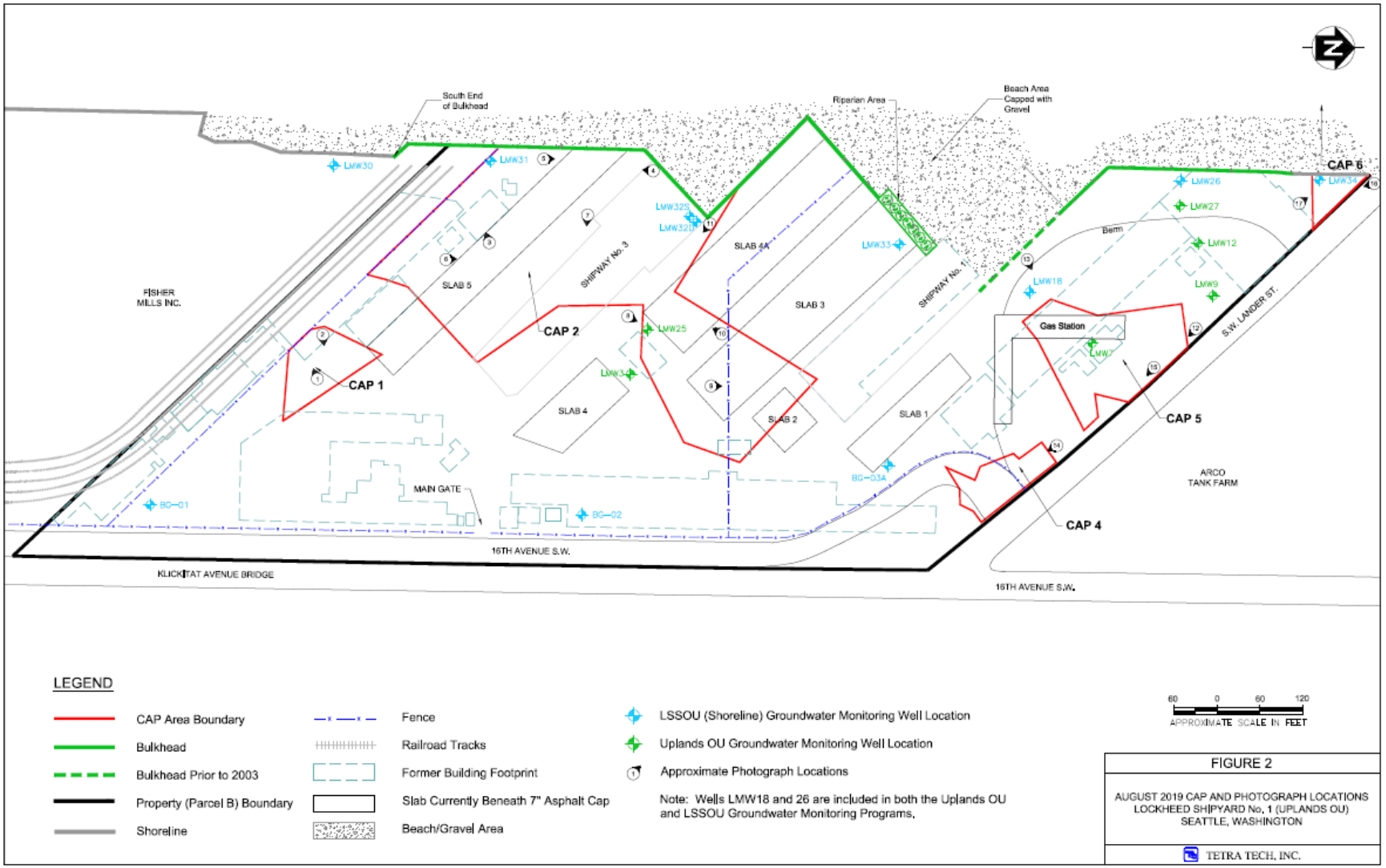

Figure 11. Lockheed Uplands Operable Unit 3, Monitoring Well Locations

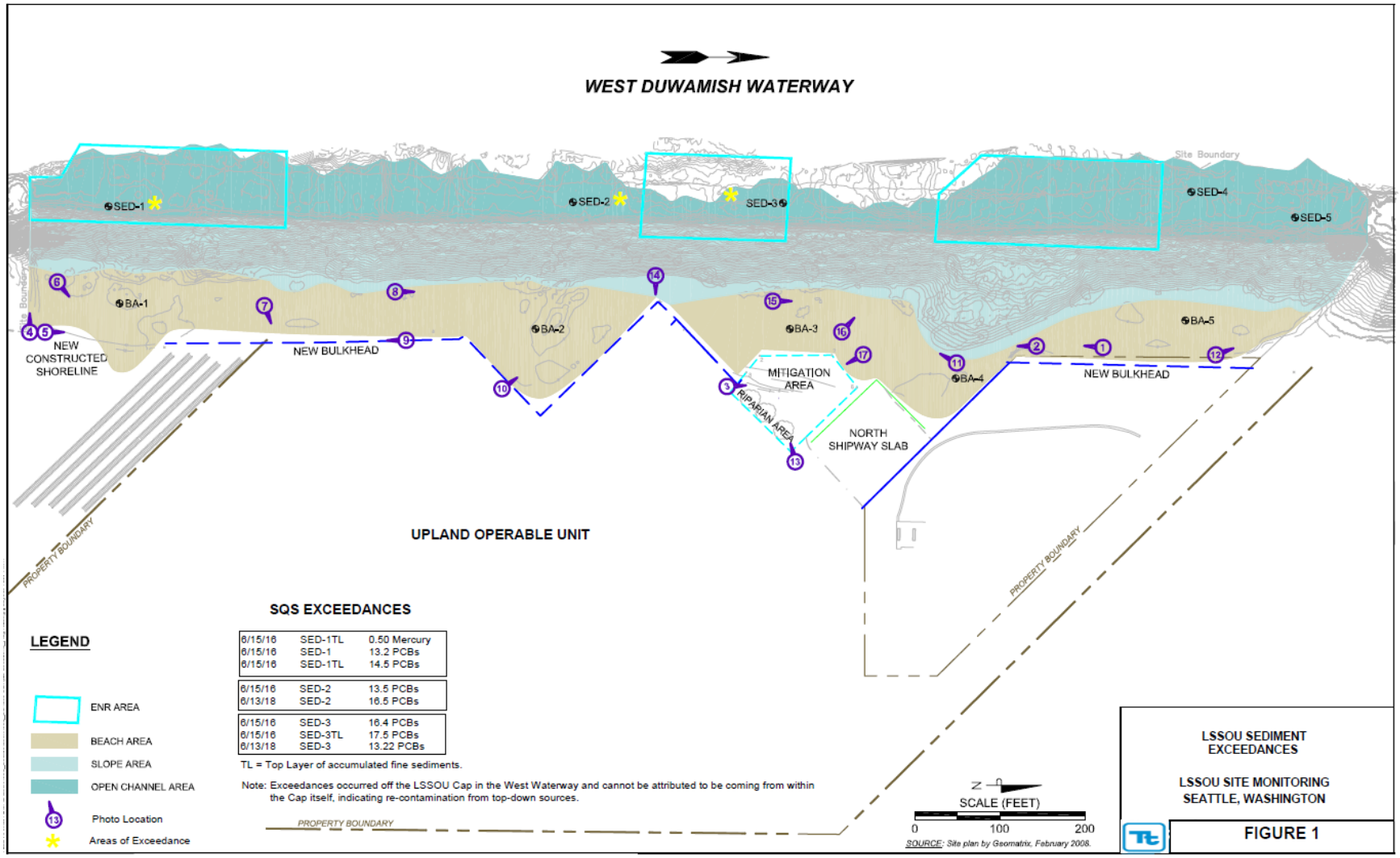

Figure 12. Lockheed Shipyard Sediments Operable Unit 7, Sediment Sample Locations and Results

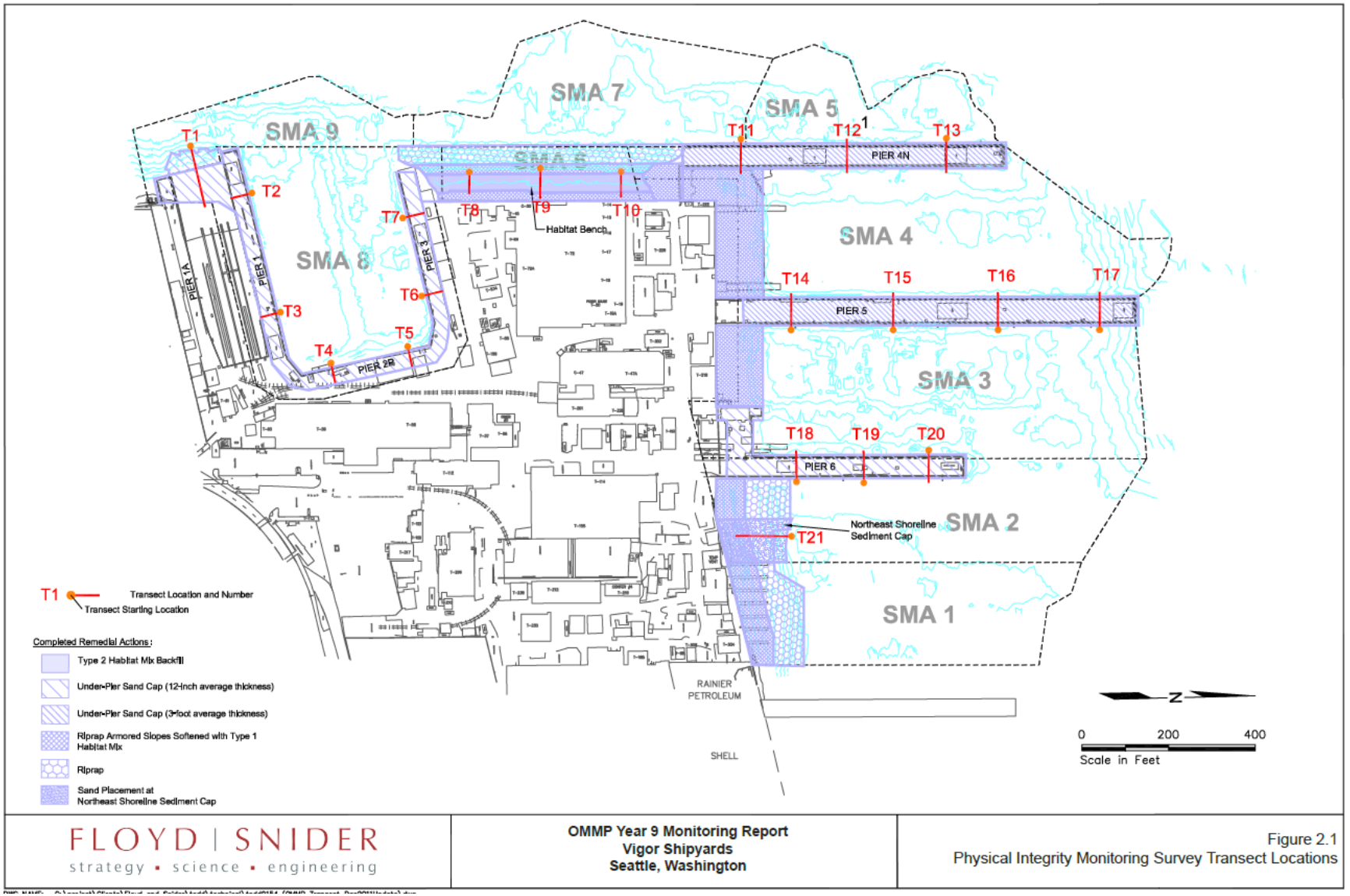

Figure 13.Todd Shipyard Operable Unit 9, Cap Monitoring Transects

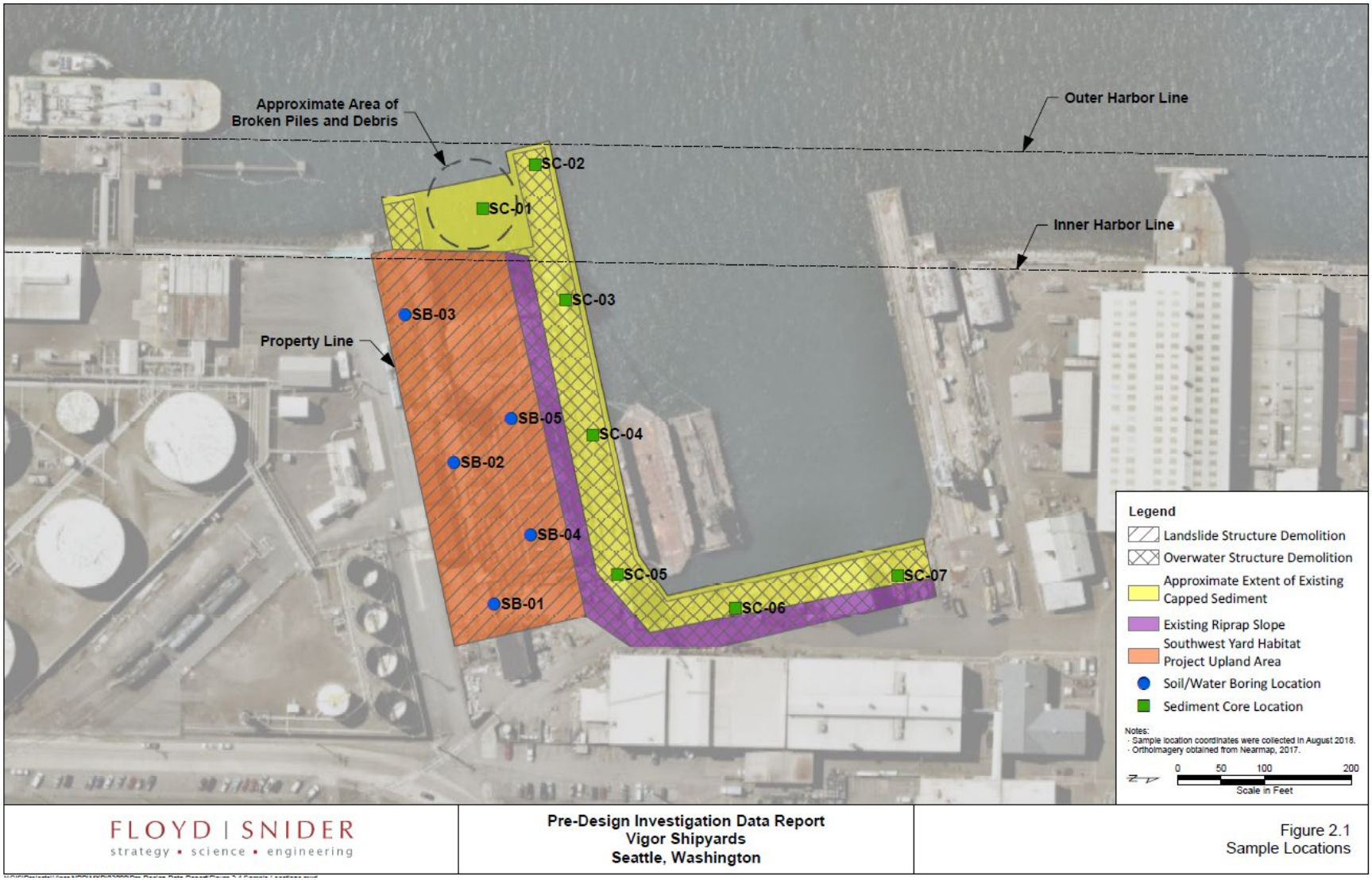

Figure 14. Todd Shipyard Operable Unit 9, Pre-Design Sample Locations

Appendix B: List of Documents Reviewed

AECOM, 2018a. 2017 Annual Groundwater Monitoring Report. Harbor Island Superfund Site – Soil and Groundwater Operable Unit. July 27, 2017

AECOM, 2018b. 2018 Annual Groundwater Monitoring Report. Harbor Island Superfund Site – Soil and Groundwater Operable Unit. September 4, 2018.

AECOM, 2018c. Bio-Sparging System Installation, Shell Oil Products. March 28, 2018.

AECOM, 2020. Annual Compliance Monitoring Report 2019, Shell Harbor Island Terminal. February, 2020.

Arcadis, 2019a. Sulfate Application Field Memorandum, Kinder Morgan Liquid Terminals, Harbor Island Terminal. November 19, 2019.

Arcadis, 2019b. Sulfate Application Field Memorandum, Kinder Morgan Liquid Terminals, Harbor Island Terminal. November 19, 2019.

Arcadis, 2020. 2019 Annual Groundwater Monitoring Report, Kinder Morgan Liquids Terminals. February 5, 2020.

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Appendix C: ARAR Analysis

Section 121(d)(1)(A) of CERCLA requires that remedial actions at CERCLA sites attain (or justify the waiver of) any federal or state environmental standards, requirements, criteria, or limitations that are determined to be legally applicable or relevant and appropriate requirements (ARARs). Federal ARARs may include requirements promulgated under any federal environmental laws. State ARARs may only include promulgated, enforceable environmental or facility-siting laws of general application that are more stringent or broader in scope than federal requirements and that are identified by the state in a timely manner. ARARs are identified on a site-specific basis from information about the chemicals at the site, the RAs contemplated, the physical characteristics of the site, and other appropriate factors. ARARs include only substantive, not administrative, requirements and pertain only to onsite activities. There are three general categories of ARARs: chemical-specific, location-specific, and action-specific.

Chemical-specific ARARs identified in the selected remedy within the applicable RODs and subsequent ROD Amendments for the groundwater at each OU and considered for this FYR for continued groundwater treatment, are shown in tables below for each OU. Contaminants with cleanup goals that exceed their current MCL are highlighted yellow in the applicable table.

Federal and State laws and regulations other than the chemical-specific ARARs are also described in the tables below for each OU, and if they have been promulgated or changed over the past five years. The tables do not include those ARARs identified from RODs that are no longer pertinent. For example, ARARs related to remedial design and construction are not included in the table if they do not continue into long-term O&M. There have been no revisions to laws or regulations that affect the protectiveness of the remedy for any OU.

1. Soil & Groundwater – OU1

ARARs Evaluation

Requirement	Citation	Description	Effect on Protectiveness	Comments	Amendment Date
Clean Air Act; Washington Clean Air Act	Federal – CAA – National Ambient Air Quality Standards (NAAQS) (42 USC 7401); State – General Regulations for Air Pollution Sources (Washington Administrative Code [WAC] 173-400, -460)	Actions that result in major sources of emissions must be designed to meet ambient air quality standards.	Protectiveness is not affected.	LNAPL vacuum-enhancement at Todd Shipyards discharges air, treated by a catalytic oxidizer, to the atmosphere.	WAC 173-400: 10/25/2018

Requirement	Citation	Description	Effect on Protectiveness	Comments	Amendment Date
Puget Sound Air Pollution Control Agency (PSAPCA)	PSAPCA (Regulations I, III)	Actions that could involve releases of contaminants to air will be performed in compliance with substantive requirements of a permit from PSAPCA.	Protectiveness is not affected.	LNAPL vacuum-enhancement system at Todd Shipyards discharges air, treated by a catalytic oxidizer, to the atmosphere.	Regulations – 09/26/2019; Regulation III – 12/15/16
Washington Water Pollution Control Act (WPCA); Washington State Water Quality Standards	State- WPCA – Water Pollution Control (Revised Code of Washington [RCW] 90.48); WPCA-Water Quality Standards for Surface Waters (WAC 173-201A)	Actions must achieve water quality standards for surface waters consistent with public health and protection of fish, shellfish and wildlife.	Protectiveness is not affected.	Hot spot removal, cap, and LNAPL removal will achieve water quality standards for protection of marine organisms.	03/25/2020
State Water Code; Water Rights	State – Water Code (RCW 90.03); Water Rights (RCW 90.14)	Specifications for the extraction of groundwater will be met during remedial activities; groundwater remediation will be consistent with beneficial uses of the resources and will not be wasteful.	Protectiveness is not affected.	Groundwater extraction and remediation processes at Todd Shipyards will follow specifications and will be consistent with beneficial uses.	None
Model Toxics Control Act (MTCA)	State – MTCA (RCW 70.105D; WAC 173-340)	MTCA soil cleanup standards for protection of human health in an industrial setting and for protection of groundwater from contaminants leaching from soil will be met.	Protectiveness is not affected.	Soil remediation is no longer active.	None
Water Well Construction Act (WWCA)	State – WWCA Standards for construction and maintenance of water wells (WAC 173-160)	Standards for construction, testing, and abandonment of water and resource protection wells will be met during remediation and monitoring.	Protectiveness is not affected.	Standards must be met for monitoring wells.	None

Requirement	Citation	Description	Effect on Protectiveness	Comments	Amendment Date
Clean Water Act (CWA)	Federal – CWA (33 U.S.C. 1251; 40 CFR Part 131)	Standards for protection of marine organisms and human health from ingestion of marine organisms will be achieved through removal of hot spots from both soil and groundwater, capping, and natural biodegradation of remaining low level organics in the groundwater.	Protectiveness is not affected.	Removal of the floating petroleum product at Todd Shipyards and cap will achieve CWA standards.	December 2017, December, 2018, January 2019.

S&G-OU1, Current and Historical Toxicity Values

Contaminant	Toxicity Value Type	Toxicity Values in 1993 ROD		Current Toxicity Criteria	
		Criteria	Source	Criteria	Source
Antimony	RfD_o	$4.0x10^{-4}$ mg/kg-day	IRIS	$4.0x10^{-4}$ mg/kg-day	IRIS
Arsenic	RfD_o	$3.0x10^{-4}$ mg/kg-day	IRIS	$3.0x10^{-4}$ mg/kg-day	IRIS
	SFO	$1.8\ (mg/kg\text{-}day)^{-1}$	IRIS	$1.5\ (mg/kg\text{-}day)^{-1}$	IRIS
Carcinogenic PAHs	SFO	$5.8\ (mg/kg\text{-}day)^{-1}$	EPA ECAO	$7.3\ (mg/kg\text{-}day)^{-1}$	IRIS
PCBs	SFO	$7.7\ (mg/kg\text{-}day)^{-1}$	IRIS	0.07 to $2.0\ (mg/kg\text{-}day)^{-1}$	IRIS

Notes

Highlight indicates current toxicity criteria is more stringent than that used in 1993 ROD

RfD_o - Oral reference dose

SFO - Oral slope factor

IRIS - EPA's Integrated Risk Information System

EPA ECAO - EPA Environmental Criteria and Assessment Office

S&G-OU1, Comparison of ROD Cleanup Goals to Current Standards

Medium	Contaminant	Cleanup Goal per 1993 ROD		Current Standards	
		Goal	Basis of Goal	Standard	Source of Standard
Soil-Surface	Lead	1,000 mg/kg	MTCA A	250 mg/kg	MTCA A
	Arsenic	3.60 to 32.6 mg/kg	1 x 10^{-5} risk	N/A	N/A
	Antimony	180 to 677 mg/kg	1 x 10^{-5} risk	N/A	N/A
	Carcinogenic PAHs	0.1 to 36.5 mg/kg	1 x 10^{-5} risk	N/A	N/A
	PCBs	0.18 to 2.99 mg/kg	1 x 10^{-5} risk	N/A	N/A
Soil-Subsurface	Lead	1,000 mg/kg	MTCA A	250 mg/kg	MTCA A
	TPH (diesel)	600 mg/kg	MTCA A	2,000 mg/kg	MTCA A
	TPH (gasoline)	400 mg/kg	WA PCS Matrix	100 mg/kg (no detectable benzene)	MTCA A
				30 mg/kg (benzene present)	MTCA A
	Cadmium	10 mg/kg	MTCA A	2 mg/kg	MTCA A
	Chromium	500 mg/kg	MTCA A	19 mg/kg (Chromium VI)	MTCA A
				2,000 mg/kg (Chromium III)	MTCA A
	Mercury	1.0 mg/kg	MTCA A	2 mg/kg	MTCA A
	PAHs (carcinogenic)	20 mg/kg	MTCA A	0.1 mg/kg[a]	MTCA A
	Arsenic	200 mg/kg	MTCA A	20 mg/kg	MTCA A
	Benzene	1.0 mg/kg	WA PCS Matrix	0.03 mg/kg	MTCA A

	Ethylbenzene	200 mg/kg	WA PCS Matrix	6 mg/kg	MTCA A
	Toluene	100 mg/kg	WA PCS Matrix	7 mg/kg	MTCA A
	Xylenes	150 mg/kg	WA PCS Matrix	9 mg/kg	MTCA A
Groundwater	Carbon Tetrachloride	4.4 µg/L	Protect Organisms	5 µg/L	CWA §304 HH - Marine Waters
	Benzene	71 µg/L	Protect Organisms	16-58 µg/L	CWA §304 HH - Marine Waters
	Trichloroethane	42 µg/L	Protect Organisms	8.9 µg/L (1,1,2-trichloroethane)	CWA §304 HH - Marine Waters
	Tetrachloroethylene	8.8 µg/L	Protect Organisms	29 µg/L	CWA §304 HH - Marine Waters
	PCBs	0.03 µg/L	Protect Organisms	0.03 µg/L	CWA §304 AL - Marine/Chronic
	Arsenic	36 µg/L	Protect Organisms	36 µg/L	CWA §304 AL - Marine/Chronic
	Cadmium	8.0 µg/L	Protect Organisms	7.9 µg/L	CWA §304 AL - Marine/Chronic
	Copper	2.9 µg/L	Protect Organisms	3.1 µg/L	CWA §304 AL - Marine/Chronic
	Lead	5.8 µg/L	Protect Organisms	5.6 µg/L	CWA §304 AL - Marine/Chronic
	Mercury	0.025 µg/L	Protect Organisms	0.025 µg/L	173-201A WAC AL - Marine/Chronic
	Nickel	7.9 µg/L	Protect Organisms	8.2 µg/L	CWA §304 AL- Marine/Chronic
	Silver	1.2 µg/L	Protect Organisms	1.9 µg/L	CWA §304 AL - Marine/Acute[b]
	Thallium	6.3 µg/L	Protect Organisms	0.47 µg/L	CWA §304 HH - Marine Waters
	Zinc	76.6 µg/L	Protect Organisms	81 µg/L	CWA §304 AL - Marine/Chronic
	Cyanide	1.0 µg/L	Protect Organisms	1.0 µg/L	CWA §304 AL - Marine/Chronic

Notes:

Highlight indicates current standard is less than the 1993 ROD cleanup goal

MTCA A - Method A Soil Cleanup Levels for Industrial Properties (MTCA Table 745-1)
1 x 10^{-5} risk - Total 1 x 10^{-5} risk excess cancer risk or Hazard Index equal to 1
WA PCS Matrix - State of Washington Petroleum-Contaminated Soil Matrix Rating Method
Protect Organisms - Protection of marine organisms or human health from consumptions of organisms
CWA §304 HH - Marine Waters - Clean Water Act Section 304 National Recommended Water Quality Criteria, Human Health for Marine Waters (consumption of organisms only)
CWA §304 AL - Marine/Chronic - Clean Water Act Section 304 National Recommended Water Quality Criteria, aquatic life, marine, chronic
173-201A WAC AL- Marine/Chronic - Washington Administrative Code Chapter 173-201A, aquatic life, marine, chronic
CWA §304 AL - Marine/Acute - Clean Water Act Section 304 National Recommended Water Quality Criteria, aquatic life, marine, chronic

[a] The latest MTCA value promulgated in 2007 uses this value as the toxicity equivalent to benzo(a)pyrene

[b] No chronic value available

2. Tank Farms – OU2

TF-OU2, ARAR Evaluation

Requirement	Citation	Description	Effect on Protectiveness	Comments	Amendment Date
Washington Clean Air Act	State – General Regulations for Air Pollution Sources (WAC 173-400, -460; WA Clean Air Act (RCW 70.94)	Actions that result in major sources of emissions must be designed to meet ambient air quality standards.	None of the revisions to WAC 173-400 affect protectiveness.	Currently operating soil vapor extraction/air sparging systems emissions to air must meet air quality standards.	WAC 173-400: 10/25/2018
Washington Water Pollution Control Act (WPCA); Washington State Water Quality Standards	State- WPCA – Water Pollution Control (Revised Code of Washington [RCW] 90.48); WPCA-Water Quality Standards for Surface Waters (WAC 173-201A)	Actions must achieve water quality standards for surface waters consistent with public health and protection of fish, shellfish and wildlife.	Protectiveness is not affected.	Remedial actions are specific to the cleanup of site groundwater. The groundwater cleanup goals are surface water standards that are protective of aquatic organisms. Much of RCW 75.20 was recodified to RCW 77.55. All remedial construction has been completed. Should additional remedial construction occur along the shoreline and in the adjacent waters RCW 75.20 would be applicable.	03/25/2020

Requirement	Citation	Description	Effect on Protectiveness	Comments	Amendment Date
Washington State Water Resources Act (WRA)	State- WRA – Water Resources Act (RCW 90.54)	Selected remediation methods should promote proper utilization of water resources, public health, economic well-being, and preservation of water's natural resources and aesthetic values.	Protectiveness is not affected.	Remedial actions to clean up site groundwater indirectly achieves surface water goals presented in this ARAR.	None
Washington Shoreline Management	State – Shoreline Management Act of 1971 (RCW 70.95)	The remedial actions will ensure that nearby water resources are protected and wisely managed.	Protectiveness is not affected.	One remediation system is located on the shoreline bulkhead, and will ensure that nearby water resources are protected.	None
Washington Model Toxics Control Act (MTCA)	State – MTCA (WAC 173-340)	MTCA cleanup regulations provide that cleanup actions must comply with cleanup levels for selected hazardous substances, points of compliance, and ARARs.	Protectiveness is not affected.	Currently operating soil vapor extraction/air sparging systems must meet cleanup levels especially for total petroleum hydrocarbons.	None
Washington Solid Waste Management (SWM)	State – SWM (WAC 173-304) (RCW 70.95)	The remedial actions will follow a comprehensive program for solid waste handling, and solid waste recovery and/or recycling that will prevent land, air, and water pollution.	Protectiveness is not affected.	Solid wastes are potentially generated as part of the remedial actions.	None
Washington Hazardous Waste Management (HWM)	State – HWM (RCW 70.105); Dangerous Waste Regulations (WAC 173-303)	The remedial action will provide for the control and management of hazardous waste that will prevent land, air, and water pollution.	None of the revisions to WAC 173-303 affect protectiveness.	Hazardous wastes are potentially generated as part of the remedial actions.	01/28/2019

TF-OU2, Comparison of Cleanup Goals to Current Standards

Medium	Contaminant	Cleanup Goal per CAP		Current Standards	
		Goal	Basis of Goal	Standard	Source of Standard
Soil-Surface	Lead	1,000 mg/kg	MTCA A	250 mg/kg	MTCA A
	Arsenic	32.6 mg/kg	1 x 10^{-5} risk	N/A	N/A
Soil-Subsurface	Total TPH (Primary Areas of Concern)	10,000 mg/kg	Protection of Surface Water at Boundary	10,000 mg/kg	Protection of Surface Water at Boundary
	Total TPH (Secondary Areas of Concern)	20,000 mg/kg	Protection of Surface Water at Boundary	20,000 mg/kg	Protection of Surface Water at Boundary
Groundwater	Benzene	71 µg/L	Protect Organisms	16-58 µg/L	CWA §304 HH - Marine Waters
	Ethylbenzene	29,000 µg/L	Protect Organisms	130 µg/L	CWA §304 HH - Marine Waters
	Toluene	200,000 µg/L	Protect Organisms	520 µg/L	CWA §304 HH - Marine Waters
	Carcinogenic PAHs	0.031 µg/L	Protect Organisms	varies per chemical (0.00013 - 0.013 µg/L)	CWA §304 HH - Marine Waters
	Copper	2.9 µg/L	Protect Organisms	3.1 µg/L	CWA §304 AL - Marine/Chronic
	Lead	5.8 µg/L	Protect Organisms	5.6 µg/L	CWA §304 AL - Marine/Chronic
	TPH (gas)	1,000 µg/L	Protect Groundwater	1,000 µg/L (no detectable benzene)	MTCA A
				800 µg/L (benzene present)	MTCA A
	TPH (diesel)	10,000 µg/L	Protect Groundwater	500 µg/L	MTCA A
	TPH (oil)	10,000 µg/L	Protect Groundwater	500 µg/L	MTCA A

Notes:

Highlight indicates current standard is less than that used in the CAP

MTCA A - Method A Soil Cleanup Levels for Industrial Properties (MTCA Table 745-)

1 x 10^{-5} risk - Total 1 x 10^{-5} risk excess cancer risk or Hazard Index equal to 1

WA PCS Matrix - State of Washington Petroleum-Contaminated Soil Matrix Rating Method

Protect Organisms - Protection of marine organisms or human health from consumptions of organisms

CWA §304 HH - Marine Waters - Clean Water Act Section 304 National Recommended Water Quality Criteria, Human Health for Marine Waters (consumption of organisms only)

CWA §304 AL - Marine/Chronic - Clean Water Act Section 304 National Recommended Water Quality Criteria, aquatic life, marine, chronic

[a] The latest MTCA value promulgated in 2007 uses this value as the toxicity equivalent to benzo(a)pyrene

3. Lockheed Upland – OU3

LU-OU3, ARAR Evaluation

Requirement	Citation	Description	Effect on Protectiveness	Comments	Amendment Date
Washington Water Pollution Control Act (WPCA); Washington State Water Quality Standards	State- WPCA – Water Pollution Control (Revised Code of Washington [RCW] 90.48); WPCA-Water Quality Standards for Surface Waters (WAC 173-201A)	Actions must achieve water quality standards for surface waters consistent with public health and protection of fish, shellfish and wildlife.	Protectiveness is not affected.	Groundwater is being monitored to assess the effectiveness of the remediation to meet water quality goals.	03/25/2020
Washington Model Toxics Control Act (MTCA)	State – MTCA (WAC 173-340)	MTCA cleanup regulations provide that cleanup actions must comply with cleanup levels for selected hazardous substances, points of compliance, and ARARs.	Protectiveness is not affected.	Groundwater is being monitored to assess the effectiveness of the remediation to meet water quality goals.	None
Clean Water Act (CWA)	Federal – CWA (33 U.S.C. 1251; 40 CFR Part 131)	Standards for protection of marine organisms and human health from ingestion of marine organisms will be achieved through removal of hot spots from both soil and groundwater, capping, and natural biodegradation of remaining low level organics in the groundwater.	Protectiveness is not affected.	Groundwater is being monitored to assess the effectiveness of the remediation to meet water quality goals.	December 2017, December, 2018, January 2019.
Water Well Construction Act (WWCA)	State – WWCA Standards for construction and maintenance of water wells (WAC 173-160)	Standards for construction, testing, and abandonment of water and resource protection wells will be met during remediation and	Protectiveness is not affected.	Standards must be met for monitoring wells.	None

Requirement	Citation	Description	Effect on Protectiveness	Comments	Amendment Date
		monitoring.			

LU-OU3, Comparison of ROD Cleanup Goals to Current Standards

Medium	Contaminant	Cleanup Goal per 1993 ROD		Current Standards	
		Goal	Basis of Goal	Standard	Source of Standard
Soil-Surface	Lead	1,000 mg/kg	MTCA A	250 mg/kg	MTCA A
	Arsenic	3.60 to 32.6 mg/kg	1 x 10^{-5} risk	N/A	N/A
	Carcinogenic PAHs	0.1 to 36.5 mg/kg	1 x 10^{-5} risk	N/A	N/A
Soil-Subsurface	Lead	1,000 mg/kg	MTCA A	250 mg/kg	MTCA A
	TPH (diesel)	600 mg/kg	WA PCS Matrix	2,000 mg/kg	MTCA A
	PAHs (carcinogenic)	20 mg/kg	MTCA A	0.1 mg/kg[a]	MTCA A
	Arsenic	200 mg/kg	MTCA A	20 mg/kg	MTCA A
	Benzene	1.0 mg/kg	WA PCS Matrix	0.03 mg/kg	MTCA A
	Ethylbenzene	200 mg/kg	WA PCS Matrix	6 mg/kg	MTCA A
	Toluene	100 mg/kg	WA PCS Matrix	7 mg/kg	MTCA A
	Xylenes	150 mg/kg	WA PCS Matrix	9 mg/kg	MTCA A
Groundwater	Benzene	71 µg/L	Protect Organisms	16-58 µg/L	CWA §304 HH - Marine Waters
	Tetrachloroethylene	8.8 µg/L	Protect Organisms	29 µg/L	CWA §304 HH - Marine Waters
	Copper	2.9 µg/L	Protect Organisms	3.1 µg/L	CWA §304 AL - Marine/Chronic
	Lead	5.8 µg/L	Protect Organisms	5.6 µg/L	CWA §304 AL - Marine/Chronic
	Zinc	76.6 µg/L	Protect Organisms	81 µg/L	CWA §304 AL - Marine/Chronic

Notes

Highlight indicates current standard is less than the 1993 ROD cleanup goal

MTCA A - Method A Soil Cleanup Levels for Industrial Properties (MTCA Table 745-)

1 x 10^{-5} risk - Total 1 x 10^{-5} risk excess cancer risk or Hazard Index equal to 1

WA PCS Matrix - State of Washington Petroleum-Contaminated Soil Matrix Rating Method

Protect Organisms - Protection of marine organisms or human health from consumptions of organisms

CWA §304 HH - Marine Waters - Clean Water Act Section 304 National Recommended Water Quality Criteria, Human Health for Marine Waters (consumption of organisms only)

CWA §304 AL- Marine/Chronic - Clean Water Act Section 304 National Recommended Water Quality Criteria, aquatic life, marine, chronic

[a]The latest MTCA value promulgated in 2007 uses this value as the toxicity equivalent to benzo(a)pyrene

4. Lockheed Shipyard Sediments – OU7

LSS-OU7, ARAR Evaluation

Requirement	Citation	Description	Effect on Protectiveness	Comments	Amendment Date
Water Quality Standards	Federal – Water Quality Standards (33 USC 1251; 40 CFR 131);	Federal criteria for the protection of marine aquatic life are relevant and appropriate for discharges to surface water during sediment remediation.	Protectiveness is not affected.	No active sediment remediation is occurring. A monitoring program is in place to provide visual inspections, hydrographic surveys, monitor sediment quality, and the quality of groundwater entering the West Waterway.	December 2017, December, 2018, January 2019.
Washington Water Pollution Control Act (WPCA); Washington State Water Quality Standards for Surface Water	State – WPCA – Water Pollution Control (RCW 90.48); WPCA Water Quality Standards for Surface Waters (WAC 173-201A)	Narrative and quantitative limitations for surface water protection are provided in these regulations. Criteria are established for each water classification, including fecal coliform, total dissolved gas, total dissolved oxygen, temperature, pH, and turbidity. During sediment remediation, discharges to marine surface waters will comply with these requirements.	Protectiveness is not affected.	No active sediment remediation is occurring. A monitoring program is in place to provide visual inspections, hydrographic and topographic surveys, monitor sediment quality, and the quality of groundwater entering the West Waterway.	03/25/2020
Washington State Sediment Management Standards	State – Sediment Management Standards (RCW 43.21C, 70.105D, 90.48, 90.52, 90.54, 90.70; WAC 173-204)	Numerical and narrative criteria for chemicals and biological effects are specified for sediment and are applicable to Harbor Island shipyard sediments.	WAC 173-204 (Sediment Management Standards or SMS) was revised in 2013. The SCO benthic protection values under the 2013 SMS are the same as the 1991 SQS values used in developing the LSS-OU7 cleanup levels for protection of benthic invertebrates. The requirements for	No active sediment remediation is occurring. A monitoring program is in place to provide visual inspections, hydrographic and topographic surveys, monitor sediment quality, and the quality of groundwater entering the West Waterway.	February 2013

Requirement	Citation	Description	Effect on Protectiveness	Comments	Amendment Date
			protection of human health and higher trophic-level species are consistent with MTCA, which was promulgated in 1990, prior to the date of the LSS-OU7 ROD.		
National Pollutant Discharge Elimination System (NPDES); Washington State Discharge Permit Program	Federal – NPDES (40 CFR 122, 125); State – NPDES (WAC 173-216, -220)	Applies to direct discharges to surface water conducted as part of remedial actions. Conditions to authorizing direct discharges to surface water are specified under 40 CFR 122. Criteria and standards for discharges are specified in 40 CFR 125. The State of Washington has been authorized by the EPA to implement the NPDES permit program.	Protectiveness is not affected.	No active sediment remediation is occurring. A monitoring program is in place to provide visual inspections, hydrographic and topographic surveys, monitor sediment quality, and the quality of groundwater entering the West Waterway. Stormwater is discharged directly to the West Waterway.	40 CFR 122: July 2012, December 2012, June 2013, August 2014, September 2014; 40 CFR 125: August 2014
Solid Waste Disposal Act; Washington State Minimum Functional Standards for Solid Waste Handling	Federal – Solid Waste Disposal (42 USC 3251; 40 CFR 257, 258); State – Solid Waste Handling (WAC 173-304)	Wastes generated by the remedial action include dredged sediment and sandblast grit, which is separated from dredged sediment. Sandblast grit may be suitable for recycling as feedstock for cement production.	Protectiveness is not affected.	No active sediment remediation is occurring. A monitoring program is in place to provide visual inspections, hydrographic and topographic surveys, monitor sediment quality, and the quality of groundwater entering the West Waterway. Solids are removed from stormwater runoff.	WAC 173-304: 10/25/2019.

Requirement	Citation	Description	Effect on Protectiveness	Comments	Amendment Date
Storm water Management Program	Federal – Water Programs (40 CFR 122 -124); State – Water Pollution Control (RCW 90.48)	TBC - This describes storm water management objectives that may apply to storm drains at LSS-OU7.	Protectiveness is not affected.	No active sediment remediation is occurring. A monitoring program is in place to provide visual inspections, hydrographic and topographic surveys, monitor sediment quality, and the quality of groundwater entering the West Waterway.	40 CFR 122: July 2012, December 2012, June 2013, August 2014, September 2014; 40 CFR 124: December 2010, September 2011, January 2013
Puget Sound Estuary Program Protocols	Local – Puget Sound Partnership	TBC - Provides sample collection, laboratory analysis, and QA/QC procedures for sampling and analyzing sediment samples.	Protectiveness is not affected.	A monitoring program is in place to provide visual inspections, hydrographic and topographic surveys, monitor sediment quality, and the quality of groundwater entering the West Waterway.	None

5. Todd Shipyards Sediments – OU9

TSS-OU9, ARAR Evaluation

Requirement	Citation	Description	Effect on Protectiveness	Comments	Amendment Date
Water Quality Standards	Federal – Water Quality Standards (33 USC 1251; 40 CFR 131);	Federal criteria for the protection of marine aquatic life are relevant and appropriate for discharges to surface water during sediment remediation.	Protectiveness is not affected.	No active sediment remediation is occurring. Only visual monitoring of the cap and the previous dredged channel is occurring.	December 2017, December, 2018, January 2019.

Requirement	Citation	Description	Effect on Protectiveness	Comments	Amendment Date
Washington Water Pollution Control Act (WPCA); Washington State Water Quality Standards for Surface Water	State – WPCA – Water Pollution Control (RCW 90.48); WPCA Water Quality Standards for Surface Waters (WAC 173-201A)	Narrative and quantitative limitations for surface water protection are provided in these regulations. Criteria are established for each water classification, including fecal coliform, total dissolved gas, total dissolved oxygen, temperature, pH, and turbidity. During sediment remediation, discharges to marine surface waters will comply with these requirements.	Protectiveness is not affected.	No active sediment remediation is occurring. Only visual monitoring of the cap and the previous dredged channel is occurring.	03/25/2020
Washington State Sediment Management Standards	State – Sediment Management Standards (RCW 43.21C, 70.105D, 90.48, 90.52, 90.54, 90.70; WAC 173-204)	Numerical and narrative criteria for chemicals and biological effects are specified for sediment and are applicable to Harbor Island shipyard sediments.	WAC 173-204 (Sediment Management Standards or SMS) was revised in 2013. The marine sediment cleanup objective (SCO) benthic protection values under the 2013 SMS are the same as the 1991 SQS values used in developing the LSS-OU7 cleanup levels for protection of benthic invertebrates. The requirements for protection of human health and higher trophic-level species are consistent with MTCA, which was promulgated in 1990, prior to the date of the LSS-OU7 ROD.	No active sediment remediation is occurring. Only visual monitoring of the cap and the previous dredged channel is occurring.	February 2013

Appendix D: Data Review

Table 17. S&G-OU1, Summary of Sampling from 2015 to 2019

Well	Location	Available Cyanide (ug/L)		Benzene (ug/L)		Tetrachloroethene (ug/L)		bis(2-Ethylhexyl)phthalate (ug/L)		Arsenic (ug/L)		Cadmium (ug/L)		Copper (ug/L)		Lead (ug/L)		Mercury (ng/L)		Nickel (ug/L)		Silver (ug/L)		Thallium (ug/L)		Zinc (ug/L)	
CUL		1		71		8.8		2.2[a]		36		8		2.9		2.8		25		7.9		1.2		6.3		76.6	
		exc/sample	max	exc/sample	max	exc/sample	max	exc/sample	max	exc/sample	max	exc/sample	max	exc/sample	max	exc/sample	max	exc/sample	max	exc/sample	max	exc/sample	max	exc/sample	max	exc/sample	max
AC-06A	early warning	0/2	-	0/1	-	0/1	-	-	-	0/2	0.13	0/2	0.048	0/2	-	1/2	*2.83*	0/2	<1	0/2	0.59	0/2	-	0/2	-	0/2	2.7
HI-1	compliance	0/5	-	0/1	-	0/1	-	0/1	-	0/2	0.4	0/2	0.03	0/5	0.48	1/5	*4.25*	0/2	<1	0/2	0.47	0/2	-	0/2	0.038	0/5	2.7
HI-2	compliance	0/5	-	0/1	-	0/1	-	0/1	-	0/2	0.16	0/2	0.009	0/5	0.27	0/5	*1.72*	0/2	<1	0/2	0.12	0/2	<0.02	0/2	-	0/5	1.17
HI-3	compliance	0/5	-	0/1	-	0/1	-	0/1	-	0/2	0.21	0/2	0.438	0/6	1.93	0/5	1.57	0/2	<1	0/2	0.23	0/2	<0.02	0/2	0.028	0/5	26.1
HI-4	compliance	1/5	7.6	0/1	-	0/1	-	0/1	-	0/2	0.1	0/2	0.243	0/7	0.56	0/5	0.428	0/2	<1	0/2	0.47	0/2	-	0/2	0.071	0/5	6.6
HI-5	compliance	1/5	*1.3*	0/1	-	0/1	-	0/1	-	0/2	0.32	0/2	-	0/5	-	0/5	0.67	0/2	<1	0/2	0.49	0/2	-	0/2	-	0/5	3.5
HI-6A	compliance	2/5	*0.68*	0/1	-	0/1	-	0/1	-	0/2	0.16	0/2	0.008	0/6	0.39	0/5	0.166	0/2	<1	0/2	0.1	0/2	-	0/2	-	0/5	1.03
HI-7	boundary	1/2	2.3	0/1	-	0/1	0.52	-	-	0/2	2.77	0/2	*0.447*	1/2	*3.19*	0/2	-	0/2	8.74	0/2	1.44	0/2	-	0/2	<0.02	0/2	15.7
HI-8	boundary	0/2	-	0/1	-	0/1	-	-	-	0/2	0.6	0/2	0.065	0/2	-	0/2	*0.667*	0/2	<1	0/2	1.53	0/2	-	0/2	0.046	0/2	<2
HI-9A	compliance	1/5	*12*	0/1	-	0/1	-	0/1	-	0/2	0.17	0/2	-	0/6	-	0/5	1.18	0/2	<1	0/2	0.24	0/2	-	0/2	0.026	0/5	3.4
HI-10	compliance	2/5	0.79	0/1	-	0/1	-	-	-	0/2	0.39	0/2	0.032	0/5	1.51	0/5	0.549	0/2	0.67	0/2	2.83	0/2	<0.02	0/2	0.041	0/5	5.3
HI-11	compliance	0/5	-	0/1	-	0/1	-	0/1	-	0/2	0.4	0/2	0.024	0/5	0.7	0/5	*0.382*	0/2	-	0/2	2.08	0/2	-	0/2	-	0/5	1.61
HI-12	compliance	1/5	2.7	0/1	-	0/1	-	-	-	0/2	0.67	0/2	0.291	3/5	*16.4*	0/5	*0.101*	0/2	5.2	0/2	6.21	0/2	0.049	0/2	0.035	1/5	*104*
HI-13	early warning	2/2	*3.6*	0/1	-	0/1	-	-	-	0/2	0.5	0/2	-	0/2	-	0/2	*0.644*	0/2	<1	0/2	0.73	0/2	-	0/2	-	0/2	1
HI-14	early warning	0/2	-	0/1	-	0/1	-	-	-	0/2	0.06	0/2	0.157	0/2	-	0/2	0.021	0/2	1.04	0/2	0.35	0/2	<0.02	0/2	-	0/2	<2
HI-15	early warning	0/2	-	0/1	-	0/1	-	-	-	0/2	0.4	0/2	0.032	0/2	-	0/2	0.208	0/2	<1	0/2	0.9	0/2	-	0/2	-	0/2	*1.9*
HI-16	compliance	1/5	3.3	0/1	-	0/1	-	0/1	-	0/2	0.4	0/2	0.048	0/5	0.46	0/5	*0.899*	0/2	<1	0/2	2.26	0/2	-	0/2	-	0/5	4.2
HI-17	interior	0/2	-	0/1	-	0/1	-	-	-	2/2	*225*	*2/2*	*1090*	*3/3*	*1110*	*2/2*	*178*	0/2	3.74	*2/2*	*782*	0/2	-	0/2	0.255	*2/2*	*4270*
HI-18	interior	1/5	*13*	0/1	-	0/1	-	-	-	0/2	2.8	0/2	0.109	0/5	0.65	0/5	*0.912*	0/2	<1	1/2	34.6	0/2	-	0/2	-	0/5	2.5
MW-01	compliance	1/1	-	-	-	-	-	-	-	0/1	-	0/1	-	0/1	-	0/1	-	0/1	0.64	0/1	0.98	0/1	-	0/1	-	0/1	2.1
MW-213	compliance	1/5	1.9	0/1	-	0/1	-	0/1	-	0/2	0.07	0/2	0.09	1/5	*3.64*	0/5	*0.747*	0/2	*1.04*	0/2	0.31	0/2	-	0/2	-	0/5	*12.4*
TD-06A	compliance	0/3	*0.56*	0/3	0.062	0/1	-	0/1	-	0/1	-	0/1	-	0/3	0.5	0/3	0.192	0/1	-	0/1	0.2	0/1	-	0/1	-	0/3	4.3

[a] Based on NRWQC Human Health consumption of organism

highlighted indicates exceendence of the CUL

exc/samples=number of CUL exceedances/number of samples in previous five years

Appendix E: Copy of Public Notice

EPA United States Environmental Protection Agency

EPA to Review Cleanups at Harbor Island Superfund Site

The U.S. Environmental Protection Agency is conducting the fifth five-year review of the environmental cleanups at the Harbor Island Superfund Site. Harbor Island is a 420-acre man-made island and industrial area located in the Duwamish River delta adjacent to Elliott Bay in Seattle. Cleanups completed on Harbor Island were focused on lead, other metals, petroleum and industrial contaminants throughout the island and in adjacent waters . The result is a complex cleanup site which includes several distinct project areas and objectives.

The areas being reviewed include:

- **Lockheed Uplands, Soils and Groundwater**
- **Lockheed Shipyard Sediments and Todd Shipyard (Vigor) Sediments and the West Waterway**
- **Tank Farms (Petroleum) – managed by the Washington Department of Ecology**

EPA reviews Harbor Island every five years to make sure the cleanup continues to be protective of people and the environment. After the review, EPA will prepare a report for each of the project areas to explain the results, these reports will be completed by September 2020.

As someone familiar with the site, you may have information that can help our review team. If you have information you would like us to consider during our review, please contact Ravi Sanga, EPA Project Manager at 206-553-4092 or Sanga.Ravi@epa.gov or Julie Congdon, EPA Community Involvement Coordinator, at 206-553-2752 or congdon.julie@epa.gov no later than August 31, 2020.

For more information or to review site documents, visit the Harbor Island web page at: https://www.epa.gov/superfund/harbor-island. Documents can also be reviewed at the EPA Superfund Records Center, 1200 Sixth Avenue, Seattle, WA 98101. (*Please call for an appointment, toll-free: 1-800-424-4372 ext. 4494)*

TDD and/or TTY users may call the Federal Relay Service at 1-800-877-8339.
Then please give the operator Julie Congdon's telephone number: 206-553-2752.