Record of Decision

Quendall Terminals Superfund Site
Operable Units 1 and 2
Renton, Washington

United States Environmental Protection Agency

U.S. Environmental Protection Agency
Region 10

July 2020

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Part 1—Declaration
Part 2—Decision Summary

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PART 1

Declaration

Site Name and Location

Site Name: Quendall Terminals Superfund Site

Location: Renton, King County, Washington

Latitude: 47.531814 North **Longitude:** -122.199556 West

U.S. Environmental Protection Agency Identification Number: WAD 980639215

Statement of Basis and Purpose

This Record of Decision (ROD) presents the Selected Remedy for Operable Unit 1 (OU1) and Operable Unit 2 (OU2) of the Quendall Terminals Superfund Site (the Site) in Renton, King County, Washington. The Selected Remedy was chosen in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), commonly known as Superfund, *United States Code* Title 42, Section 9601 et seq., as amended by the Superfund Amendments and Reauthorization Act of 1986, and to the extent practicable, the National Oil and Hazardous Substances Pollution Contingency Plan, *Code of Federal Regulations*, Title 40, Part 00, as amended. This decision is based on the Administrative Record for the Site.

The State of Washington, acting through the Washington State Department of Ecology, concurs with the Selected Remedy.

Assessment of the Site

The response actions selected in this ROD are necessary to protect public health or welfare or the environment from actual or threatened releases of hazardous substances into the environment and pollutants or contaminants that may present an imminent and substantial endangerment to the public health or welfare.

Description of the Selected Remedy

The Selected Remedy is the final action for both the upland part of the Site (OU1) and the offshore part of the Site (OU2). It addresses unacceptable human health risks associated with exposure to contaminated soil, groundwater, and sediment, and consumption of resident fish and shellfish. It also addresses ecological risks to terrestrial and aquatic plants, invertebrates, and wildlife.

Based on consideration of CERCLA requirements, the detailed analysis of remedial alternatives, and public comments, EPA selected in situ smoldering combustion and/or in situ solidification (ISS) of dense nonaqueous phase liquid (DNAPL), and soil capping, as the remedy for OU1. EPA selected DNAPL removal, engineered sand cap, and enhanced natural recovery, as the remedy for OU2.

The Selected Remedy to address contamination in OU1 will consist of the following components:

- In situ smoldering combustion treatment of DNAPL to destroy source material causing contamination in both the shallow and deep aquifers (estimated at 2.3 acres, treating 17,000 cubic yards [CY] of DNAPL-impacted soil).
- ISS treatment of DNAPL to stabilize remaining source material outside treatment sectors identified for in situ smoldering combustion (estimated at 6.7 acres, treating 13,500 CY of DNAPL-impacted soil).

- A pretreatment high-resolution site characterization study (HRCS) will be conducted to refine the conceptual site model (CSM) specific to DNAPL distribution and characteristics to support optimization and definition of remedial treatment sectors.
- A soil cap, 3 feet thick, where contaminants of concern (COCs) exceed cleanup levels in the top 15 feet of soil, with institutional controls to restrict subsurface direct contact.
- Other institutional controls and monitoring to help ensure the integrity of engineering controls and the effectiveness of the remedy.

The actual locations for smoldering combustion versus ISS are expected to be refined and modified and will be based on pretreatment characterization contaminant concentrations as determined during remedial design and remedy implementation. Remedial action implementation will include ongoing evaluation of the technology performance and optimization of the implementation approach.

No active groundwater treatment is included in the OU1 Selected Remedy because treatment of the DNAPL source is expected to immediately and substantially reduce contaminant loading and concentrations and allow achieving cleanup levels in groundwater in a reasonable timeframe (25 to 30 years). Groundwater will be monitored to verify that the remedy is performing as intended (concentrations of COCs are decreasing over time and are estimated to reach cleanup levels within the estimated timeframe).

The Selected Remedy to address contamination in OU2 will consist of the following components:

- Dredging of contaminated sediments in the offshore DNAPL areas to address shallow DNAPL in lake sediments (3.3 acres, approximately 15,200 CY) with placement of a reactive cover to manage residuals, if necessary.
- Dredging of contaminated sediments in the DNAPL areas close to the shoreline to address deep DNAPL in lake sediments along the shoreline (3.1 acres, approximately 41,200 CY), including temporary sheet pile, and placement of a reactive cover to manage residuals.
- Dredging of contaminated sediments in the areas close to the shoreline, outside of DNAPL areas to maintain bathymetry beneath the engineered sand cap (approximately 1,900 CY).
- Onsite dewatering of dredged sediment and shipment offsite for disposal.
- Engineered sand cap placement to address sediment outside DNAPL areas impacted by upwelling contaminated groundwater (5.5 acres, 1.5 feet thick).
- Enhanced natural recovery to remediate remaining areas within OU2 (17.6 acres, 6 inches thick).
- Institutional controls and monitoring to help ensure the integrity of engineering controls and the effectiveness of the remedy.

The Selected Remedy for OU1 is estimated to take 5 years to design and construct, after which time the upland part of the Site would be ready for anticipated reuse. The Selected Remedy for OU2 is estimated to take 4 years to design and construct.

The Selected Remedy includes short-term monitoring during construction and long-term monitoring of groundwater, caps, dredge areas, and enhanced sediment natural recovery areas after construction to evaluate long-term effectiveness and ensure the remedies function as designed.

Total estimated net present-value costs (discounted at 7 percent) for the Selected Remedy are $106,000,000. The total nondiscounted capital costs are $104,900,000, and periodic costs are $1,100,000.

Statutory Determinations

The Selected Remedy is protective of human health and the environment, complies with federal and state requirements that are applicable or relevant and appropriate to the remedial action, is cost effective, and uses permanent solutions and alternative treatment technologies to the maximum extent practicable.

The Selected Remedy will satisfy the statutory preference for treatment as a principal element of the remedy by treating DNAPL in soil using smoldering combustion and/or ISS, by treating dredged sediment to reduce contaminant mobility before transport and disposal in a landfill (if necessary), and by using reactive materials in dredged areas to manage residuals.

The Selected Remedy will result in hazardous substances, pollutants, or contaminants remaining onsite above levels that allow unlimited use and unrestricted exposure. Therefore, statutory reviews will be conducted every 5 years after the initiation of the remedial action to ensure the remedy continues to provide adequate protection of human health and the environment.

Data Certification Checklist

The following information is included in the Decision Summary (Part 2) of this ROD. Additional information can be found in the Administrative Record for the Site.

- COCs and their respective concentrations are in Section 5, "Site Characteristics."
- Baseline risks for human health and the environment represented by the COCs are in Section 7, "Summary of Site Risks."
- Cleanup levels established for COCs and the basis for these levels are in Section 8, "Remedial Action Objectives and Cleanup Levels."
- How source materials or highly toxic materials that are principal-threat wastes are addressed is in Section 11, "Principal-Threat Waste."
- Current and reasonably anticipated future land use assumptions used in the baseline risk assessment and the ROD are in Section 6, "Current and Potential Future Land and Water Use."
- Estimated capital, operations and maintenance, and total present-worth costs; discount rate; and number of years over which the remedy cost estimates are projected are in Section 12.5, "Summary of Estimated Remedy Costs."
- Key factors that led to the selection of the remedy (i.e., how the Selected Remedy provides the best balance of tradeoffs, with respect to the balancing and modifying criteria, highlighting criteria key to the decisions) are in Section 10, "Summary of Comparative Analysis of Alternatives" and Section 13, "Statutory Determinations."

Authorizing Signature:

7-17-2020

Andrew Wheeler, Administrator
U.S. Environmental Protection Agency

Date

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Acronyms and Abbreviations

AOC	Administrative Settlement Agreement and Order on Consent
ARAR	applicable or relevant and appropriate requirement
AWQC	Ambient Water Quality Criteria
bgs	below ground surface
BERA	baseline ecological risk assessment
BHHRA	baseline human health risk assessment
BMP	best management practice
BTV	background threshold value
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (commonly known as Superfund)
CFR	*Code of Federal Regulations*
COC	contaminant of concern
COPC	contaminant of potential concern
cPAH	carcinogenic polycyclic aromatic hydrocarbon
CSM	conceptual site model
CWA	Clean Water Act
CY	cubic yard(s)
DNAPL	dense nonaqueous phase liquid
Ecology	Washington State Department of Ecology
Eco-SSL	ecological soil screening levels
ELCR	excess lifetime cancer risk
ENR	enhanced natural recovery
EPA	U.S. Environmental Protection Agency
EPC	exposure point concentration
ESBQ	equilibrium partitioning sediment benchmark quotient
FS	feasibility study
HHRA	human health risk assessment
HI	hazard index
HQ	hazard quotient
HPAH	high-molecular-weight PAH
HRSC	high-resolution site characterization
IC	institutional control
IP	ignition point
ISS	in situ solidification
LOAEL	lowest observed adverse effects level
LPAH	low-molecular-weight PAH
MCL	maximum contaminant level
mg/kg	milligram(s) per kilogram
mg/kg-day	milligram(s) per kilogram per day
MTCA	Washington State Model Toxics Control Act

NAPL	nonaqueous phase liquid
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NOAEL	no observed adverse effects level
O&M	operations and maintenance
OU	operable unit
OU1	Operable Unit 1
OU2	Operable Unit 2
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
PCP	pentachlorophenol
ppm	part(s) per million
Proposed Plans	*Quendall Terminals Superfund Site, Operable Unit 1 Proposed Plan* (EPA 2019a) and *Quendall Terminals Superfund Site, Operable Unit 2 Proposed Plan)* (EPA 2019b)
PRP	potentially responsible person
PTW	principal-threat waste
QP-S	Quendall Pond Sediment
Quendall Site	Quendall Terminals Superfund Site
RAO	remedial action objective
RCM	reactive core mat
RCRA	Resource Conservation and Recovery Act
RfD	reference dose
RI	remedial investigation
RME	reasonable maximum exposure
ROD	Record of Decision
SF	slope factor
Site	Quendall Terminals Superfund Site
SMS	Washington State Sediment Management Standard
STAR	Self-sustaining Treatment for Active Remediation
TDI	total daily intake
TPH	total petroleum hydrocarbon
TRV	toxicity reference value
UCL	upper confidence limit
WAC	Washington Administrative Code

PART 2

Decision Summary

The Decision Summary provides an overview of the contamination present at the Quendall Terminals Superfund Site (the Site or Quendall Site), the associated risks to human health and the environment, the cleanup alternatives considered, and the U.S. Environmental Protection Agency's (EPA's) Selected Remedy to address these risks. This Decision Summary also explains how the Selected Remedy fulfills statutory and regulatory requirements.

1 Site Name, Location, and Brief Description

The Quendall Site is located at 4503 Lake Washington Boulevard North on the southeastern shore of Lake Washington, near the northernmost limits of the City of Renton, Washington, as shown on Figure 1-1. The Site was listed on the National Priorities List on April 19, 2006, due to concerns about contamination resulting from historical creosote-manufacturing processes and associated activities.

The EPA Identification Number for the Site is WAD 980639215. The Site comprises approximately 22 acres of upland shorefront property (Operable Unit 1 [OU1]) and approximately 29 acres of contaminated lake sediment (Operable Unit 2 [OU2]). OU1 and OU2 are shown on Figure 1-2.

Contaminant releases at the Site are primarily related to historical creosote-manufacturing processes and associated activities. The human health and ecological risk assessments concluded that contamination within the Site poses unacceptable risk to human health and the environment due primarily to the presence of contaminants associated with coal-tar and creosote, including carcinogenic polycyclic aromatic hydrocarbons (cPAHs), naphthalene, and benzene.

EPA is the lead agency at the Quendall Site, and the Washington State Department of Ecology (Ecology) is the supporting agency. The Site is located within the usual and accustomed fishing grounds used by the Muckleshoot Tribe, and the Muckleshoot Tribe has been invited to consult.

In 2006, an Administrative Settlement Agreement and Order on Consent (AOC) to Conduct a Remedial Investigation (RI) and Feasibility Study (FS) was signed by EPA and the Quendall Terminals owners (Altino Properties and J.H. Baxter & Company). EPA conducted an extensive search for potentially responsible persons (PRPs) and, to date, has identified four parties as potentially responsible for releases of hazardous substances at the Site. Funding for the RI/FS was provided by the PRPs listed in the 2006 AOC. EPA intends to seek PRP funding for the cleanup activities.

2 Site History and Enforcement Actions

This section provides background information on past activities that have led to the current contamination at the Site, and federal and state investigations and enforcement actions conducted to date under CERCLA, commonly known as Superfund, and other authorities.

2.1 History of Site Operations

Creosote manufacturing was conducted at the Site from 1916 through 1969. Coal and oil-gas tar residues (collectively referred to as coal tars) were distilled into three fractions that were shipped offsite for a variety of uses or transported to the neighboring J.H. Baxter & Co. site for use in wood-treating operations. The light distillate fraction was typically used as a feedstock in chemical manufacturing. The middle distillate fraction, creosote, was a thick, oily liquid used in the wood-preserving industry. The bottom fraction, or "pitch," was used for applications such as roofing tar (Hart Crowser 1994 as referenced in Aspect and Arcadis 2016). At Site locations where product transport, production, storage, and/or disposal were performed, coal tars and distillate products were released to the environment.

Releases of coal tars and distillate products occurred in five upland areas as follows (see Figure 2-1 for Site features referenced below, and Figure 2-2 for a general timeline):

- Coal tar was distilled, and creosote and light distillates were transferred to surrounding tanks via piping near the former Still House. A pipeline was present between the tanks west of the former Still House and the property to the north of the Site (formerly occupied by J. H. Baxter & Co., which operated a wood-treatment plant at that location from 1955 until 1982). This pipeline was used to transport creosote for wood-treatment processes. Reported releases include product spills and leaks directly onto the earthen floor of the Still House (CH2M 1983 and Ecology 1989 as referenced in Aspect and Arcadis 2016).
- Historical spills appeared to have occurred at the former railroad tank car loading area southeast of the Still House, based on the amount of dense nonaqueous phase liquid (DNAPL) in the area. The loading area was situated on a trestle built over May Creek. A solid material-loading platform was located farther north along the tracks.
- Wastes from historical operations were released into the former May Creek Channel, located south of the former Still House and storage tanks. Wastes from nearby tanks were reportedly placed in the eastern portion of the former channel, and the western portion of the channel reportedly received creosote wastes discharged from the former Still House sewer outfall. Wastes from the former May Creek Channel area have migrated into adjacent Lake Washington.
- The former Still House cooling lines released influent into the north and south sumps; this effluent sometimes contained creosote and tars. Shortly after the plant shut down, approximately 50 truckloads of material were excavated from the north sump and disposed of at the Coal Creek Landfill. The south sump was reportedly filled in before 1950 (Hart Crowser 1994, as referenced in Aspect and Arcadis 2016). There were no reports that any materials were removed from the south sump before it was filled in.
- Quendall Pond, located near the shoreline, was constructed in 1972 as an area where tank bottoms from nearby storage tanks were placed. This area also received wastes from north sump overflows. Wastes from the Quendall Pond area have migrated into adjacent Lake Washington through the subsurface and possibly by overland surface water flow.

Some solid wastes were also disposed of at the Site. Heavy tar produced by the distillation process was cooled and solidified in pitch bays located north of the Still House. The waste pitch, also called Saturday coke, was chiseled out and reportedly placed near the Site shoreline (CH2M HILL 1983, as referenced in Aspect and Arcadis 2016). Solid tar products have also been observed in shallow soils around the northern railroad loading area, where solid products were loaded onto railcars.

After the creosote plant was closed in 1969, all structures, except for six aboveground storage tanks and the office, were demolished. Petroleum was stored at the Quendall Site using the remaining tanks for approximately 13 years—from 1969 to 1982. While spills of petroleum product were reported around the aboveground storage tanks, light nonaqueous phase liquid has not been detected at the Site.

2.2 Previous Investigations

Numerous investigations have been conducted at the Quendall Site beginning in 1963. Characterization data collected through 2004 were compiled and incorporated in an earlier RI/FS process overseen by Ecology under the Washington State Model Toxics Control Act (MTCA) and its implementing regulations (Chapter 173-340 Washington Administrative Code [WAC]; Chapter 70.105D Revised Code of Washington). These earlier investigations revealed that polycyclic aromatic hydrocarbons (PAHs) and other organic chemicals such as benzene detected at the Quendall Site are present at concentrations that would likely trigger cleanup actions under MTCA.

As part of EPA's RI/FS process, documents containing Site characterization data were reviewed, and more than 30 associated data sets were obtained and assessed. Data of sufficient quality were used to develop a preliminary conceptual site model (CSM) and identify data gaps. Data gaps were addressed during a field investigation conducted in 2008 and 2009 and led to the completion of the RI report under EPA direction in 2012 (Anchor QEA and Aspect 2012).

No remedial actions have taken place to date.

2.3 History of Enforcement Actions

In 1993, Ecology negotiated an Agreed Order with Quendall Terminals. Under the Agreed Order, amended in 1997, Quendall Terminals was to:

- Complete an RI to characterize the Site and define the extent of contamination.
- Complete a baseline risk assessment to characterize potential health threats to humans and the environment.
- Complete an FS to develop and evaluate cleanup options.

A schedule for completion of this work was developed as part of the Agreed Order, and the initial RI was completed in 1997.

The Agreed Order schedule was amended in 1998 when the City of Renton and Port Quendall Company, a Vulcan Inc. affiliate, expressed interest in purchasing the Quendall Terminals Property. Before the Agreed Order was amended, Ecology held a 30-day comment period from September 30 through October 29, 2002. The City of Renton and Port Quendall Company declined on their purchase and redevelopment option for the Site, and in 2004, Ecology continued negotiations with Quendall Terminals to complete the risk assessment and FS, pursuant to the Agreed Order. In accordance with the order, Quendall Terminals submitted a draft risk assessment and FS to Ecology. These documents were not finalized under Ecology's oversight.

In May 2005, Ecology requested that EPA take the lead for overseeing the cleanup at the Site. The Site was listed on the National Priorities List on April 19, 2006, and the resulting AOC between EPA, Quendall Terminals, Altino Properties, and J.H. Baxter & Co. was finalized pursuant to CERCLA.

In addition to the enforcement actions described above, EPA conducted activities to identify additional PRPs who may have contributed to contamination at the Quendall Site. Information request letters were sent to seven unrelated parties from 2008 to 2016. General notice letters were sent to six unrelated parties during this same period. The general notice letters provided notification of the recipients' opportunity to comment on the *Quendall Terminals Superfund Site, Operable Unit 1 Proposed Plan* (EPA 2019a) and *Quendall Terminals Superfund Site, Operable Unit 2 Proposed Plan)* (EPA 2019b) (Proposed Plans).

3 Tribal Participation and Community Engagement

3.1 Offer of Government-to-Government Consultation to the Muckleshoot Tribe

The Muckleshoot Tribe is a successor in interest to tribes and bands that were parties to the Treaty of Point Elliott, 12 Stat. 927, and the Treaty of Medicine Creek, 10 Stat. 1132. Through these treaties, the Tribe has the right to take fish at its usual and accustomed fishing grounds and stations that include Lake Washington.

The Tribe was offered government-to-government consultations with EPA on the cleanup process and decisions. EPA provided the Tribe with the opportunity to review and comment on key documents related to development of the CSM and identification of data gaps, and development of the baseline risk assessment. The Tribe was also provided the opportunity to review the draft RI/FS reports before they were finalized. EPA will continue to engage with the Tribe throughout the decision-making process of response actions, including design, construction, and long-term monitoring.

3.2 Community Outreach and Engagement

EPA led a robust community involvement effort associated with the Proposed Plans. Before issuing the Proposed Plans, EPA produced a fact sheet to inform people about the Site and its status, and to alert them to the upcoming issuance of the Proposed Plans. In addition, EPA worked with the local community to learn about their questions, concerns, and perspectives on the Site. EPA fostered relationships with local people, including the head of a local neighborhood association and a community leader within the residential area next to the Site. EPA also made a presentation to the City Council and hosted a booth about the Site at a local fair. Informed by these efforts, EPA created a Community Involvement Plan to guide the agency as it moves forward with planning and decision-making. The plan lays out how EPA will provide information and engage with the local community over time. It also documents the agency's commitment to working in a positive way with residents and other stakeholders.

EPA provided the Proposed Plans to the public for review and comment on September 9, 2019. These, as well as other relevant Site documents, can be found in the Administrative Record. Copies of the Administrative Record are available to the public at the Renton Public Library, located at 100 Mill Avenue South, Renton, and on EPA's Superfund project website at: https://www.epa.gov/superfund/quendall-terminals.

Notice of the availability of the Proposed Plans and associated documents was published in the *Renton Reporter* and the *Bellevue Reporter* on September 13, 2019, and the *Mercer Island Reporter* on September 18, 2019, along with notice of a public meeting to be held on September 24, 2019.

Information about the Proposed Plan comment period and public meeting was sent by email to about 180 individuals who had signed up previously to receive project updates by email. The EPA webpage for Quendall Terminals featured relevant information and documents. A new fact sheet summarizing the Proposed Plan and announcing the public meeting was mailed to 107 individuals on the Site's mailing list. Flyers informing the community about the public meeting were posted at the libraries, City Hall, and the history museum. EPA also posted information several times on its social media platforms about the comment period and public meeting. Additionally, EPA issued a press release to local media outlets.

EPA hosted a public meeting at Stan Head Cultural Center at Aegis Gardens in Newcastle, Washington, on September 24, 2019. During the open house part of the meeting, EPA displayed posters, offered handouts, and answered questions about the proposed remedy approaches. The City of Renton also hosted a table and heard concerns and answered questions about reasonably anticipated future land use at the Site.

EPA accepted verbal and written comments at the public meeting. EPA's responses to comments received on the Proposed Plans during the public comment period, including those received during the public meeting, are contained in the Responsiveness Summary (Part 3), which is part of this ROD.

The original 30-day public comment period was to have ended on October 9, 2019. EPA granted a 30-day extension of the public comment period through November 8, 2019, in response to public request. Notice of the extension was emailed to the distribution list on October 4, 2019, posted to social media, published in the *Renton Reporter* and the *Bellevue Reporter* on October 11, 2019, and in the *Mercer Island Reporter* on October 9, 2019. Before the close of the comment period, EPA sent a reminder notification to the Site's email distribution list.

Prior to the Proposed Plans, EPA and Ecology coordinated throughout the development of the FS and held meetings with natural resource stakeholders (for example, the Washington Department of Natural Resource and the National Oceanic and Atmospheric Administration) to provide updates on Site findings. The complete *Feasibility Study, Quendall Terminals Site* (Aspect and Arcadis 2016) was made available to the public in December 2016.

4 Scope and Role of Response Action

As with many Superfund sites, the problems at the Quendall Site are complex. EPA split the Site into two OUs representing distinctly different geographic areas:

- OU1: Contamination of upland soil and groundwater
- OU2: Contamination of Lake Washington sediment

The two OUs will employ different but complementary cleanup strategies, and different factors will influence the timing of remedy implementation in each OU.

EPA's remedial strategy for OU1 addresses soils containing DNAPL and contaminated groundwater beneath the upland portion of the Site. Risks to future residents, occupational/office workers, and construction/excavation works exceed EPA's acceptable risk range and concentrations in groundwater are greater than the maximum contaminant levels (MCLs) for drinking water (as specified in the Safe Drinking Water Act). EPA's Selected Remedy for OU1 uses a combination of technologies, including in situ smoldering combustion and/or in situ solidification (ISS) of soil, plus capping in the uplands. Institutional controls (ICs) and monitoring will also be part of the Selected Remedy for OU1.

EPA's remedial strategy for OU2 cleanup addresses sediment in Lake Washington adjacent to the Site that contains DNAPL and other Site-related contaminants. Risks to current and future recreational beach users, recreational fish/shellfish consumers, and subsistence fish/shellfish consumers exceed EPA's acceptable risk range.[1] EPA's Selected Remedy for OU2 includes dredging and ex situ treatment of sediment, sediment capping, and enhanced natural recovery (ENR) in sediment. ICs and monitoring will also be part of the Selected Remedy for OU2.

Although the Selected Remedy does not employ active treatment of groundwater or surface water, EPA anticipates that taking action on creosote and coal-tar DNAPL in the upland soil and offshore sediment will reduce contaminant concentrations in all media, including groundwater and fish/shellfish tissue, to acceptable levels. Remedial action objectives (RAOs) will be met through reduction of contaminant concentrations in all media, thereby significantly reducing human health and ecological risks at the Site to acceptable levels. The Selected Remedy is intended to be the final response action for OU1 and OU2, and it addresses the principal threat at the Site through the treatment of DNAPL source material in OU1 and removal of DNAPL source material in OU2.

It is likely that the OU1 and OU2 response actions will be implemented concurrently, with OU1 beginning construction first. Implementation of the Selected Remedy and associated schedule is discussed in Section 12.4.

5 Site Characteristics

This section of the ROD summarizes information obtained during the RI and other investigations conducted after the RI/FS. More detailed information is included in the RI report (Anchor QEA and Aspect 2012).

5.1 Site Overview and Physical Characteristics

The Quendall Site covers an area of approximately 52 acres (Figure 1-2). The upland portion of the Site (OU1) encompasses approximately 22 acres of land adjacent to Lake Washington, and the offshore portion of the Site (OU2) encompasses approximately 29 acres in Lake Washington.

5.1.1 Geographical and Topographical Information

The Site is located within the Puget Sound Lowland on the southeast side of Lake Washington, in Renton, Washington. The Site is relatively flat with hills rising to the east beyond I-405. Upland elevations at the Site range

[1] Since risks to subsistence fish/shellfish consumers exceeded EPA's acceptable risk range, EPA and the Muckleshoot Tribe assume that if tribal consumption rates were identified and used in the human health risk assessment, that the risks would also be unacceptable.

from approximately 35 feet on the east side of the property to about 20 feet at the lakeshore (elevations reported in North American Vertical Datum 1988).

Much of what is now the upland portion of the Site was formerly the lakebed of Lake Washington before the lake was lowered 9 feet in 1916, which exposed the alluvial delta of May Creek. When the Site was first developed in the 1910s and 1920s, May Creek flowed across the southern portion of the Site.

Historical aerial photographs indicate that the creek was diverted south of the Site by 1936. It currently flows through the Barbee Mill neighborhood located immediately south of the Quendall Site.

Site topography has been modified over the past 90 years by filling and grading activities. Fill (silt, sand, and gravel, as well as wood debris, glass, brick, and pitch-like materials) is present at the ground surface and ranges from 1 foot to more than 10 feet thick. Several wetlands are present at the Site (Figure 5-1), many within 100 feet of the shoreline (defined as the “habitat area,” discussed in more detail in Section 9). Site drainage is relatively poor because of the flat topography and the fine-grained nature of the shallow soil.

5.1.2 Site Geology and Hydrology

Beneath the fill, a shallow alluvial layer (delta deposit) extends from the base of the fill to depths of between 30 and 50 feet below ground surface (bgs). The shallow alluvium was deposited as a series of gently dipping forest beds consisting of very soft peat and organic silts interbedded with very loose, silty, fine to medium sand. The depositional history, including repeated slumping, has resulted in discontinuous layers that generally slope downward toward the west and northwest. A more homogeneous alluvial layer consisting of coarser materials extends to depths of between 90 and 140 feet bgs. Near the top of the deeper alluvium, lower-permeability interbedded silt to silty sand layers are also present; these layers are most likely a transitional zone representing the continuation of the May Creek delta. Silty sand layers have been observed as deep as 83 feet bgs. Beneath the deeper alluvium, a layer of lacustrine clay at least 10 feet thick has been encountered at depths below 90 feet bgs.

Two aquifers are recognized at the Site: The shallow aquifer is present from approximately 30 to 50 feet bgs. The deep aquifer occurs to a depth of approximately 140 feet bgs. There is no continuous aquitard layer separating the shallow and deep aquifers; however, the deep aquifer is considered to be a semi-confined aquifer, as the vertical hydraulic interaction between the shallow and deep aquifers is limited by the horizontal stratification and low-permeability layers within the shallow alluvium, and varies depending on the location on the Site. Groundwater generally flows horizontally across the Site from east to west, ultimately discharging to Lake Washington. The presence of flowing conditions in the former plant water supply well (180 feet deep) indicates a confined aquifer below the deep aquifer, separated by a layer of lacustrine silt/clay (Hart Crowser 1994, as referenced in Anchor QEA and Aspect 2012).

5.1.3 Bathymetry and Sediment Characteristics

The primary bathymetric feature in the area close to the shoreline is the sand spit to the north of the former T-Dock (Figure 2-1). The lake bottom is relatively flat between the Site inner and outer harbor lines, with water depths at the outer harbor line ranging from 26 to 31 feet (as measured at the normal high-water line). The maximum water depth between the Site and Mercer Island is approximately 70 feet (Retec 1997, as referenced in Anchor QEA and Aspect 2012).

The lake bottom substrate is typically a fine silt/mud, although there are several areas with a sandier bottom, including a sand spit north of the former T-Dock and sediment near the outer harbor line south of the former T-Dock. Except for an area with wood debris along the southern shoreline, aquatic vegetation is dominated by dense areas of Eurasian water milfoil.

5.1.4 Surface and Subsurface Features

The Site is currently vacant, with only two remaining structures from historical operations. These include the former office building and a truck-loading scale (Figure 5-1).

In 2008, several stormwater best management practices (BMPs) were implemented at the Site to control runoff (Aspect 2008). Activities included installation of two shallow swales that directed stormwater away from Quendall Pond, installation and improvements of berms along the lake shore, and mulching and hydroseeding soil disturbed from former log yard operations.

5.1.5 Areas of Archaeological or Historical Importance

A cultural resource analysis conducted for the East Side Rail Corridor (King County Parks 2016) concluded that there are possible archaeological artifacts and areas of historical importance at the Site. Quendall is located in the Lakefront Segment of the East Side Rail Corridor. The analysis noted that remains of a former Native American village may exist in this vicinity, but no evidence of it has been identified (Bowden et al. 1997:17; Hilbert et al. 2001; cited in King County Parks 2016).

According to the East Side Rail Corridor analysis, the “Quendall Log Yard property” contains the remains of the Reilly Tar & Chemical Wharf and T-Dock (45-KI-1107; Kelly 2012; cited in King County Parks 2016). The other two archaeological sites near the Lakefront Segment are the remnants of a dry dock (45-KI-814), and a submerged aircraft, both in Lake Washington. None of the three sites have been evaluated for listing in the National Register of Historic Places.

The East Side Rail Corridor analysis concluded that based on the ethnographic record, Washington State’s Department of Archaeology and Historic Preservation Statewide Predictive Model, previous cultural resources surveys, and known precontact use, there remains a “High” to “Very High Risk” of encountering buried cultural resources along parts of the Lakefront Segment, likely due to its proximity to the shores of Lake Washington. Most of these artifacts are expected to be Native American protected objects.

If Native American cultural items or gravesites are identified during construction, an inventory of such items will be compiled, and items will be returned to the tribes. If removal of cairn, burial, human remains, funerary objects, or other sacred objects takes place, reinternment will occur under the supervision of the appropriate Indian tribe. Any proposed excavation by a professional archaeologist of a Native American cairn or burial will require written notification to the State Historic Preservation Officer (Archaeologist Cultural Resources 39015 172nd Avenue SE Auburn, WA 98092) and consultation with the appropriate Indian tribe.

5.2 Sampling Strategy

The Quendall Site was the subject of early environmental investigations in the 1960s and 1970s, with more comprehensive studies being conducted in the 1980s through early 2000s. In 2006, when the Site was added to the National Priorities List, EPA required review of the historical data to determine whether it usable for characterizing the nature and extent of contamination and estimating risk. EPA decided that for sampling events conducted before 1995, only the physical information was potentially suitable.

Historical soil sampling in the uplands was mostly biased in areas known or suspected to be contaminated. Groundwater monitoring wells were initially installed along the shoreline. Early sediment sampling was also focused along the former T-Dock, where spills were suspected, and in the areas close to the shoreline with contaminated upwelling groundwater.

The objectives of the 2008/2009 field RI of DNAPL contamination in both the upland and Lake Washington were to determine lateral and vertical boundaries of DNAPL occurrences, identify areas of DNAPL that may contribute most to groundwater contamination throughout the Site, characterize soil stratigraphy surrounding DNAPL occurrences, and estimate volumes of DNAPL. Additional monitoring wells were also installed during the RI. Data collected during the RI and historical data determined to be definitive were used collectively to identify known or suspected sources, and the nature and extent of contamination.

In summer of 2018, additional soil sampling was conducted during a pilot study to evaluate the smoldering combustion technology. These samples were used to evaluate small-scale variability in DNAPL architecture in two areas of the Site (former May Creek Channel and Quendall Pond area, discussed in the next section).

5.3 Known or Suspected Sources of Contamination

The primary product manufactured at the Quendall Site was creosote—a thick, oily liquid distilled from coal-tar feedstock. Most coal-tar and creosote present in the soil and groundwater is in the form of an oily DNAPL, which is present within the shallow alluvium (delta deposits) to depths up to approximately 30 feet bgs. Approximately 377,500 gallons of DNAPL are estimated to be present within OU1, and 67,500 gallons are estimated to be present in OU2. Figure 5-2 illustrates the approximate extent and thickness of DNAPL.

The majority of contamination at the Site, including DNAPL, is present within the shallow alluvium (delta deposit). Evidence from field observations suggests that interbedded, low-permeability layers in the shallow alluvium can stop, slow, or alter migration of DNAPL.

Creosote and coal-tar DNAPL has been observed in six general Site areas, including both upland and offshore areas (Figure 2-1 and Figure 5-2). Each of these six areas is correlated with historical releases of creosote and coal-tar products:

- In soils surrounding the former Railroad Tank Car Loading Areas, to depths of 33 feet bgs
- In soils beneath the former May Creek Channel, to depths of 32 feet bgs
- In soils near the former Still House, to depths of 16 feet bgs
- In soils beneath the former North Sump and the Quendall Pond area, to depths of 22 feet bgs
- In sediment within 100 feet offshore of the Quendall Pond area, to depths of 9 feet below the mudline
- In shallow near-surface sediments beneath the former T-Dock, at depths of less than 5 feet below the mudline

Based on the findings of the RI, DNAPL is estimated to be present within an estimated 8.0 acres of the Site uplands (of the 22-acre upland portion of the Site) and approximately 1.7 acres of sediment (of the 29-acre total Lake Washington portion of the Site).

5.4 Nature and Extent of Contamination

Chemicals associated with the DNAPL have affected soil, groundwater, sediment, and surface water and porewater at the Site. Creosote contains more than a hundred individual chemicals, including PAHs such as naphthalene and benzo(a)pyrene. Coal tars also contain PAHs and more volatile hydrocarbons such as benzene.

Benzene, naphthalene, cPAHs, and arsenic are the primary COCs at the Site. Benzene, benzo(a)pyrene, and arsenic are classified as a known human carcinogens, while naphthalene is classified as a possible human carcinogen.

The organic COCs (benzene, naphthalene, and cPAHs) originated from creosote and coal-tar releases. Arsenic is believed to have been released from natural soil deposits as the groundwater conditions changed in response to the presence of creosote and coal-tar, and due to naturally occurring organic delta deposits. Arsenic was also introduced to the surface soil through the use of sodium arsenate products for weed control over OU1 for many years (CH2M HILL 1983 and Hart Crowser 1994, as referenced in Aspect and Arcadis 2016). Arsenic in deeper groundwater may also be coming from the Barbee Mill property from the south. The Barbee Mill Site COCs include arsenic in soil and groundwater, and there is an ongoing groundwater monitoring and treatment program to address the plume.

5.4.1 Types of Contamination and Affected Media

Contaminant concentrations measured at the Site are summarized in Tables 5-1 through 5-5 for soil, groundwater, nearshore sediment, sitewide sediment, and surface water/porewater, respectively.

Benzene and naphthalene are relatively mobile, and Site data indicate they have migrated deeper (up to 110 feet bgs, impacting groundwater in the deeper alluvium) and further downgradient (i.e., towards

Lake Washington) from DNAPL source areas compared to the less mobile cPAHs. Groundwater transport of soluble coal-tar-product constituents from the upland portion of the Site has also contributed contaminants to sediment in inner harbor areas. The migration of contaminated groundwater from DNAPL source areas represents a secondary source of contamination to soil and sediment; therefore, the horizontal and vertical extent of contamination in groundwater is a good indicator of the extent of impacts to these other media.

If generated, remediation waste, including contaminated fill, sludge, or soil within the footprints of the north and south sumps (defined based on aerial photographs; see Figure 5-2), to the depth of the groundwater table, would be designated as K035-listed waste. Resource Conservation and Recovery Act (RCRA)-listed wastes are not expected to be encountered elsewhere on the Site; however, principal-threat waste (PTW) soil may be designated as a characteristic RCRA waste based on the presence of benzene or a state-only dangerous waste based on the presence of PAHs.

5.4.2 Location of Contamination and Known or Potential Routes of Migration

RI and historical boring and test pit data indicate that DNAPL impacts approximately 9.7 acres of the Site and is present as deep as 34 feet bgs; however, it is most typically observed below the water table in the upper 20 feet bgs. Approximately 445,000 gallons of DNAPL are estimated to be present at the Site. Figure 5-2 illustrates the estimated areal extent of Site DNAPL occurrences.

DNAPL in the shallow alluvium migrates vertically until it encounters low-permeability materials where it may move laterally or become trapped by other intersecting lower-permeability layers. As such, it is observed as numerous laterally discontinuous thin sand or silty sand layers separated by low-permeability silt or peat layers. As DNAPL migrates through soil, it leaves behind a residual coating of product on the soil grains (referred to as “residual DNAPL” or “oil-coated” soil), diminishing the available volume of mobile DNAPL. DNAPL mobility in sediment is affected by the same parameters as mobility in soil.

In groundwater and soil, the highest COC concentrations have been detected in the shallow aquifer, and at the top of the deep aquifer, within and downgradient of DNAPL. Below the upper portion of the deep aquifer, chemical concentrations are much lower. Dissolved contaminants enter the deep aquifer through the shallow aquifer in response to downward vertical gradients and dispersion (especially in the eastern portion of the Site). Once contaminants enter the deep aquifer, they continue to migrate to depth in the deep aquifer through the dispersion process, as documented by Site monitoring data and computer modeling results.[2]

The areal extent of groundwater contamination for COCs in the shallow and deep aquifers is illustrated on Figures 5-3 and 5-4, respectively. On Figure 5-4, the deep aquifer arsenic plume appears as though it may be coming from the property to the south; however, these exceedances may not be contiguous with the arsenic plumes in shallow groundwater on either the Quendall Terminals or the property to the south, and may be caused by localized reducing conditions associated with peat deposits in the vicinity of both wells. Figure 5-5 shows the estimated extent of groundwater contamination for indicator chemicals along a representative cross-section (parallel to groundwater flow in the center of the Site).

In sediment, the highest chemical concentrations have also been detected within and downgradient of DNAPL. Sediments near the shoreline are downgradient of contaminated groundwater that flows through upland DNAPL areas prior to discharging to Lake Washington. Surface sediment in areas to the north, south, and west of the T-Dock has been contaminated from historical T-Dock spills and pipeline leaks. The approximate extent of surface sediment contamination beyond the inner harbor groundwater discharge area that is attributable to historical spills along the T-Dock is represented by the area exceeding the cPAH background threshold value (BTV) of 17.5 milligrams per kilogram (mg/kg) normalized to organic carbon.[3] The derivation of the BTV is described in

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2 A three-dimensional numerical groundwater flow model using MODFLOW and contaminant fate and transport model using MT3DMS were developed in the RI (Anchor QEA and Aspect 2012) and refined in the FS (Aspect and Arcadis 2016).

3 Organic carbon normalization of surface sediment cPAH concentrations was performed to provide a measure of the potentially bioavailable concentration to evaluate potential human health risks resulting from consumption of aquatic organisms (Anchor QEA and Aspect 2012).

Section 8. As depicted on Figure 5-6, approximately 29 acres of sediments at the Site exceed the BTV, which defines the OU2 boundary (Figure 5-6).

5.5 Conceptual Site Model Overview

Figure 5-7 provides a graphical depiction of the CSM.

As discussed in previous sections, DNAPL originating as creosote and other coal-tar products is the primary source of contamination at the Site. Coal-tar products were released into the subsurface in the historical processing, storage, and offloading areas located in the upland portion of the Site. Releases of coal-tar also occurred offshore in Lake Washington along the T-Dock during product offloading operations, directly impacting sediments.

The DNAPL tends to occur within discrete layers or thin lenses in the shallow alluvium rather than in continuous pools. The movement of DNAPL in the subsurface is influenced by the prevailing east-to-west groundwater flow direction, but the deltaic nature of the shallow alluvium (i.e., sloping and interbedded silt, sand, and peat layers) also plays a significant role in how DNAPL migrates in the subsurface.

Contaminants in DNAPL migrate via a variety of transport mechanisms into other media at the Site, including soil, groundwater, sediment, and air. The migration of dissolved contaminants in groundwater is primarily controlled by the advective east-to-west groundwater flow and contaminant-specific mobility. Groundwater transport of soluble coal-tar-product constituents from the upland portion of the Site has also contributed contaminants to sediment in inner harbor areas. The migration of contaminated groundwater from DNAPL source areas represents a secondary source of contamination to soil and sediment; therefore, the horizontal and vertical extent of contamination in groundwater is an indicator of the extent of impacts to these other media. Contaminants present in the subsurface are transported via soil gas into the aboveground air. Contaminants present in DNAPL and soil in the unsaturated zone, and in groundwater at the top of the water table, can volatilize into soil gas but may be retarded by sorption onto soil, and contaminants may be also be affected by biodegradation.

Potential human and ecological exposure scenarios and associated estimated risks are discussed in Section 7, Summary of Site Risks.

6 Current and Potential Future Land and Water Use

6.1 Land Use

Currently, the upland portion of the Site (OU1) is vacant and unused. The Site is fenced, and access is restricted. This privately owned Site encompasses the upland portion (OU1) and the aquatic lands immediately offshore to the inner harbor line (property line). The submerged land beyond the inner harbor line is state-owned aquatic land that is managed by the Washington State Department of Natural Resources. The private and state-owned aquatic lands encompass OU2.

The Site and surrounding properties are zoned commercial/office/residential. To the east, the property is bordered by the Eastside Rail Corridor (former Burlington Northern Railroad right-of-way), which in turn is bordered on the east by Ripley Lane and Lake Washington Boulevard North. Adjacent to the south is the Barbee Mill community, consisting of residential townhomes. The Virginia Mason Athletic Center – Seahawks Headquarters property to the north has been developed for office and recreational field use. The adjacent properties to the north (Barbee Mill) and south (Virginia Mason Athletic Center) are both subjects of MTCA cleanup actions.

The Quendall Site is located on prime upland and shoreline property that is one of the last developable properties on Lake Washington in an urban area with high development pressures. The current owners will likely work with a third party to redevelop the Site for residential and commercial uses after the cleanup remedy has been implemented. Based on discussions with the City of Renton, there is currently a permitted development plan, including multifamily housing, retail space, restaurant space, and parking. DNAPL is present in soils throughout the upland area that is planned for development. In general, the DNAPL can be found within the top 20 feet of soil. Under the Selected Remedy, the DNAPL will be treated in place, and areas with residual soil contamination will be capped with 3 feet of soil.

The Site is located within the usual and accustomed fishing grounds used by the Muckleshoot Tribe. Recreational fishing also occurs offshore from the property. There are lake-wide fish advisories for certain species (northern pikeminnow, carp, yellow perch, and cutthroat trout). It is assumed that fishing as described will continue in the future.

6.2 Ground and Surface Water Use

Site facilities and all surrounding properties are served by City of Renton and Coal Creek Water District municipal water lines, which will continue to be used in the future. Coal Creek Water District is supplied with water from the City of Seattle system, which uses surface water from the Cedar River watershed. The City of Renton system is supplied by groundwater from wells located approximately 4 miles southeast of the Quendall Site, in downtown Renton. To protect its groundwater supply, the City of Renton has established an aquifer protection zone (Renton Municipal Code 4-3-050).

During preparation of the RI report (Anchor QEA and Aspect 2012), a search of well records and water-right certificates and permits was conducted to identify any possible water supply uses within a half-mile of the Site, from either a groundwater source or Lake Washington. The only wells identified within a half-mile are completed in aquifers upgradient of the Site and cannot be impacted by Site contamination. A search of the Water Rights Tracking System identified two certificates for Lake Washington and no groundwater certificates or permits. The certificates for Lake Washington designated uses include aquatic life use (core summer salmonid habitat); recreational use (extraordinary primary contact recreation); and water supply (domestic, agriculture, industrial, and stock water). Lake Washington has not been available for consumptive appropriation since 1979 when it was closed to further withdrawals under Chapter 173-508 of the WAC.

The surrounding community is serviced by public water systems, which have sources outside the Site area. The use of private wells in the area is limited, and those wells are located upgradient of the Site. In accordance with the King County Comprehensive Plan, individual private water supply wells will not be permitted within municipal water supply service area boundaries, which include the Quendall Site.

The dissolved-phase groundwater plume is located below much of the central portion of the property and is migrating in a northwesterly direction toward Lake Washington. It is estimated that COCs in groundwater will meet MCLs in 25 to 30 years, as a result of the remedy implementation (e.g., source reduction, dilution and dispersion). This estimate is based on Site groundwater data for benzene and cPAHs (COCs with MCLs) that indicate a close association of MCL exceedances with the occurrence of DNAPL. EPA also expects that when the DNAPL in soil is removed, arsenic will be addressed, as the presence of DNAPL in the subsurface allows arsenic to more readily leach from soil (at naturally occurring concentrations) into the groundwater, and is the primary reason that arsenic is above the MCL in groundwater at the Site. There is no MCL for naphthalene, the other primary COC in groundwater; however, EPA expects that when the DNAPL in soil is removed, the naphthalene plume will also dissipate within a reasonable timeframe (25 to 30 years).

7 Summary of Site Risks

As part of the 2012 RI/FS, baseline human health and ecological risk assessments (BHHRAs) were conducted to estimate the potential for current and future effects of contaminants in soil, groundwater, surface water, sediment, and fish tissue on human health and the environment. A baseline risk assessment is an analysis of the potential adverse human health and ecological risks from releases of hazardous substances from a site assuming the absence of any actions or controls to mitigate such releases, under current and future land and resource uses. The baseline risk assessments provide the basis for taking action and identifying the contaminants of potential concern (COPCs) and exposure pathways that the remedial action should address. The baseline risk assessments are included in the RI report (Anchor QEA and Aspect 2012). This section of the ROD summarizes the results of the baseline risk assessments.

7.1 Human Health Risks

The BHHRA estimated cancer risks and noncancer health hazards from exposures to a set of chemicals in soil, groundwater, surface water, sediments, and fish tissue[4] from samples collected at the Site.

A four-step process was used for assessing Site-related human health risks:

1. **Hazard identification** uses the analytical data collected to identify the COPCs at the Site for each medium based on such factors as toxicity, frequency of occurrence, fate and transport of the contaminants in the environment, concentration, mobility, persistence, and bioaccumulation.
2. **Exposure assessment** evaluates the different exposure pathways through which people might be exposed to contaminants based on media-specific contaminant concentrations, the frequency and duration of these exposures, and the pathways by which humans are potentially exposed (e.g., ingestion of, inhalation of, and dermal contact with, contaminants in soil or groundwater, dermal contact with contaminated sediment, and consumption of contaminated fish and shellfish).
3. **Toxicity assessment** determines the types of adverse health effects associated with chemical exposures and the relationship between magnitude of exposure (dose) and severity of adverse effects (response).
4. **Risk characterization** summarizes and combines outputs of the exposure and toxicity assessments to provide a quantitative assessment of Site-related cancer risks and noncancer hazards. The risk characterization also identifies contamination with concentrations that exceed acceptable levels, identified in the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) and EPA guidance as an excess lifetime cancer risk (ELCR) greater than 10^{-6} to 10^{-4} (1 in 1,000,000 to 1 in 10,000) or a noncancer hazard index (HI) greater than 1. Contaminants at these concentrations are considered COCs and are typically those that will require remediation at a site. This characterization includes a discussion of the uncertainties associated with these risks.

7.1.1 Hazard Identification

The BHHRA identified COPCs present in soil, groundwater, sediment, and surface water within the Site. Media-specific COPCs were selected for inclusion in the BHHRA by comparing Site analytical data to risk-based screening values. If the maximum detected concentration of a chemical exceeded its appropriate risk-based screening level or if a risk-based screening level was not available, the contaminant was selected as a COPC. The BHHRA estimated cumulative risks for all COPCs. Consistent with EPA risk assessment guidance (EPA 1989, 1991), the findings of the BHHRA were used to narrow the list of COPCs to a shorter of list COCs. COCs are those contaminants estimated to pose an unacceptable risk and, therefore, need to be addressed in the FS.

The data used in the BHHRA by medium are summarized as follows:

- **Soil:** Soil samples collected across the Site from the surface to depths of 15 feet bgs.
- **Groundwater:** Groundwater samples from the shallow and deep aquifers.
- **Inner Harbor Sediment:** Surface sediment from the upper 10 centimeters along the shoreline, extending to the inner harbor line, where groundwater from the Site discharges to Lake Washington.
- **Nearshore sediment:** Surface sediment from the upper 10 centimeters where water depths are 10 feet or less.
- **Sitewide Sediment:** Surface sediment from the upper 10 centimeters, encompassing the OU2 boundary.
- **Surface Water:** Surface water and porewater samples, encompassing the OU2 boundary.

[4] No tissue samples were collected. Contaminant concentrations in fish and shellfish were modeled using sediment concentrations.

The COCs identified for both human and ecological receptors are summarized in Tables 5-1 (soil), 5-2 (groundwater), 5-3 (inner harbor sediment), 5-4 (sitewide sediment), and 5-5 (surface water/porewater).

7.1.2 Exposure Assessment

Consistent with EPA risk assessment guidance (EPA 1989, 1991), the BHHRA serves as a baseline and assumes no remediation or ICs to mitigate or remove hazardous substance releases. Cancer risks and noncancer HIs were calculated based on estimates of reasonable maximum exposure (RME) to describe the magnitude and range of exposures that might be incurred by receptor groups under current and future conditions at the Site. The RME is defined as the highest exposure that is reasonably expected to occur at a site. Risk decisions are based on the RME, consistent with the NCP.

Conceptual Site Model

The CSM describes potential contaminant sources, transport mechanisms, potentially exposed populations, exposure pathways, and routes of exposure. Figure 7-1 shows the CSM.

Identification of Potentially Exposed Populations

Based on the present understanding of current and anticipated future land uses and beneficial water uses at and near the Site, the most plausible exposure scenarios considered for characterizing human health risks include the following:

- **Future Residential Exposure Scenario.** This scenario is based on potential redevelopment of the Site for residential purposes and future Site use by adults and children. The potential routes of exposure to contaminants in soil (to a depth of 15 feet bgs) and groundwater include incidental ingestion, dermal contact, and inhalation of fugitive dusts and vapors. Inhalation of vapors migrating from groundwater into future residential buildings is also possible in the absence of vapor controls.
- **Future Occupational Worker Exposure Scenario.** Adult workers could potentially be exposed to chemicals in soil (from 0 to 15 feet bgs) by incidental ingestion, dermal contact, and inhalation of ambient dust and vapors. Vapor intrusion into future nonresidential buildings and exposure to groundwater by occupational workers are also possible; however, these pathways are addressed under the more health-conservative residential exposure scenario.
- **Future Construction/Excavation Worker Exposure Scenario.** Adult construction/excavation workers could potentially be exposed to chemicals in soil (from 0 to 15 feet bgs) by incidental soil ingestion, dermal contact with soil, and inhalation of ambient dusts and vapors generated during excavation activities. Potential routes of exposure to shallow groundwater for the construction/excavation worker include dermal contact and inhalation of ambient vapors generated during excavation activities.
- **Current and Future Recreational Beach User Exposure Scenario.** The recreational beach user scenario addresses individuals engaged in recreation at the shoreline, gaining access either from the upland or via a boat. Potential routes of exposure to nearshore surface sediment (0 to 4 inches below mudline) and surface water include incidental ingestion and dermal contact.
- **Current and Future Recreational Fishing Exposure Scenario.** The recreational fishing exposure scenario addresses adult recreational anglers gaining Site access by boat or land and harvesting fish or shellfish for personal consumption using hook and line, traps, digging, or other methods. Potential exposure routes include ingestion of contaminants that may bioaccumulate in fish/shellfish tissue, and incidental ingestion of and dermal contact with sediment during angling activities.
- **Current and Future Subsistence Fishing Exposure Scenario.** Lake Washington is a usual and accustomed fishing ground for the Muckleshoot Tribe. Potential exposure routes under this scenario include ingestion of contaminants that may bioaccumulate in fish/shellfish tissue and incidental ingestion of and dermal contact with sediment during angling activities.

Exposures and Exposure Point Concentrations

Exposure point concentrations (EPCs) were calculated to represent the average concentration contacted over the duration of the exposure. Exposures were evaluated on a sitewide basis. Consistent with EPA guidance, the 95 percent upper confidence limit (UCL) on the mean was used to represent the average concentration.

UCLs were calculated for each analyte using concentrations directly measured in soil, groundwater, sediment, and surface water. EPCs in ambient and indoor air were estimated from soil and/or groundwater concentrations, and fish and shellfish tissue EPCs were estimated from surface sediment concentrations using the modeling approaches described in RI report Section 7.1.4.3 (Anchor QEA and Aspect 2012).

EPCs were calculated for each exposure medium as follows:

- EPCs in soil were calculated using detected concentrations in soil (from 0 to 15 feet bgs) at the Site.
- Groundwater EPCs for the residential exposure scenario were identified on a well-specific basis (i.e., maximum detected concentrations from the RI field data set at each well-point were used) rather than aggregating data spatially. Groundwater EPCs for the construction/excavation worker exposure scenario were the maximum detected sitewide concentrations from the RI data set.
- Indoor air EPCs for evaluation of residential vapor intrusion were calculated by adjusting the well-specific groundwater EPCs for volatile organic compounds using a groundwater-to-indoor-air attenuation factor of 0.001 (see RI Section 7.1.4.3.8). Trench vapor EPCs for the construction/excavation worker exposure scenario and EPCs for inhalation of vapors while showering or performing other activities for the residential scenario were estimated from the maximum detected sitewide volatile organic compound concentrations from the RI field investigation data set using a generic volatilization factor (see RI Sections 7.1.4.3.6 and 7.1.4.3.7).
- Sediment EPCs for the recreational beach user exposure scenario were 95 percent UCLs calculated using detected concentrations in nearshore sediment (from 0 to 4 inches or 0 to 10 centimeters bgs). Sediment EPCs for the recreational and subsistence fishing exposure scenarios were 95 percent UCLs calculated using detected concentrations in both nearshore and offshore sediment (from 0 to 4 inches bgs).
- Surface water EPCs for the recreational beach user exposure scenario were conservatively assumed to be maximum detected concentrations in surface water at the Site.
- Fish tissue EPCs for the recreational and subsistence fishing exposure scenarios were calculated by adjusting the sitewide sediment concentrations by a biota-sediment accumulation factor (BSAF). Tissue EPCs were calculated for each of three organism groups (mollusks, crustaceans, and bottom-feeding fish) using the 95 percent UCL of the organic-carbon-normalized Site surface sediment data, the BSAF, and the geometric mean of freshwater lipid data as reported for the BSAF data, further described in RI Section 7.1.4.3.9. The average of the mollusk, crustacean, and bottom-feeding fish EPCs was used as the EPC for the risk assessment. The same approach was used for calculating EPCs based on background surface sediment concentrations.

Appendix 2A contains the EPCs for soil, groundwater, sediment, and surface water (RI Table 7.1-3), as well as EPCs for fish and shellfish tissue (RI Table 7.1-4).

Consistent with EPA guidance (EPA 1989), the maximum detected concentration is used as the EPC when the calculated 95 percent UCL is greater than the maximum detected value.

Estimation of Chemical Intakes

The amount of each chemical incorporated into the body is defined as the dose and is expressed in units of milligrams per kilogram per day (mg/kg-day). The dose is calculated differently when evaluating carcinogenic effects than when evaluating noncarcinogenic effects.

Each is described as follows:

- **Noncarcinogens:** The dose is averaged over the estimated exposure period. This is done to be consistent with the assumption that adverse effects are not expected to occur after exposure has ceased. Thus, the average daily dose is used to represent the potential for adverse noncancer health effects over the period of exposure.
- **Carcinogens:** The dose is based on the estimated exposure duration, extrapolated over an estimated 70-year lifetime. This is consistent with cancer slope factors (SFs), which are based on lifetime exposures and on the assumptions that the risk of carcinogenic effects is cumulative and continues even after exposure has ceased.

For nonoccupational direct-contact scenarios where exposures to children are considered likely, exposures to both adult and child were evaluated. Children often exhibit behavior such as outdoor play activities and greater hand-to-mouth contact, which can result in greater exposure than for a typical adult. In addition, children have a lower overall body weight relative to the predicted intake. As cancer risks are averaged over a lifetime, they are directly proportional to the exposure duration. Accordingly, a combined exposure from childhood through adult years was evaluated, where appropriate, to account for the increased relative exposure and susceptibility associated with childhood exposures.

In general, Superfund exposure assessments assess RME by using a combination of 90th or 95th percentile values for contact rate, exposure frequency, and duration. Table 7-1 provides the RME exposure assumptions available at the time and used for the BHHRA.

The fish consumption rates used in the risk assessment used a default recreational and subsistence fish and shellfish consumption rate from *Estimated Per Capita Fish Consumption in the United States* (EPA 2002) was applied. The subsistence consumption rate, based on the 99th percentile consumption rate for the U.S. population, was 143.4 grams of fish per day (wet basis). The Human Health and Ecological Risk Assessment Work Plan (Anchor QEA and Aspect 2009) noted “if no risk is indicated from subsistence fishing, regional tribal consumption rates, which may be greater than the default subsistence rates, may need to be evaluated to ensure tribal subsistence fishers are adequately protected” (Figure 7-2). The Muckleshoot Tribe was consulted and chose not to provide their subsistence rate; therefore, the RI BHHRA only evaluated risks to adult fish/shellfish consumers using default subsistence rates.

7.1.3 Toxicity Assessment

The toxicity assessment determines whether exposure to COCs may result in adverse health effects in humans and the relationship between the magnitude of exposure (dose) and incidence and/or severity of adverse effects (response). For risk assessment purposes, chemicals are generally separated into categories based on whether a chemical exhibits carcinogenic or noncarcinogenic health effects. As appropriate, a chemical may be evaluated separately for both effects. Noncancer effects are evaluated using a reference dose (RfD), which is the dose at or below which adverse health effects are not expected. Carcinogenic effects are assessed using the cancer SF, which is typically expressed in units of mg/kg-day. The SF represents an upper-bound estimate on the increased cancer risk. SFs are generally accompanied by a weight-of-evidence descriptor, which expresses the confidence as to whether a specific chemical is known or suspected to cause cancer in humans.

Noncancer Assessment

Noncancer health effects were evaluated using RfDs. An RfD is an estimate of a daily oral exposure for a given duration to the human population (including susceptible subgroups) that is likely to be without an appreciable risk of adverse health effects over a lifetime. Chronic RfDs are specifically developed to be protective against long-term exposure to COCs. Table 7-2 shows the RfDs available at the time, which were used to assess noncancer effects.

Cancer Assessment

Potential cancer effects are expressed as the probability that an individual will develop cancer over a lifetime based on the exposure assumptions described in Section 7.1.2. The cancer SF is a plausible upper-bound estimate of carcinogenic potency used to calculate cancer risk from exposure to carcinogens by relating estimates of lifetime average chemical intake to the incremental probability of an individual developing cancer over a lifetime. Table 7-2 shows SFs available at the time, which were used for assessing oral and dermal exposure.

7.1.4 Risk Characterization

Risk characterization integrates the information from the exposure assessment and toxicity assessment, using a combination of qualitative and quantitative information. Risk characterization involves estimating the magnitude of the potential adverse health effects associated with the COCs. It also involves making judgments about the nature of the human health threat to the defined receptor populations. The risk characterization combines the results of the dose-response (toxicity assessment) and exposure assessment to calculate cancer risks and noncancer health hazards. In accordance with EPA's guidelines, this assessment assumes that the effects of all contaminants are additive through a specific pathway within an exposure scenario.

The potential for noncancer health effects is estimated by comparing the average daily dose of a chemical for an adult, adolescent, or child with the RfD for the specific route of exposure (e.g., oral). The ratio of the intake to reference dose (average daily dose/RfD) for an individual chemical is the hazard quotient (HQ). HQs are calculated for each chemical that has an RfD available and could elicit a noncancer health effect. Typically, chemical-specific HQs are summed to calculate an HI value for each exposure pathway. EPA's goal of protection for noncancer health effects is an HI less than or equal to 1. When the HI exceeds 1, there may be a concern for health effects. This approach can result in a situation where HI values exceed 1 even though no chemical-specific HQs exceed 1 (i.e., adverse systemic health effects would be expected to occur only if the receptor were exposed to several contaminants simultaneously). In this case, chemicals are segregated by common effect on a target organ, and a separate HI value for each effect/target organ is calculated. If any of the separate HI values exceed 1, adverse noncancer health effects are possible. It is important to note, however, that an HI exceeding 1 does not predict a specific disease.

For carcinogens, risks are generally expressed as the incremental probability of an individual developing cancer over a lifetime as a result of exposure to the carcinogen. ELCR (a unitless probability of an individual developing cancer) is calculated by multiplying the chronic daily intake averaged over 70 years (mg/kg-day) and the SF (per mg/kg-day).

These risks are probabilities that usually are expressed in scientific notation (e.g., 1×10^{-6}). An ELCR of 1×10^{-6} indicates a probability that the RME individual has a 1 in 1,000,000 chance of developing cancer as a result of Site-related exposure. This is referred to as an "excess lifetime cancer risk or ELCR" because it would be in addition to the risks of cancer individuals face from other exposures. The upper-bound ELCR risks derived in this assessment are compared to the risk range of 10^{-6} to 10^{-4} established in the NCP. EPA's goal of protection for cancer risk is 10^{-6}, and risks greater than 10^{-4} typically will require remedial action.

Risk Characterization Results

The risk characterization results, based on assumptions and parameters available at that time, are summarized in Tables 7-3 and 7-4 for OU1 and OU2, respectively. The results are presented below by receptor and exposure scenario. Full results are included in RI BHHRA Tables 7.1-7 through 7.1-15, which are provided in Appendix 2A.

- **Future Residents.** Risks to future residents were estimated on a sitewide basis. The estimated ELCRs were 3×10^{-2} for exposure to soil, greater than 8×10^{-1} for exposure to groundwater, and 2×10^{-2} for exposure to indoor air. The estimated HIs ranged from 8 for exposure to soil to approximately 8,000 for exposure to groundwater.
- **Future Occupational Workers.** Risks to future occupational workers were estimated on a sitewide basis. The estimated ELCR was 2×10^{-3} for exposure to soil. Exposure to groundwater was not evaluated for occupational workers.

- **Future Construction/Excavation Workers.** Risks to future residents were estimated on a sitewide basis. The estimated ELCRs were 2 x 10^{-4} for exposure to soil, 1 x 10^{-5} for exposure to groundwater, and 8 x 10^{-4} for exposure to trench vapor. The estimated HIs ranged from 3 for exposure to soil to 0.00001 for exposure to groundwater.
- **Current and Future Recreational Beach Users.** Risks to current and future recreational beach users were estimated using nearshore sediment and surface water data. The estimated ELCRs ranged from 3 x 10^{-4} for exposure to sediment to 3 x 10^{-6} for exposure to surface water. The estimated HIs ranged from 0.00001 for exposure to groundwater to 486 for exposure to trench vapor.
- **Current and Future Recreational Fishers.** Risks to current and future recreational fishers were estimated using sitewide sediment data and fish tissue concentrations modeled from sitewide sediment data. The estimated ELCRs ranged from 4 x 10^{-5} for exposure to sediment to 2 x 10^{-4} for ingestion of fish tissue.
- **Current and Future Subsistence Fishers.** Risks to current and future subsistence fishers were estimated using sitewide sediment data and fish tissue concentrations modeled from sitewide sediment data. The estimated ELCRs ranged from 6 x 10^{-5} for exposure to sediment to 5 x 10^{-3} for ingestion of fish tissue.

In summary, the results of the human health risk characterization indicated that the noncancer HI exceeded 1 for each scenario, except the recreational beach user and recreational fishing scenarios. HIs exceeding 1 ranged from 3 (subsistence fish ingestion) to 7,995 (groundwater exposure for the future resident). ELCR estimates exceeded 1 x 10^{-4} for the six scenarios using Site data, ranging from 2 x 10^{-4} (recreational fish ingestion) to greater than 8 x 10^{-1} (groundwater exposure for the future resident). The ELCR estimate for the residential indoor air pathway was 2 x 10^{-2}, with the primary risk contributors being benzene, naphthalene, and ethylbenzene.

Recreational beach user, recreational fishing, and subsistence fishing scenarios were also evaluated using a background sediment data set. HIs were less than 1 for these three scenarios, and ELCR estimates for recreational and subsistence fish ingestion exceeded 1 x 10^{-6}, but were less than 1 x 10^{-4}.

7.1.5 Uncertainty Analysis for the BHHRA

The presence of uncertainty is inherent in the risk assessment process. Estimates of risk should present not only point estimates, but also consider the sources and magnitude of uncertainty associated with these estimates, provide characterizations of risk that are both qualitative and quantitative, consider the limits of scientific knowledge, and identify when there is a possibility of either overestimation or underestimation. Sources of uncertainty in risk assessment range from the assumptions and methodologies used in the evaluation of exposures and risks, to data gaps in the qualitative and quantitative information used to characterize the risks and hazards posed by Site contaminants.

Several sources of uncertainty can affect the overall estimates of human health risks presented in this assessment. The following sections discuss the primary sources.

Sampling, Analysis, and Data Evaluation

Uncertainties associated with soil, groundwater, sediment, and surface water sampling and analysis include the inherent variability (standard error) in the analysis, the representativeness of the samples, sampling errors, and the heterogeneity of the sample matrix. The quality assurance/quality control programs used during Site investigations are intended to maintain acceptable precision and accuracy in the measurement of chemical concentrations, but they cannot eliminate all errors associated with sampling and analysis. The degree to which sample collection and analyses reflect real exposure concentrations will influence the reliability of the risk estimates.

Most of the data used in the Quendall BHHRA included full documentation and full validation of the data by an independent party. Some data with less documentation were selectively used for performing BHHRA exposure calculations (for soil and surface water). In these cases, there may be more uncertainty associated with the corresponding risk estimates.

Chemical Fate and Transport Estimation

The BHHRA assumes that no chemical loss or transformation has occurred since the sampling data were collected, or will occur over the course of the assessed exposure durations. In cases for which natural attenuation or other degradation processes are moderate or high, the analytical data chosen to represent exposure concentrations likely overstate actual long-term exposure levels. This uncertainty is likely to be more relevant for organic chemicals (e.g., PAHs) that can be expected to undergo some limited biodegradation over the assumed 30- to 70-year exposure duration than for those that are more environmentally stable (e.g., metals).

Exposure Assessment

The estimation of exposures in the BHHRA required many assumptions. There are uncertainties regarding the likelihood of exposure, the frequency of contact with contaminated media, EPCs, the intake rates, and the total duration of exposure. In the absence of Site-specific information, the exposure assumptions used in the BHHRA were selected to reduce the likelihood of underestimating actual risks and are thus are intended to be health-protective.

Uncertainties in exposure estimates also include potential bias from sampling targeted towards areas of the highest Site contamination and conservatively modeled inputs, such as for indoor air or fish and shellfish tissue. The following are specific uncertainties and their potential effects on exposure calculations:

- Soil data available to characterize the beach for nearshore wading were limited to two samples collected in a Site area with relatively high concentrations. In this case, the maximum value was used.
- Surface soil samples collected from two locations near the former railroad contained cPAH concentrations 2 to 3 orders of magnitude higher than other Site samples. These two locations are in the Solid Material Loading Area where pitch was one of the materials formerly loaded, and the area likely contains fragments of pitch. The calculated sitewide concentrations may be substantially weighted towards the sample results from these two locations.
- Arsenic concentrations in groundwater measured at one well near the former railroad were an order of magnitude higher than the next highest concentrations, which were detected in a well in the southwest corner of the Site. The concentrations detected at the well near the former railroad contributed substantially to the overall calculated risk estimates.

There are also uncertainties related to subsistence fish consumption rates as the Muckleshoot Tribe does not have consumption rates. In the absence of a tribal-specific rate, the rate used to represent subsistence consumption is a 99th percentile consumption rate for freshwater fish/shellfish (143.4 grams per day) from the Estimated Per Capita Fish Consumption documentation (EPA 2002). The BHHRA only evaluated risks to adult fish/shellfish consumers.

In addition to the consumption rates, uncertainty also exists with respect to the relative percentage of the diet obtained from the Site versus other nearby sources of fish and the degree to which different methods of preparation and cooking may reduce concentrations of contaminants.

Toxicity Assessment

Uncertainties in toxicological data can also influence the reliability of risk management decisions. The toxicity values used for quantifying risk in the BHHRA have varying levels of confidence that may affect the confidence in the resulting risk estimates. A general source of toxicological uncertainty includes the extrapolation of dose-response data to predict effects on humans. Toxicity values were also not available for several chemicals detected. However, most of the Site contamination was derived from coal-tar and creosote sources associated with historical facility operations. Toxicity values for chemicals associated with these sources are readily available, and chemicals without toxicity values do not represent a significant uncertainty in the BHHRA.

Risk Characterization

In the risk characterization for the Quendall Site, the assumption was made that the total risk of developing cancer from exposure to Site chemicals is the sum of the risk attributed to each individual contaminant. Likewise, the potential for the development of noncancer adverse effects is the sum of the HQs estimated for exposure to each individual contaminant. This approach, in accordance with EPA guidance, does not account for the possibility that some chemicals may act synergistically or antagonistically. In the absence of specific information about the interaction, the default assumption of additivity is considered appropriate.

7.2 Ecological Risks

The baseline ecological risk assessment (BERA) estimates risk for terrestrial- and aquatic-dependent species exposed to hazardous substances in the upland and Lake Washington portions of the Site using a weight-of-evidence approach.

The BERA steps are listed below and described in the following sections:

- **Problem Formulation** includes identification of COPCs, exposure pathways, and known ecological effects of the contaminants; receptors and selection of assessment endpoints (environmental values to be protected) for further study and a CSM.
- **Exposure Assessment** includes characterization of exposure pathways and receptors; and measurement or estimation of EPCs.
- **Ecological Effects Assessment** includes literature reviews, field studies, and toxicity tests, linking contaminant concentrations to adverse effects on ecological receptors on a media-, receptor-, and chemical-specific basis.
- **Risk Characterization** includes measurement or estimation of both current and future adverse effects, as well as the overall degree of confidence in the risk estimates.

7.2.1 Problem Formulation

This section summarizes identification of COPCs, ecological receptors, exposure pathways, assessment and measurement endpoints, and lines of evidence used in the BERA.

Identification of Chemicals of Potential Concern

COPCs for ecological receptors were selected for inclusion in the BERA by comparing Site analytical data to ecological risk-based screening values. If the maximum detected concentration of a chemical exceeded its appropriate risk-based screening level or if a risk-based screening level was not available, the contaminant was selected as a COPC.

The data used in the BERA by medium are summarized as follows:

- **Soil:** Soil samples collected across the Site from the surface to depths of 5 feet bgs.
- **Sediment:** Surface sediment from the upper 4 inches, encompassing the OU2 boundary.
- **Surface Water and Sediment Porewater:** Surface water and porewater samples, encompassing the OU2 boundary. Surface water exposure was estimated for sediment porewater data by applying a dilution factor of 10 to the porewater data.
- **Bioassay Data:** Bioassay data from two sets of tests to evaluate risk from hydrocarbons and to assess the deleterious properties of wood debris. For each bioassay sample, 28-day amphipod (*Hyalella azteca*) and 20-day midge (*Chironomus dilutus*) tests were run. For both tests, the endpoints were end-of-test survival and growth.

COPCs for ecological receptors are summarized in Table 7-5 and detailed RI BERA Tables J-8-1 through J-8-3, provided in Appendix 2A.

Ecological Receptors

Terrestrial feeding guild categories include plants, invertebrates, birds, and mammals. Soil invertebrates and terrestrial plants were assessed on a community-level basis for direct effects and were also included as a food source to upper-trophic-level organisms, as discussed below. The specific receptors selected for bird and mammal feeding guilds included the following:

- Insectivorous bird (robin)
- Avian predator (red-tailed hawk)
- Herbivorous mammal (eastern cottontail rabbit, meadow vole)
- Insectivorous mammal (mole)
- Omnivorous Mammal (racoon)
- Carnivorous Mammal (coyote)

Terrestrial reptiles and amphibians were not directly assessed in the BERA because exposure models and toxicological data for reptiles and amphibians are limited; however, it is assumed that the risk characterization and risk-based management for other assessment endpoints (e.g., soil invertebrates, mammals, fish, and birds) will provide protection of reptiles and amphibians at the Site.

Aquatic feeding guild categories include plants, invertebrates, fish and shellfish, birds, and mammals. Aquatic macrophytes (plants) and benthic invertebrates were assessed as general communities and, for benthos, using surrogate test species.

The representative fish receptors selected for each feeding guild included the following:

- Piscivorous Fish (yellow perch)
- Omnivorous Fish (salmonid fry)
- Benthivorous Fish and Shellfish (brown bullhead)

The above fish guilds were also included as prey to both fish and wildlife.

The feeding guilds for aquatic-dependent birds include piscivorous raptors, shorebirds, sediment-probing birds, dabbling ducks, and diving ducks. Aquatic-dependent mammals include piscivorous mammals. The specific receptors selected for each feeding guild included the following:

- Piscivorous Raptor (bald eagle)
- Shorebird (great blue heron)
- Sediment-Probing Bird (spotted sandpiper)
- Dabbling Duck (mallard duck)
- Diving Duck (lesser scaup)
- Piscivorous Mammal (otter)

The bald eagle and salmon fry are representative threatened or endangered species for the BERA. Though federally delisted in most of the United States, the eagle is still a sensitive species in the State of Washington, as noted previously, and is still protected by the Migratory Bird Treaty Act and the Bald and Golden Eagle Protection Act.

Exposure Pathways

Figures 7-3 and 7-4 show the ecological CSMs for terrestrial- and aquatic-dependent wildlife, respectively. The routes of exposure are the means by which contaminants are transferred from a contaminated medium to an ecological receptor. The most significant pathways for Site COPCs are:

- **Terrestrial and aquatic plants**: Root uptake; direct contact with soil/sediment and groundwater/surface water
- **Soil and benthic invertebrates**: Direct contact with soil/sediment, and groundwater/surface water; ingestion of soil/sediment and food

- **Fish/Shellfish**: Direct contact with sediment and surface water; ingestion of sediment and food
- **Birds and mammals**: Ingestion of soil, sediment, and food

Assessment and Measurement Endpoints and Lines of Evidence

Assessment endpoints are the valued attributes of ecological entities upon which risk management actions are focused. More specifically, assessment endpoints are—an explicit expression of the environmental value to be protected, operationally defined as an ecological entity and its attributes (EPA 1998). The selection criteria for assessment endpoints include ecological relevance, susceptibility (exposure plus sensitivity), and relevance to management goals (EPA 2004).

Unless an ecological receptor is listed as a threatened and endangered species, assessment endpoints are generally selected that are relevant to population- or community-level rather than individual effects. For evaluation of threatened, endangered, or rare species (i.e., bald eagle) that may have exposure to Site COPCs, assessment endpoints are based on protecting individual organisms rather than populations or communities.

Assessment endpoints for receptors of concern evaluate survival, growth, and reproduction. The selection of assessment endpoints is based on the available information and the criteria listed previously. In the BERA, endpoints were selected that would likely result in protection of other valued entities and were amenable to assessment through existing data for exposure pathways quantitatively assessed in the BERA.

Measurement endpoints are frequently numerical expressions of observations (e.g., toxicity tests results, contaminant concentrations in sediment) and include measures of exposure and measures of effect.

Evaluation of overall ecological risk is based on a weight-of-evidence approach that combines multiple assessment endpoints as described in Table 7-6 and summarized below for each receptor:

- **Soil Invertebrates and Terrestrial Plants:** Comparison of Site data with soil screening values for single chemicals or chemical groups.
- **Terrestrial Birds and Mammals**: Comparison of Site data with soil screening values for single chemicals or chemical groups; multi-media exposure model calculations and comparisons with single-chemical toxicity data.
- **Aquatic Macrophytes**: Comparison of Site data with surface water screening values for single chemicals or chemical groups.
- **Benthic Invertebrates**: Comparison of Site data with sediment porewater screening values or benchmarks for single chemicals or chemical groups; comparison of Site data with bulk sediment screening values or benchmarks for single chemicals or chemical groups; and Site-specific sediment bioassays using amphipods and midges with Site and statistical comparisons with reference sediment tests.
- **Fish and Shellfish**: Comparison of Site data with surface water and sediment porewater screening values or benchmarks for single chemicals or chemical groups; modeled tissue residue values for single chemicals or chemical groups; and dietary exposure model calculations and comparisons with single-chemical toxicity data.
- **Aquatic-Dependent Birds and Mammals**: Multi-media exposure model calculations and single-chemical toxicity data.

7.2.2 Ecological Exposure Assessment

Exposure Pathways and Receptors

Exposure data were evaluated at the scale over which the receptors are likely to be exposed and, where pertinent, the variety of potentially contaminated prey the receptor may consume. For terrestrial receptors, the exposure area encompassed the entire upland portion of the Site. For aquatic receptors, the exposure area encompassed the entire offshore portion of the Site.

Exposure Concentrations

For dietary risks to fish and wildlife, exposure estimates were determined for a diet consisting of multiple prey species. Exposure concentrations were based both on measured contaminant concentrations and, for some lines of evidence, on modeled values.

7.2.3 Ecological Effects Assessment

Terrestrial Receptors

For terrestrial birds and mammals, the primary line of evidence for characterizing risk was a multi-media exposure model comparing total daily intake (TDI) of COPCs to dietary toxicity reference values (TRVs), while Site soil concentrations were compared to soil screening values as an additional line of evidence. Comparison of Site data with soil screening values was the sole line of evidence for characterizing risk to soil invertebrates and terrestrial plants.

The potential risks to the wildlife receptor groups were evaluated using modeled COPC concentrations in prey tissue and measured COPC concentrations in Site soil. Foraging strategies, the home range, dietary composition, and allometric information—such as body weight and ingestion rates for the representative receptor(s)—chosen for each receptor group were used to assess exposure. More specifically, the ingested dose received by each representative receptor was estimated by multiplying species-specific food and incidental soil ingestion rates (normalized to body weight) by the concentrations of COPCs in prey species and soil. Estimated ingested doses were compared to appropriate TRV values for survival, growth, and reproduction.

If the ingested dose of one or more COPC was in excess of the respective TRV for a representative receptor, (i.e., the HQ was greater than 1), or if the soil EPC exceeded the respective soil screening value, members of the receptor group were considered to be potentially at risk. HQs shown in the tables supporting this section are presented at two significant figures, reflecting the maximum precision of the TRVs and screening levels.

Aquatic Receptors

Aquatic macrophytes were assessed by comparing a combined data set of measured porewater and modeled surface water data (considered to be the surface water data set in the BERA) to surface water screening levels. A conservative dilution factor of 10 was applied to the porewater data prior to inclusion with the surface water data in order to calculate surface water EPCs.

Risk to the benthic invertebrate community was assessed using synoptic Site-specific bioassays and porewater sediment chemistry data as the primary and secondary lines of evidence to determine the risk.

Three types of toxicity data were used to evaluate risk to fish and shellfish: surface water benchmarks, estimated tissue body burdens, and estimated dietary intake.

Aquatic-dependent wildlife was evaluated by the TDI/TRV measure of exposure and effects, similar to the approach for terrestrial wildlife.

7.2.4 Risk Characterization

A summary of the hazard estimates for ecological receptors is provided in Table 7-7. HQs are shown for bulk soil screening results, for TDI results based on no observed adverse effects level (NOAEL) TRVs (for the terrestrial and aquatic-dependent bird and mammal species with the maximum HQs), surface water screening results, and fish diet HQs.

The following subsections briefly describe the risk characterization for terrestrial and aquatic-dependent ecological receptors.

Terrestrial Receptors

Terrestrial receptors evaluated in the BERA included soil invertebrates, plants, and birds and mammals representing carnivores, herbivores, omnivores, insectivores, and predators. The risk characterizations for these receptors are summarized as follows:

- **Soil Invertebrates and Terrestrial Plants**. Invertebrate ecological soil screening levels (Eco-SSLs) were exceeded for high-molecular-weight PAHs (HPAHs) (HQ of 226) and low-molecular-weight PAHs (LPAHs) (HQ of 47), and plant Eco-SSLs were exceeded for lead (HQ of 5.3). The samples with the highest concentrations of lead, HPAHs, and LPAHs were collected on the railroad property.
- **Terrestrial Wildlife**. Avian Eco-SSLs were exceeded for chromium (HQ of 2.2), lead (HQ of 58), and pentachlorophenol (PCP) (HQ of 34 based on non-detect). For mammals, Eco-SSLs were exceeded for chromium (HQ of 1.7), lead (HQ of 11.4), PCP (HQ of 25.4 based on non-detect), HPAHs (HQ of 3,692), and LPAHs (HQ of 14). The results of the TDI assessment for terrestrial wildlife indicate benzo(a)pyrene, chromium, lead, PCP, HPAHs, and, LPAHs had NOAEL HQs greater than 1 for at least one terrestrial receptor. NOAEL HQs for benzo(a)pyrene and total HPAHs, total LPAHs, PCP, and lead exceeded 1 for the majority of terrestrial receptors, primarily due to ingestion of soil and ingestion of earthworms and/or other soil invertebrates. HPAHs were the primary risk-driver chemicals. The terrestrial receptor with the highest NOAEL HQs for HPAHs was the raccoon (HQ of 1,101). The potential risk from surface water exposure is minimal.

As anticipated, the BERA indicates that upland soil poses an unacceptable risk to terrestrial ecological receptors. The primary risk drivers are PAHs. HQs for chromium and total polychlorinated biphenyls (PCBs) in soil were based on QA1-quality data, and conclusions are therefore uncertain. PCP exposure was based on non-detect data and, although HQs exceeded 1, PCP is not considered to pose a risk to terrestrial receptors.

Aquatic-Dependent Receptors

Aquatic-dependent receptors evaluated in the BERA included aquatic macrophytes, benthic invertebrates, fish and shellfish, and birds and mammals including piscivorous raptors and shorebirds, diving and dabbling ducks, and sediment-probing birds. The risk characterizations for these receptors are summarized as follows:

- **Aquatic Macrophytes.** Surface water screening levels were exceeded with HQs of 10 or more for several PAHs, including anthracene (HQ of 42), benzo(a)anthracene (HQ of 15), benzo(a)pyrene (HQ of 50), fluoranthene (HQ of 49), naphthalene (HQ of 123), phenanthrene (HQ of 13), and pyrene (HQ of 62). The samples with the highest concentrations of PAHs were in the nearshore area and along the T-Dock.
- **Benthic Invertebrates.** Sediment toxicity tests evaluated adverse effects of Quendall sediment on survival and biomass (a combined survival and growth endpoint) of larvae of the midge and amphipod. The toxicity tests demonstrated that exposure of these animals to sediment from some Quendall locations resulted in increased mortality and/or reduced biomass of these two species within 20 to 28 days—a direct measure of sediment toxicity to benthic invertebrates. A weight-of-evidence analysis identified 17 benthic areas of concern within the Site. In the hydrocarbon test series, amphipod and midge survival and growth were strongly associated with PAH equilibrium partitioning sediment benchmark quotients (ESBQs) in surface sediment porewater and with bulk sediment PAH ESBQs,[5] total PAH concentrations, and total petroleum hydrocarbons (TPH) concentrations.
- **Fish and Shellfish.** Risk to fish and shellfish was addressed using screening-level comparisons (i.e., a dietary evaluation). Because PAHs are readily metabolized by fish, the tissue residue line of evidence was not carried forward to the risk characterization. Surface water screening HQs for PAHs (HQ of 53 for benzo(a)pyrene) and

[5] EPA's equilibrium partitioning sediment benchmark approach for PAHs (EPA 2003) was applied as an additional line of evidence for estimating risk to benthic communities. The PAH ESB approach is a method to estimate potential narcotic toxicity to benthic invertebrates based on sediment porewater exposure to dissolved PAHs. Because PAHs share the same toxic mode of action, a toxic unit (TU) approach is used. A TU is calculated as a quotient, i.e., the sum of the ratio of each individual PAH concentration in sediment porewater divided by a final chronic value (FCV) for that PAH. The model can be used on a sediment porewater basis by calculating a porewater PAH TU based on direct comparison of porewater to the FCV, or on a bulk sediment basis by calculating a PAH ESB quotient (ESBQ, expressed in TUs) based on the equilibrium partitioning estimate of porewater PAH concentrations.

PAH ESBQs (HQ of 15) exceeded 1, which is consistent with the evaluation of benthos described above. For the dietary line of evidence, NOAEL and lowest observed adverse effects level (LOAEL) HQs for all sediment bioaccumulative COPCs were below 1 for the piscivorous fish. The HPAH NOAEL HQs for omnivorous and benthivorous fish were just above 1, but the LOAEL HQs did not exceed 1. Therefore, potential risk to omnivorous and benthivorous fish and shellfish via the dietary screening evaluation is low. Overall, the fish and shellfish lines of evidence are consistent with those used to characterize risk to benthos.

- **Aquatic-Dependent Wildlife**. The results of the TDI assessment for aquatic-dependent wildlife indicate benzo(a)pyrene, chromium, HPAHs, LPAHs, and total PAHs exceeded 1 for at least one receptor, with the largest HQs estimated for the spotted sandpiper and the river otter. The total PAH NOAEL HQ for the sandpiper (consuming sediment, crustaceans, mollusks, and surface water) was 10, while the corresponding LOAEL was less than 1. The total PAH NOAEL HQ for the river otter (consuming sediment, demersal fish, pelagic fish, crustaceans, mollusks, and surface water) was 9, while the corresponding LOAEL was less than 1. No dibenzofuran data are available in the data set used for assessing direct exposure to aquatic-dependent wildlife. The NOAEL HQs for the bald eagle (representing rare, threatened, and endangered receptors) were all less than 1. Because the NOAEL HQs for the eagle and the LOAEL HQs (excluding totals for all chemicals) for all aquatic-dependent wildlife receptors were less than 1, it is concluded that contaminant concentrations in sediment at the Quendall Site do not pose a significant risk to this group of receptors.

7.2.5 Risk Characterization Summary

Table 7-8 summarizes the results for each group of receptors. In general, the results are as follows:

- Ecological Site risk for terrestrial and aquatic-dependent wildlife receptors exceeded an HQ of 1. The primary contaminants that pose risk to ecological receptors throughout the Site are PAHs.
- Site sediment that poses a PAH-related risk to benthic macroinvertebrates was associated with hydrocarbon releases (delineated in the T-Dock Area and nearshore Site areas adjacent to Quendall Pond).
- Benthic toxicity measured in sediment bioassays correlated closely with porewater PAH concentrations, consistent with EPA's current PAH toxicity model.

7.2.6 Uncertainty Analysis for the BERA

Sources of uncertainty in a BERA can be generally classified in the following four categories:

- Measurement errors—associated with the measurement of physical, chemical, and/or biological parameters.
- Extrapolation errors—associated with the extrapolation that is necessary to characterize or describe a parameter or an effect when collection of specific data is not achievable.
- Modeling errors—associated with how well a model approximates true relationships between Site-specific environmental conditions.
- Data gaps—resulting from a lack of information that could conceivably be addressed through additional measurement, extrapolation, or modeling of conditions.

Uncertainty in EPCs, wildlife exposure factors, dietary fractions, uptake factors, BSAFs, and TRVs all contribute to the overall uncertainty associated with the BERA. For the assumptions where alternate values are possible (e.g., ingestion rates and TRVs), the values used in the BERA were selected to be consistent with EPA guidance and other BERAs conducted in EPA Region 10. The majority of the alternative parameters, whether qualitatively or quantitatively assessed, were considered to have a low likelihood for affecting threshold exceedances, pathway identifications, and/or risk decisions.

Not all uncertainties create a conservative bias. Some can lead to an underestimation of risk such as unavailability of exposure or effects data, thresholds that do not account for untested sensitive species, uncertainty whether multiple Site COPCs interact synergistically, and uncertainty whether metabolic processes increase the toxicity of accumulated contaminants in ways that are not observed in toxicity tests.

Unquantified ecological risks from contaminants without baseline TRVs are a source of uncertainty in the BERA that could lead to underestimating ecological risks within the Quendall Site because most other types of uncertainty are handled by making conservative assumptions.

7.3 Basis for Action

The response action selected in this ROD is necessary to protect the public health or welfare or the environment from actual or threatened releases of hazardous substances into the environment or from actual or threatened releases of pollutants, or contaminants from the Site that may present an imminent and substantial endangerment to public health or welfare. A response action is necessary for the Site because:

- **Human health risk:** Risks resulting from exposure to soil, groundwater, sediment, and consumption of fish and/or shellfish exceed EPA's cancer risk range and HI assessment, as summarized in Section 7.1.4.
  - **Soil:** Exposure to soil results in elevated risks to all of the receptors evaluated.
  - **Groundwater:** Exposure to groundwater and resulting indoor air and trench vapors results in elevated risks to future residents and construction/excavation workers.
  - **Nearshore sediment:** Exposure to sediment in the nearshore results in elevated risks to recreational beach users.
  - **Biota (modeled from sediment):** Consumption of fish and shellfish results in elevated risks to subsistence and recreational fishers.
  - **PTW:** DNAPL-contaminated soil and sediment act as uncontrolled sources to groundwater that discharges to Lake Washington.
- **Ecological risk**: Risks exceed acceptable levels (HQs ≥ 1.0) for several terrestrial- and aquatic-dependent receptors, as summarized in Section 7.2.4.
  - **Soil:** Exposure to soil results in elevated risks to terrestrial invertebrates, plants, birds, and mammals.
  - **Terrestrial biota (modeled from soil):** Exposure to PAHs in terrestrial biota are associated with ecological risks to terrestrial-dependent mammals and birds.
  - **Surface water:** Exposure to surface water results in elevated risks to aquatic plants and fish.
  - **Sediment:** Exposure to sediment results in elevated risk to benthos.
  - **Aquatic biota (modeled from sediment):** Exposure to PAHs in aquatic biota are associated with ecological risks to aquatic-dependent birds and mammals.

8 Remedial Action Objectives and Cleanup Levels

8.1 Remedial Action Objectives

RAOs consist of media-specific goals for protecting human health and the environment. RAOs have been developed for COCs in the environmental media of interest; exposure pathways, including exposure routes and receptors; and an acceptable contaminant concentration or range of concentrations for each exposure route. The nine RAOs developed to address the human health and ecological risks posed by the contamination at the Site are presented below.

One of the expectations to be considered by EPA is the ability of remedial alternatives to address PTW to the extent practicable. PTW is defined at this Site as all DNAPL, including oil-coated and oil-wetted soil/sediment. RAO 1 for OU1 and RAO 1 for OU2 address PTW.

Following are the RAOs for OU1:

- **RAO 1 (OU1)**—Reduce migration of COCs from DNAPL to groundwater to levels that allow restoration of groundwater to drinking water standards.
- **RAO 2 (OU1)—**Restore groundwater in the shallow alluvium and deeper alluvium aquifers to its highest beneficial use (drinking water) by reducing COCs to drinking water standards within a reasonable timeframe.
- **RAO 3 (OU1)—**Reduce to acceptable levels the risk to future residents from direct contact or incidental ingestion of COCs in surface and subsurface soil.
- **RAO 4 (OU1)—**Reduce to acceptable levels the risk to terrestrial wildlife from direct contact or incidental ingestion of COCs in soils or soil invertebrates.
- **RAO 5 (OU1)—**Reduce to acceptable levels the human health risk from inhalation of vapors from groundwater and/or soils contaminated with COCs and DNAPL.

Following are the RAOs for OU2:

- **RAO 1 (OU2)—**Reduce migration of COCs from DNAPL to sediment to levels that allow restoration of sediment to acceptable levels.
- **RAO 2 (OU2)—**Reduce to acceptable levels the risk to adults and children from ingestion of resident fish and shellfish taken from the Site.
- **RAO 3 (OU2)—**Reduce to acceptable levels the risk to future beach users from playing or wading in shallow water near shore resulting in incidental ingestion or/and dermal exposure to contaminated sediments.
- **RAO 4 (OU2)—**Reduce to acceptable levels the risk to aquatic organisms (benthos, aquatic plants, and fish) and aquatic-dependent wildlife (sediment-probing birds and piscivorous mammals) from direct contact and/or incidental ingestion of COCs in sediment, surface water/porewater, and prey.

Achieving the above RAOs relies on the remedial alternatives' ability to meet cleanup levels. Section 8.2 discusses cleanup level development, including risk-based cleanup levels, cleanup levels based on background concentrations, and applicable or relevant and appropriate requirements (ARARs).

It is EPA's expectation that actions to treat or remove DNAPL source materials in soil and sediment and cap remaining contaminated areas in OU1 and OU2 will adequately address contaminated soils, groundwater, sediment, and surface water, consistent with CERCLA. The remedial strategy for the Site is to address all contaminated media and complete exposure pathways that pose unacceptable risk within the Site.

Tables 8-1 and 8-2 summarize how achievement of each RAO will be determined for OU1 and OU2, respectively.

8.2 Cleanup Levels and ARARs

This section describes the selected cleanup levels and ARARs for OU1 and OU2. Cleanup levels are the long-term contaminant concentrations that need to be achieved by the remedial alternatives to meet RAOs. The selected cleanup levels are contaminant concentrations that will be used to measure the success of the cleanup alternatives in meeting the RAOs. Cleanup levels are based on ARARs, which provide minimum legal standards, and other information such as toxicity information from the HHRA and ERA. In the absence of ARARs, cleanup levels are based on Site-specific risk analysis.

Cleanup levels must comply with ARARs and result in residual risk levels that fully satisfy the CERCLA requirements for the protection of human health and the environment. ARARs are legally applicable or relevant and appropriate substantive (as opposed to administrative) standards, requirements, criteria, or limitations under any federal environmental law, or promulgated under any state environmental or facility siting law that is more stringent than federal law. Section 13.2 further discusses ARARs.

Tables 8-3 and 8-4 present cleanup levels for OU1 and OU2, respectively.

8.2.1 Cleanup Levels for OU1

Cleanup levels for soil and groundwater were based on human health risk, ecological risk, or background (see Table 8-4 for details).

Human Health Risk-Based Cleanup Levels

Human health risk-based cleanup levels for surface soil and groundwater were calculated using RME assumptions for future residents based on direct contact (including dermal, ingestion, inhalation, absorption, etc.) (OU1 RAOs 1, 2, and 3). Risk-based cleanup levels for cancer effects are based on an excess cancer risk of 1×10^{-6} (1 individual out of 1 million), and risk-based cleanup levels for noncancer effects are concentrations that would equate to an HQ of 1 for individual COCs, and an HI of 1 for COCs with similar noncarcinogenic toxic effects. Of the 20 COCs for soil, 11 are based on human health risk (Table 8-3). Of the 19 COCs for groundwater, 13 are based on human health risk.

Ecological Risk-Based Cleanup Levels

Ecological risk-based cleanup levels developed for surface soil were back-calculated from the ecological risk assessment food-web models based on the highest HQs to predict acceptable COC concentrations (OU1 RAO 4). The lowest value for each COC was selected as the risk-based cleanup level for to be protective of all species. Of the 20 COCs for soil, 7 are based on ecological risk.

Cleanup Levels Based on Background

Arsenic risk-based concentrations for human health are lower than background; therefore, the soil cleanup level for arsenic is based on Washington State's *Natural Background Soil Metals Concentration in Washington State (Ecology 1994).*

8.2.2 ARARs for OU1

Cleanup levels for several groundwater COCs are based on federal MCLs (40 *Code of Federal Regulations* [CFR] 141). These include arsenic, benzene, ethylbenzene, total cPAHs, and total xylenes.

8.2.3 Cleanup Levels for OU2

Cleanup levels for sediment apply to two different areas: 1) nearshore sediment where recreational beach users may engage in recreation at the shoreline (defined by areas where water depths are less than 10 feet); and 2) sitewide sediment that includes all sediment within the defined site (inclusive of the nearshore sediment) (see Table 8-4 for details).

Human Health Risk-Based Cleanup Levels

Human health risk-based cleanup levels for nearshore sediment were calculated using RME assumptions for recreational beach users based on direct contact (OU2 RAOs 1 and 3). Nearshore sediment is delineated by areas covered with 10 feet or less of water. Risk-based sediment cleanup levels for cancer effects are based on an excess cancer risk of 1×10^{-6} and risk-based cleanup levels for noncancer effects are concentrations that would result in an HQ of 1. Of the 10 COCs for nearshore sediment, 8 are based on human health risk (Table 8-4).

Human health risk-based cleanup levels for sitewide sediment were calculated to be protective of subsistence fish and shellfish consumers (OU2 RAO 2). The cleanup levels incorporate both direct exposure to sediment while fishing/shellfish gathering and ingestion of Site fish/shellfish. A default subsistence fish and shellfish consumption rate from *Estimated Per Capita Fish Consumption in the United States* (EPA 2002) was applied, consistent with the approach approved by the Muckleshoot Tribe in the RI human health risk assessment (Anchor QEA and Aspect 2012). The subsistence consumption rate, based on the 99th percentile consumption rate for the U.S. population, was 143.4 grams of fish per day (wet basis) (EPA 2002).[6] Current EPA default values for other exposure parameters (e.g., body weight, skin surface area, exposure duration) were used. The biota-to-sediment accumulation factors, lipid fractions, and diet proportioning between mollusks, crustaceans, and fish are the same as those used in the RI baseline risk assessment (Anchor QEA and Aspect 2012).

Risk-based sediment cleanup levels for cancer effects are based on an excess cancer risk of 1×10^{-6}, and risk-based cleanup levels for noncancer effects are concentrations that would result in an HQ of 1.[7] All 8 sitewide sediment COCs (cPAHs) are based on human health risk (Table 8-4).

Ecological Risk-Based Cleanup Levels

Ecological risk-based cleanup levels developed for sediment were back-calculated from the ecological risk assessment food-web models based on the highest HQs to predict acceptable COC concentrations (RAO 4). The lowest value for each COC was selected as the risk-based cleanup level to be protective of all species. Of the 10 COCs for sediment, 1 (total HPAHs) is based on ecological risk.

Benthic Community Cleanup Levels

The cleanup level for total PAHs in the nearshore (areas covered in 10-feet or less of water) and sitewide sediment is based on the Washington State Sediment Management Standard (SMS) for the protection of the benthic community (WAC 173-204-563, Table VI, Sediment Cleanup Objective, protection of the benthic community).[8] The total PAH cleanup level for protection of the benthic community (RAO 4) is point-based and applicable to any sample location. Of the 10 COCs for sediment, 1 (total PAH) is based on the SMS protection of the benthic community.

Cleanup Levels Based on Background

None of the OU2 cleanup levels are based on background. A Site-specific BTV for cPAHs in sediment was calculated to delineate the OU2 boundary (see Section 9.1.1.2); however, all sediment cleanup levels are based on either risk-based concentrations or, for total PAHs, the SMS protection of the benthic community table value (WAC 173-204-563, Table VI, Sediment Cleanup Objective, protection of the benthic community).

8.2.4 ARARs for OU2

Surface Water ARARs

Surface water ARARs consist of applicable promulgated state water quality standards and, in accordance with Section 121(d)(2)(A)(ii) and (B)(i) of CERCLA, federal recommended Clean Water Act (CWA) Section 304(a) Ambient Water Quality Criteria (AWQC) guidance values where they are relevant and appropriate. The AWQC for human health include values to protect for consumption of organisms only, and those to protect for consumption of organisms or water.

As part of the comprehensive sediment cleanup, some contaminated sediment will remain in place underneath caps. Monitoring plans will be designed to ensure that water quality is protected in addition to sediment quality.

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6 The baseline human health risk assessment (Anchor QEQ and Aspect 2012) indicated unacceptable risk for subsistence fish and shellfish consumers using default subsistence consumption rate from "Estimated Per Capita Fish Consumption in the United States" (EPA 2002), and concluded that the input assumptions, including consumption rate, were sufficiently conservative to assess risk to subsistence fishers.

7 The baseline human health risk assessment (Anchor QEA and Aspect 2012) modeled tissue concentrations from sediment concentrations (i.e., no tissue samples were collected).

8 The SMS is identified as To Be Considered in Table 10-4 "Chemical-Specific ARARs, Operable Unit 2."

9 Description of Alternatives

EPA has determined that cleanup actions are necessary to protect human health and the environment (see Section 7.3, Basis for Action). This section summarizes the remedial alternatives, including the technologies considered and the common elements among alternatives, and a description of each remedial alternative developed and evaluated for OU1 and OU2.

9.1 Summary of Remedial Alternatives

The FS for the Quendall Site (Aspect and Arcadis 2016) was completed prior to EPA's decision to split the Site into two OUs. It presented and evaluated 11 sitewide remedial alternatives that encompassed and addressed contaminated media in both the uplands (OU1) and in Lake Washington (OU2). In 2017, EPA evaluated and added in situ smoldering combustion to the array of potentially viable technologies for use on DNAPL in upland soil.

Following these changes, EPA developed six remedial alternatives for OU1 and six remedial alternatives for OU2 that were carried forward into the Proposed Plans for OU1 and OU2, respectively.

The OU1 Alternatives developed were:

- 1 No Action
- 7 In situ solidification of DNAPL and soil capping
- 7a In situ smoldering combustion and/or ISS of DNAPL, and soil capping
  This is the Selected Remedy for OU1.
- 8 Removal/onsite ex situ thermal treatment of DNAPL and soil capping
- 9 In situ solidification and removal/onsite ex situ thermal treatment of DNAPL and contaminated soil, and soil capping
- 10 Removal/onsite ex situ thermal treatment of DNAPL and contaminated soil, soil capping, and active groundwater treatment

The OU2 Alternatives developed were:

- 1 No Action
- A Amended sand cap, reactive core mat (RCM) cap, engineered sand cap, and ENR
- B Targeted DNAPL removal (T-Dock DNAPL Area), amended sand cap, RCM cap, engineered sand cap, and ENR
- C Targeted DNAPL removal (T-Dock and Quendall Pond Sediment [QP-S] DNAPL Areas), RCM cap, engineered sand cap, and ENR
- D DNAPL removal, engineered sand cap, and ENR
  This is the Selected Remedy for OU2.
- E DNAPL and contaminated sediment removal/onsite thermal treatment, engineered sand cap, and ENR.

The alternatives listed above and presented in this section address the RAOs, satisfy the requirements of CERCLA and the NCP, and reflect the complex nature of the Site. CERCLA mandates that remedial actions must be protective of human health and the environment, be cost effective, and use permanent solutions and alternative treatment of technologies or resource recovery alternatives to the maximum extent practicable. CERCLA § 121(d), 42 *United States Code* § 9621 (d) further specifies that a remedial action must require a level or standard of control of the hazardous substances, pollutants, and contaminants, which at least attains ARARs under federal and state laws, unless a waiver can be justified pursuant to CERCLA § 121(d)(4), 42 *United States Code* § 9621 (d)(4).

Several of the FS Alternatives for the uplands were not carried forward into the Proposed Plan for OU1. These were FS Alternatives 2 through 6, which ranged from containment (capping) to various degrees of targeted DNAPL treatment or removal. EPA determined that Alternatives 2 through 6 did not meet the RAO to restore groundwater to its highest beneficial use (OU1, RAO 2) and associated ARARs, and were not carried forward into the Proposed Plan for OU1. Therefore, only Alternatives 7 through 10 were presented in the Proposed Plan for OU1 and are described in this section.

While the FS considered 10 active sitewide alternatives, there were only 5 distinct approaches to addressing contamination in Lake Washington (OU2). EPA determined that these approaches for OU2 would meet all RAOs and associated ARARs and were therefore carried forward in the Proposed Plan for OU2 as Alternatives A through E.[9]

9.1.1 OU1 Technologies

This section describes the technologies considered for addressing DNAPL and contaminated soil in OU1. Alternatives 7, 7a, 8, 9, and 10 use a combination of these technologies to varying degrees.

For **soil** containing DNAPL, three technologies were considered:

- **In Situ Self-sustaining Smoldering Combustion.** Smoldering combustion is a thermal oxidation process that uses self-sustained smoldering combustion (analogous to charcoal burning in a grill) to thermally destroy contaminants. Ignition points (IPs; heating rods) are placed in the ground that ignite the fuel (creosote/coal-tar at Quendall) with delivery of compressed air to propagate the smoldering reaction such that the heater can be turned off once the fuel is ignited. Compressed air delivery continues until the smoldering reaction subsides. The smoldering also stops immediately if the air flow is turned off. Soil vapors are captured and treated. The net products of thermal oxidation are carbon dioxide, carbon monoxide, water, and heat. This technology can be used to treat DNAPL above or below the water table.

  In summer 2018, EPA conducted a field pilot study of smoldering combustion and demonstrated that it can achieve reductions of 73 to greater than 99 percent for TPH and 80 to greater than 99 percent for lighter fractions, which are the contaminants impacting groundwater (Savron 2018). The study at Quendall indicated that a single smoldering combustion IP where TPH concentrations are greater than 3,000 parts per million (ppm) has a radius of influence (treatment) of 7 feet (horizontally and vertically).

- **In Situ Solidification (ISS)**. Using this method, organic and inorganic COCs in soil are physically bound within a stabilized mass (solidified), while chemical reactions between the stabilizing agent and the contaminants reduces contaminant mobility. Potential amendments evaluated include bentonite, activated carbon, and cement. Amendments can be mixed with soil in situ using large-diameter augers or jet-grouting equipment. Through this process, free-phase DNAPL is reduced to below its residual saturation level by mixing with amendments, which reduce soil permeability and contaminant leachability. ISS operations would include active vapor management, such as the use of temporary portable enclosures to control nuisance odors and allow for capture and treatment of vapors.

- **Excavation and Thermal Treatment.** Contaminated soils are removed by excavation. Excavators, backhoes, and other conventional earth-moving equipment are the most common equipment used to remove contaminated soil from upland areas. Below the water table, dewatering may be required to use soil excavation equipment. Excavated materials may be thermally treated (heated), either at the Site or at an offsite facility, to destroy organic contaminants within the soil. Low-temperature thermal desorption involves heating soils to temperatures between 200 and 600 degrees Fahrenheit until volatile organic compounds and semivolatile organic compounds, such as benzene and naphthalene, evaporate. Exhaust gases produced by the process are typically combusted. Onsite thermal treatment would be used for alternatives that excavate large volumes of soil.

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9 Alternative A equates to FS Alternatives 2 and 3; Alternative B equates to FS Alternative 4a; Alternative C equates to FS Alternatives 4, 5, and 6; Alternative D equates to FS Alternatives 7 and 8; and Alternative E equates to FS Alternatives 9 and 10.

A **soil cap** was included for all alternatives. It is assumed that approximately 3 feet of clean material would be placed over areas of the Site where contaminant concentrations in soil (upper 15 feet) exceed cleanup levels. The soil cap will consist of the following components:

- A marker fabric layer will be placed across the entire Site to delineate existing soil from the future clean fill and cap material as a result of this action.
- A 3-foot-thick permeable soil cap will be placed over the entire Site where the upper 15 feet of soil exceeds the cleanup levels. The cap will prevent exposure to contaminated media that remains in place at the Site.

The 3 feet of clean material, combined with ICs, will prevent unprotected human exposure and ecological exposure to the contaminated soil. Additionally, the entire upland area may require up to 10 feet of fill for redevelopment purposes.

Aggressive source treatment with STAR and ISS technologies will target DNAPL co-located with high concentration areas of the groundwater plume. As such, these source control technologies will address and remediate these areas of the groundwater plume. Therefore, a separate groundwater technology was not included in alternatives with these source control approaches. Alternative 10, carried forward a separate groundwater remediation technology, **pump-and-treat**, because this alternative does not include source control technologies that remediate contaminated groundwater co-located with DNAPL.

9.1.2 OU2 Technologies

This section describes the technologies considered for addressing DNAPL and contaminated sediment in OU2. Alternatives A, B, C, D, and E use a combination of these technologies to varying degrees.

- **Removal (dredging)**. Dredging is a method of excavation that allows removal of sediments in wet conditions. Dredging is generally accomplished with two main technologies:
  - **Hydraulic**. Removal using a cutterhead or auger, which dislodges the sediment, or using plain suction. The dredged material is conveyed along with water using a suction pipe and slurry pumps. The resulting sediment slurry is pumped to a barge or upland location for processing.
  - **Mechanical**. Removal using an articulated fixed arm (e.g., backhoe) dredge, enclosed (environmental) bucket, or clamshell bucket on a barge. The mechanical dredge removes the sediment and transfers it into a separate barge for transport to the primary staging area.

The Quendall FS assumed that shallow DNAPL (like that observed along the former T-Dock) would be hydraulically dredged, and deeper DNAPL would be mechanically dredged. The dredging method would be determined in remedial design. The dredged sediments would be either dewatered and transported offsite for disposal or treated (using a thermal technology) and managed onsite depending on the volume.

- **Amended sand caps**. Amended sand caps are a type of permeable reactive cap. This technology can be used in targeted areas where DNAPL or oily sheens are an issue. In permeable reactive capping, a permeable cap is placed above contaminated sediments, and an amendment (e.g., organoclay) is placed within the sediment cap to sorb NAPL and/or dissolved-phase constituents, limiting migration into overlying sediment porewater and surface water. This typically involves alternating layers of clean sand and amendment placed over the contaminated sediment. The amendment would sorb DNAPL in the sediments as well as COCs from upwelling contaminated groundwater and prevent exposure to contaminated sediment.

  The Quendall FS assumed the amended sand cap would consist of alternating layers of clean sand, with a layer of organoclay in between, topped with approximately 6 inches of clean sand for bioturbation/habitat layer. Along the shoreline in areas with less than 15 feet of water depth, the amended sand cap would require erosion protection (armoring) from wave energy.

- **Reactive core mat (RCM) caps**. RCM caps are a type of permeable reactive capping similar to an amended sand cap, but the reactive material is enveloped within geotextile to provide capacity for contaminant sequestration. In certain applications, reactive caps may lose their effectiveness when the reactive material becomes saturated. Therefore, for continued effectiveness, a reactive cap would be designed such that the capacity of the reactive material is greater than the estimated restoration timeframe, or there must be a way to replace the reactive media when it becomes saturated.

  The Quendall FS assumed RCM caps would consist of an approximately 0.25-inch-thick organoclay layer sandwiched between two geotextiles layers stitched together. The organoclay RCM would be overlain by 6 inches of clean sand to provide a bioturbation/habitat layer. The RCM cap would sorb DNAPL and COCs from upwelling contaminated groundwater, control DNAPL migration (when present in near surface), and prevent exposure to contaminated sediment and porewater (groundwater coming through the sediments into the lake). RCMs would be used in areas where DNAPL is relatively limited in volume, is expected to be relatively immobile due to weathering (e.g., in the T-Dock area), or where the shoreline bathymetry needs to be maintained. Along the shoreline in areas with less than 15 feet of water depth, the RCM cap may require erosion protection from wave energy and when used along the banks, would be permanently secured using an anchoring system. Details would be further refined as part of the remedial design.

- **Engineered Sand Cap**. An engineered sand cap (typically up to 3 feet thick) can be designed to effectively contain and isolate contaminated sediments from the biologically active surface zone. The cap can be designed to be thick enough and of sufficient grain size to maintain its integrity under reasonable worst-case environmental and land use conditions. A sediment cap system's surface layers would likely be constructed of clean sand and could be placed by a number of mechanical and hydraulic methods. A demarcation layer may be required (e.g., geotextile). Engineered caps may also include erosion protection or stability layers such as geosynthetics or armoring materials. Armored caps (e.g., with a gravel surface) may be potentially appropriate for consideration in sediment areas with high potential for disturbance (e.g., areas likely to experience propeller wash).

  The Quendall FS assumed a 1.5-foot-thick engineered sand cap would be used to prevent exposure to contaminated sediment and porewater and reduce concentrations of COCs entering the lake from upwelling contaminated groundwater (approximately 350 feet lakeward from the shoreline).

  Modeling done during the FS that considered various chemical and physical processes indicated that a 1.5-foot thickness would be adequate; however, the actual thickness of the cap would be determined during remedial design. CWA Section 404 regulates the discharge of dredged or fill material into waters of the United States. Remedial design information will be required to fully assess impacts and specify all requirements and controls that will need to be placed on placing cap materials to minimize or avoid impacts. Through the Section 404 analysis during remedial design, exact amounts of compensatory mitigation for unavoidable loss of aquatic habitat will be determined and mitigation plans developed.

- **Enhanced Natural Recovery (ENR)**. Deposition of clean sediment plays a role in the natural recovery of contaminated sediments. ENR is a remedial approach that enhances natural recovery by adding a thin layer of clean sediment over impacted sediment (i.e., thin-layer placement).

  The Quendall FS assumed ENR would involve placement of a thin layer of clean sand (approximately 0.5 foot) over the sediment to accelerate the rate of natural recovery by immediately reducing surface chemical concentrations and facilitating the reestablishment of benthic organisms. This would be applicable within the remediation areas beyond the inner harbor zone of upwelling contaminated groundwater that are not otherwise addressed by another technology.

9.1.3 OU1 Common Elements

Preconstruction Activities

Preconstruction activities for OU1 would include developing 100 percent remedial design drawings and specifications, developing health and safety and other work plans, and mobilizing equipment. EPA assumes that the uplands portion of the Quendall Terminals Property would be redeveloped upon OU1 remedy completion, but a 100-foot-wide corridor of beach habitat would be maintained along the entire shoreline at the Site.

Redevelopment Considerations

The Quendall Site is currently vacant and unused. The uplands portion of the Quendall Terminals Property is expected to be available for redevelopment upon OU1 construction completion. Based on Site zoning and the most recent development plan, the future Site grade may be raised to meet the grades on adjacent properties and to allow installation of a gravity sewer system. As a result, excess material that may be generated during implementation of some alternatives (for example, an increase in soil volume during ISS) can likely remain on the Site. This was considered during alternatives development.

Site development is also assumed to include impermeable engineered surfaces, such as roadways, sidewalks, parking lots, and building foundations. Future buildings may include deep foundation elements (for example, driven pilings) that would need to be designed to ensure that they are compatible with the cleanup.

Vapor intrusion would need to be assessed and, if needed, mitigated for any new construction. Indoor air modeling, conducted in support of the RI, indicated that exceedances of risk-based levels for benzene and naphthalene are possible for future structures if vapor controls are not implemented.

Shoreline Habitat Considerations

Several wetlands are present in the Site uplands (Figure 5-1). The upland alternatives were designed to minimize filling these wetlands to the extent practicable, but some filling would be necessary under all of the OU1 alternatives (except Alternative 1). Impacts to existing shoreline habitats within the 100-foot shoreline area would also be minimized, but some impacts likely would be necessary to complete the Site cleanup.

As a result of the likely impacts to existing wetlands and shoreline habitat, the FS assumed compensatory mitigation would be required pursuant to CWA Section 404(b)(1) to offset these impacts. Therefore, all OU1 alternatives assumed that the entire shoreline and the area landward 100 feet (the habitat area, see Figure 5-1) would be excavated and recontoured to allow for development of functional wetland and riparian habitat following cleanup and would remain undeveloped (about 3.5 acres).

Habitat mitigation plans would be developed during the remedial design phase of the cleanup process. All alternatives (except Alternative 1) consider the CWA 404(b)(1) statute and its requirements; therefore, these alternatives included provisions for future habitat along the Quendall shoreline.

Remedial components planned and/or selected for the habitat area would need to consider potential access and use limitations. Accordingly, some potential remedial components of the alternatives may not be compatible with future habitat areas. For example, repair and replacement of sediment caps along the shoreline may require periodic use of heavy equipment that could cause degradation of the habitat area. EPA, the Muckleshoot Tribe, National Marine Fisheries Service, and trustees would need to agree that such access for purposes of installation, operation, and maintenance were acceptable.

For alternative development and evaluation, the following assumptions regarding habitat were made:

- The habitat area would consist of a 100-foot-wide corridor along the shoreline. Remedial components requiring future access for monitoring or maintenance, such as groundwater extraction wells, would be placed outside and east of the habitat area.

- Soil caps in the habitat area could require clean material to a minimum depth of 3 feet below current grade. Whether or not a soil cap would be necessary for the habitat area would be determined as part of remedial design, and in conjunction with the design for habitat and wetland mitigation.
- Filling onsite wetlands likely would be necessary to complete the Site cleanup. Mitigation for the loss of the Site wetlands would be required pursuant to CWA Section 404(b)(1). A mitigation plan would be developed and approved in concert with EPA, Ecology, Department of Natural Resources, and the Muckleshoot Tribe.

Potential Generation of Dangerous Waste During Remediation

Washington State Dangerous Waste-regulated listed wastes may be generated by remedial activities that remove soil above the water table in the footprint of the north and south sumps (Figure 5-2 shows the general locations of the sumps). In addition, Washington State characteristic wastes may be generated by remedial activities that remove soil or sediment containing DNAPL, where benzene exceeds the 0.5 milligram per liter toxicity characteristic leaching procedure and total PAHs exceed 1 percent by weight. For the FS cost estimates, including soil disposal, it was assumed that:

- Soil located above the water table within the footprint of the north and south sumps, if removed, would designate as K035 Dangerous Waste and would be disposed of at a RCRA Subtitle C landfill.
- DNAPL-containing soil, if removed, would designate as D018 and/or WP01 waste and would be disposed of at a RCRA Subtitle C landfill.
- Other soil generated during construction could be disposed of in a nonhazardous (Subtitle D) landfill. The final disposal site would be selected following waste characterization determination and testing.

Institutional Controls

ICs are administrative or legal mechanisms intended to minimize the potential for people to be exposed to contamination by limiting land or resource use, and to maintain the integrity of the engineered components of the remedy. ICs would be required for all OU1 alternatives and would be an important part of the overall Site remedy because varying degrees of contamination exceeding cleanup levels would initially remain onsite for all alternatives. Many types of ICs may be applied at the Site to control human exposure pathways, including government controls, proprietary controls (e.g., MTCA environmental covenant), enforcement and permit tools, and informational devices.

ICs would include prohibitions regarding disturbance of caps and soils with post-treatment concentrations above surface soil cleanup levels. The areas where contaminated soils have been solidified are not expected to require a soil cap but would require prohibitions against any action that may compromise the integrity of the solidified soil. ICs would also be used to control activities in the habitat area. ICs would be needed to prohibit future use of groundwater for drinking or other domestic purposes and construction of wells (other than for remediation or monitoring purposes). Easements would also be needed to ensure access to remedy components such as monitoring wells. A MTCA covenant could be used to restrict future issues and control activities as described above, and to provide access to monitor the effectiveness of the remedy, and to inspect and maintain remedy components such as monitoring wells and caps in perpetuity. ICs will also include the need for vapor intrusion assessments and mitigation, if needed, for any redevelopment. Mitigation measures may include engineering controls and ongoing monitoring.

The IC objectives (nature and geographic extent of restrictions that may be needed) would change slightly with each alternative and anticipated future uses. Additional IC mechanisms that can accomplish the IC objectives may be analyzed and implemented during remedial design and remedial action.

Inspections, Monitoring, and Reporting

Monitoring would be conducted to confirm that the remedy is functioning as intended and evaluate the short-and long-term effectiveness of the remedy. At OU1, monitoring would require, at a minimum:

- Inspecting soil cap integrity and sampling to confirm uncapped areas remain below cleanup levels.
- Long-term monitoring would be conducted periodically where contamination is left in place to ensure the remedy is still protective of human health and the environment.
- Monitoring groundwater for Site COCs to assess the performance of the Quendall remedy and ensure groundwater cleanup levels are met within a reasonable timeframe.

For all alternatives, monitoring activities described above would also be conducted after significant natural events, such as earthquakes. Statutory 5-year reviews would be required in perpetuity.

ARARs

CERCLA requires remedial actions to comply with ARARs or waive them. Because all alternatives use similar technologies within OU1, the primary ARARs are the same for all alternatives. The following is a summary list of key ARARs associated with the remedial alternatives for OU1; Tables 10-1, 10-2, and 10-3 list specific requirements that are ARARs for OU1:

- Federal MCLs established under the Safe Drinking Water Act are relevant and appropriate for protection of drinking water for human consumption, as groundwater at Quendall is potable and qualifies as drinking water.
- The MTCA (RCW 70.105D; WAC 173-340) specifies risk thresholds for developing cleanup levels. EPA-developed cleanup levels would meet the substantive MTCA requirements.
- Section 404 (b) of the CWA requires protection of aquatic ecosystems by dredging or filling waters during the cleanup activities. This is applicable for treatment of contaminated wetlands and riparian habitat adjacent to the shoreline.
- Federal Migratory Bird Treaty Act and Bald and Golden Eagle Protection Act protects migratory birds and eagles. Remedial action work plans would specify measures to minimize disturbances to migratory birds and eagles.
- State solid and dangerous waste regulations would apply for characterizing and managing material onsite.
- Washington State Water Pollution Control Act Water Quality Standards prohibit the discharge of polluting matter into state waters.
- Washington State Shoreline Management Act established regulations, enforcement procedures, and policies for protecting Washington's shoreline areas. Remedial activities within 200 feet of the ordinary high-water mark would comply with shoreline requirements to mitigate impacts.

9.1.4 OU2 Common Elements

Preconstruction Activities and Assumptions

Preconstruction activities for OU2 would include developing 100 percent remedial design drawings and specifications, obtaining permits, developing health and safety and other work plans, and mobilizing equipment.

Sediment Remediation Area

The area of sediment contamination attributable to Quendall was determined by comparing surface sediment data from Quendall to an organic carbon-normalized cPAH[10] BTV using a Site-specific background data set comprising a total of 10 sediment samples collected approximately a mile north and a mile south of the Site.[11] The Quendall cPAH BTV of 17.5 mg/kg organic carbon was calculated as the 95 percent UCL on the 95th percentile UCL (95/95 upper tolerance limit) of the Site-specific background data set.[12] The BTV was used to define the sediment remediation area for all OU2 remedial alternatives.

The sediment remediation area encompasses sediment that exceeds the human health and ecological risk-based sediment cleanup levels and the SMS (Chapter 173-204 WAC) freshwater criterion for total PAHs of 17 mg/kg-dry weight, based on protection of the benthic community. The Quendall BTV is not intended to be used to define either natural or regional background as defined in the SMS.

Shoreline Habitat Considerations

Shoreline habitat in the uplands is managed under OU1 (see Section 9.1.3).

In OU2, remedial components planned and/or selected for the in-water habitat area near the shoreline would need to consider potential access and use limitations. Accordingly, some potential remedial components of the OU2 alternatives may not be compatible with future habitat areas. For example, repair and replacement of sediment caps along the shoreline may require periodic use of heavy equipment, requiring EPA, the Muckleshoot Tribe, and natural resource agencies to agree that such access for purposes of installation, operation, and maintenance were acceptable.

In accordance with the Endangered Species Act, the habitat needs of juvenile Chinook salmon were an important focus when evaluating alternatives in the FS and would be a key element of the mitigation plan development during remedy design. A mitigation plan would be developed and approved in concert with EPA, the natural resource agencies, and the Muckleshoot Tribe.

For OU2 alternative development and evaluation, the following assumptions regarding habitat were made:

- The habitat area of OU1 would consist of a 100-foot-wide corridor along the shoreline and must be preserved if remedial components for OU2 require future access for monitoring or maintenance.
- In-water work, such as sediment capping, dredging, backfilling, and sheet pile installation, would occur during the allowable in-water work window when Endangered Species Act-protected juvenile Chinook salmon are not migrating through the area, which currently extends from July 16 to December 31 annually. However, dredging within sheet pile enclosures could occur outside of the in-water work window as the sheet pile isolates the dredge area from the lake.
- Remedy implementation would result in no net loss of aquatic habitat or function. For most alternatives, this is accomplished by maintaining the existing bathymetry near the shoreline (within 75 feet of the ordinary high-water mark) and ensuring a habitat-friendly cap treatment (e.g., fish mix). For alternatives for OU2 with sediment caps along the shoreline, existing sediment would be removed to offset the cap thickness.

Potential Generation of Dangerous Waste During Remediation

Based on RI sediment data, most of the sediment in proposed dredged areas has concentrations of contaminants that are lower than the Washington State Dangerous Waste criteria. For the FS cost estimates, it was assumed

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[10] cPAHs consist of a family of compounds that all have the same mechanism of toxicity. To derive the overall toxicity of a cPAH mixture, the concentration of each cPAH in the mixture is expressed in terms of the concentration of an index compound, benzo[a]pyrene, that is equivalent in toxicity (i.e., toxic equivalent or TEQ) to that of each mixture component. The toxicity of the mixture is the sum of the TEQs for all of the cPAHs found in the mixture.

[11] As detailed in the Quendall FS (Aspect and Arcadis 2016), Appendix B1. cPAH Background Threshold Value and Replacement Value Calculation Memo.

[12] The 95/95 upper tolerance limit was based on a gamma distribution, as determined using ProUCL (EPA 2015). *ProUCL Version 5.1 Technical Guide Statistical Software for Environmental Applications for Data Sets with and without Non-detect Observations*. EPA/600/R-07/041.

that none of the dredged material would be designated as a Washington State Dangerous Waste. For the FS cost estimates including sediment disposal, it was assumed that sediment generated would be disposed of at a RCRA Subtitle D landfill.

Institutional Controls

ICs would be required for all OU2 alternatives and would be an important part of the overall Site remedy because varying degrees of contamination exceeding cleanup levels would initially remain onsite for all alternatives. Many types of ICs may be applied at the Site to control human exposure pathways, including government controls, proprietary controls (e.g., MTCA environmental covenants), enforcement and permit tools, and informational devices.

ICs would include prohibitions against sediment-disturbing activities in capped areas and limitations on beach access, which would require coordination with both the private aquatic landowners and Washington State Department of Natural Resources for the state-owned aquatic lands. Easements would also be needed to ensure access to remedy components such as caps.

Inspections, Monitoring, and Reporting

Monitoring would be conducted to confirm that the remedy is functioning as intended and to evaluate the short- and long-term effectiveness of the remedy. Monitoring requirements would reflect the extent of contamination left onsite, the reliability of engineering controls, and repair and/or replacement frequency.

At OU2, monitoring would require at a minimum:

- Short-term monitoring during construction and post-construction until the remedial action performance goals and cleanup levels are met.
- Long-term monitoring is expected to include bathymetric surveys to assess the integrity of sediment caps and covers and sampling to determine whether the sediment remedy continues to function as designed and meets performance criteria.

For all alternatives, all monitoring activities would also be conducted after significant natural events such as earthquakes. Statutory 5-year reviews would be required in perpetuity.

ARARs

CERCLA requires remedial actions to comply with ARARs or waive them. Because all alternatives use similar technologies within OU2, the primary ARARs are the same for all alternatives. The following is a summary list of key ARARs associated with the remedial alternatives for OU2; specific requirements that are ARARs for OU2 are listed in Tables 10-4, 10-5, and 10-6:

- Section 404 (b) of the CWA requires protection of aquatic ecosystems by dredging or filling waters during the cleanup activities. This is applicable for treatment of contaminated wetlands and riparian habitat adjacent to the shoreline.
- Section 401 of the CWA requires protection of water quality from discharges of pollutants into waters of the United State. Dredging or capping sediments may cause dispersion of contaminated sediments through the water column during cleanup activities.
- Section 304 (a) of the CWA includes water quality criteria for surface water protective of aquatic life and human health.
- MTCA and SMS specify risk thresholds for developing cleanup levels. EPA-developed cleanup levels would meet the substantive MTCA and SMS requirements.
- The Endangered Species Act protects endangered or threatened species and critical habitat that may be present at or migrate through the Site.

- Washington State Water Pollution Control Act Water Quality Standards prohibit the discharge of polluting matter into state waters.
- State solid and dangerous waste regulations would apply for characterizing and managing dredged sediment onsite.

9.2 Remedial Alternatives

This section describes the alternatives evaluated by EPA and presented in the Proposed Plan for OU1 and OU2. Remedial alternatives considered for OU1 include the No Action Alternative (Alternative 1) and five remedial alternatives, designated as Alternatives 7, 7a, 8, 9, and 10. Remedial alternatives considered for OU2 include the No Action Alternative (Alternative 1), and five remedial alternatives, designated as Alternatives A, B, C, D, and E.

A full description of the Selected Remedy for OU1 (Alternative 7a) and the Selected Remedy for OU2 (Alternative D) is provided in Section 12 of this ROD.

9.3 OU1 Remedial Alternatives

This section describes the upland alternatives evaluated by EPA. Alternatives 7 through 10 treat or remove DNAPL source, which is expected to immediately and substantially reduce contaminant concentrations and allow for achievement of the RAO for groundwater restoration in a reasonable timeframe. The first two alternatives rely on in situ treatment of the DNAPL source, while the later alternatives rely increasingly on removal to address DNAPL and associated soil contamination at the Site. All alternatives include groundwater monitoring to evaluate the effectiveness of the remedy.

Area, depth, and volume estimates are based on information provided in the FS and would be refined, as appropriate, in the remedial design.

The operations and maintenance (O&M) costs and the total estimated present-value costs were developed using a 7 percent discount rate. The construction durations presented in this discussion include time for the remedial design, and the time to meet RAOs includes construction time and confirmation monitoring to ensure that the remedies are protective.

Alternative 1 – No Further Action

The Superfund program requires that the No Action Alternative be considered as a baseline for comparison with the other alternatives. Under Alternative 1, no further action would be taken for OU1. Alternative 1 is not considered protective and does not meet ARARs or achieve RAOs.

Alternative 1 – No Action

Estimated Capital Costs: $0	Estimated Construction Timeframe: 0
Estimated O&M Costs: $0	Estimated Time to Achieve RAOs: Not Applicable
Total Estimated Present Value: $0	

Alternative 7 – In Situ Solidification of DNAPL and Soil Capping

Alternative 7 actively addresses the upland DNAPL source and includes the following components (Figure 9-1):

- ISS treatment of DNAPL to stabilize source material causing contamination in both the shallow and deep aquifers (9 acres, maximum depth of 36 feet bgs,[13] solidifying 241,000 CY, of which 30,500 CY is DNAPL-impacted soil[14]).
- Soil cap where COCs exceed cleanup levels in surface soil, to maintain protectiveness (3 feet thick).
- ICs and monitoring to help ensure the integrity of engineered controls and the effectiveness of the remedy.

In this alternative, it is assumed the extent of ISS would be advanced approximately 2 feet below the deepest DNAPL source material in each treatment area to provide a buffer between solidified DNAPL and the surrounding aquifer.

Areas where COCs exceed cleanup levels in surface soil would be covered with a soil cap to prevent direct contact with affected soil.

No active groundwater treatment is included in Alternative 7 because ISS of the DNAPL source is expected to immediately and substantially reduce contaminant concentrations and allow for achievement of cleanup levels in groundwater in a reasonable timeframe (25 to 30 years). Groundwater would be monitored to verify that the remedy is performing as intended (concentrations of COCs are decreasing over time and are expected to reach cleanup levels within the estimated timeframe).

O&M would include cap inspections and groundwater monitoring.

Alternative 7 – In Situ Solidification of DNAPL and Soil Capping

Estimated Capital Costs: $65,300,000	Estimated Construction Timeframe: 4.8 years of design/construction[15]
Estimated O&M Costs: $700,000	Estimated Time to Achieve RAOs: Ready in 5 years for anticipated reuse; RAO for groundwater expected to be met in reasonable timeframe since DNAPL is addressed
Total Estimated Present Value: $66,000,000	

Alternative 7a – In Situ Smoldering Combustion and/or In situ Solidification of DNAPL, and Soil Capping (Selected Remedy)

Alternative 7a actively addresses the upland DNAPL source and includes the following components (Figure 9-2):

- In situ smoldering combustion treatment of DNAPL to destroy source material causing contamination in both the shallow and deep aquifers (2.3 acres, average depth of 19 feet bgs, for a total of 71,400 to 17,000 CY of which is DNAPL-impacted soil).[16]
- ISS treatment of DNAPL to stabilize remaining source material outside treatment sectors identified for in situ smoldering combustion (6.7 acres, maximum depth of 36 feet bgs, for a total of 169,600 CY, of which 13,500 CY is DNAPL-impacted soil).
- A pretreatment high-resolution site characterization study (HRCS) to refine the CSM specific to DNAPL distribution and characteristics to support optimization and definition of remedial treatment sectors and development of groundwater flux performance requirements.

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13 The deepest observed DNAPL is 34 feet bgs; therefore, 36 feet represents the depth 2 feet below the maximum depth.

14 Based on the volume of DNAPL-impacted soil presented in FS Table 6-2.

15 Design and construction duration estimates were based on information provided in Figure 7-5 of the FS (Arcadis 2012). Design duration presented in the FS included a combined design effort for OU1 and OU2. For purposes of this ROD, the full design duration was included.

16 For the purpose of cost estimating, the Proposed Plan assumed that areas targeted for smoldering combustion would include at least 4 feet of cumulative DNAPL in a single location; the estimate of 17,000 CY of DNAPL-impacted soil for these areas is from FS Table 6-2 (Arcadis 2012).

- Soil cap (3 feet thick) where COCs exceed cleanup levels in soil (upper 15 feet), to maintain protectiveness with ICs to restrict subsurface direct contact.
- Other ICs and monitoring to help ensure the integrity of engineering controls and the effectiveness of the remedy.

Alternative 7a is similar to Alternative 7 but adds in situ smoldering combustion as the primary DNAPL treatment technology. During remedial design and prior to the implementation of the combustion treatment, an implementation plan would be developed to detail the implementation process. This plan would be developed in coordination with technical experts from the Region and other EPA offices. Predesign characterization data would be collected to evaluate DNAPL source strength using a high-resolution site characterization (HRSC) method. This information would be used to delineate separate treatment sector boundaries for smoldering combustion and ISS and performance measures (e.g., mass reduction, residual concentration limits) for each technology. In general, HRSC values indicating the presence of DNAPL with TPH concentrations greater than 3,000 ppm would be treated using smoldering combustion. HRSC values indicating significant sources of DNAPL with TPH less than 3,000 ppm would be identified as potential ISS sectors. Remedial action implementation will include ongoing evaluation of the smoldering technology and optimization of the implementation approach. An adaptive management approach will be used throughout source treatment to optimize the implementation and fine-tune sector boundaries for each technology.

For ROD-level cost-estimating purposes, it was assumed that smoldering combustion would destroy 17,000 CY of a total of 30,500 CY of DNAPL-impacted soil (approximately 56 percent), and ISS would be used to treat the remainder of the DNAPL-impacted soil. Even though the total area (acres) treated by smoldering combustion (2.3 acres) is less than the area estimated for ISS (6.7 acres), the areas estimated for smoldering combustion contain greater thicknesses of DNAPL than the areas identified for ISS. While these estimates are based on separate application of the two technologies, the HRCS may identify areas where both technologies may be needed.

Areas where COCs exceed cleanup levels in the top 15 feet of soil would be covered with a soil cap to prevent direct contact with contaminated soil.

No active groundwater treatment is included in Alternative 7a because treatment of the DNAPL source is expected to immediately and substantially reduce contaminant loading and concentrations and allow achieving cleanup levels in groundwater in a reasonable timeframe (25 to 30 years). Groundwater would be monitored to verify that the remedy is performing as intended (concentrations of COCs are decreasing over time and are expected to reach cleanup levels within the estimated timeframe). The groundwater decision diagram, Figure 12-4, depicts the logic that will be used to assess progress towards achievement of groundwater cleanup levels.

O&M would include cap inspections and groundwater monitoring.

Alternative 7a – In Situ Smoldering Combustion and/or In Situ Solidification of DNAPL and Soil Capping

Estimated Capital Costs: $65,400,000	Estimated Construction Timeframe: 5 years of design/construction
Estimated O&M Costs: $700,000	Estimated Time to Achieve RAOs: Ready in 5 years for anticipated reuse; RAO for groundwater expected to be met in reasonable timeframe since DNAPL is addressed
Total Estimated Present Value: $66,100,000	

Alternative 8 – Removal and Ex Situ Thermal Treatment of DNAPL and Soil Capping

Alternative 8 actively addresses the upland DNAPL source and includes the following components (Figure 9-3):

- Removal of DNAPL by excavation of source material causing contamination to both the shallow and deep aquifers (9 acres, to a maximum depth of 34 feet bgs).
- Onsite ex situ thermal treatment of the excavated materials (approximately 210,000 CY); contaminants in the off-gas would be incinerated.

- Shoring and dewatering to facilitate the excavation.
- Soil cap where COCs exceed cleanup levels in surface soil, to maintain protectiveness (3 feet thick).
- ICs and monitoring to help ensure the integrity of engineered controls and the effectiveness of the remedy.

In this alternative, DNAPL and overlying soil would be excavated, treated onsite, and reused as backfill. Thermal treatment of the excavated soil would be performed onsite, and contaminants in the off-gas would be incinerated. It is assumed that thermal treatment of the excavated soil would remove DNAPL, but the treated soil could still exceed cleanup levels and require containment (such as capping).

Areas where COCs exceed cleanup levels in surface soil would be covered with a cap to prevent direct contact with affected soil.

No active groundwater treatment is included in Alternative 8 because removal of the DNAPL source is expected to immediately and substantially reduce contaminant concentrations and allow for achievement of cleanup levels in groundwater in a reasonable timeframe (25 to 30 years). Groundwater would be monitored to verify that the remedy is performing as intended (that is, concentrations of COCs are decreasing over time and are expected to reach cleanup levels within the estimated timeframe).

O&M would include cap inspections and groundwater monitoring.

Alternative 8 – Removal and Ex Situ Thermal Treatment of DNAPL and Soil Capping

Estimated Capital Costs: $99,400,000	Estimated Construction Timeframe: 4.3 years of design/construction
Estimated O&M Costs: $600,000	Estimated Time to Achieve RAOs: Ready in 5 years for anticipated reuse; RAO for groundwater expected to be met in reasonable timeframe since DNAPL is addressed
Total Estimated Present Value: $100,000,000	

Alternative 9 – In Situ Solidification and Removal/Ex Situ Thermal Treatment of DNAPL and Contaminated Soil, and Soil Capping

Alternative 9 actively addresses the upland DNAPL source and contaminated soil in the shallow alluvium, defined by the extent of MCL exceedances within the groundwater plume. It includes the following components (Figure 9-4):

- Removal of shallow upland DNAPL and contaminated soil (to 15 feet bgs) by excavation to address the source of contamination to the shallow aquifer and affected media (14 acres).
- Onsite ex situ thermal treatment of the excavated materials (340,000 CY); contaminants in the off-gas would be incinerated.
- Shoring and dewatering to facilitate the excavation.
- ISS of deep upland DNAPL and contaminated soil to address the source of contamination to the deep aquifer and affected media (14 acres, to a maximum depth of 40 feet bgs, approximately 360,000 CY).
- Soil cap where COCs exceed cleanup levels in surface soil, to maintain protectiveness (3 feet thick).
- ICs and monitoring to help ensure the integrity of engineered controls and the effectiveness of the remedy.

Alternative 9 assumes that upland source-area soils are excavated to a depth of 15 feet. Thermal treatment of the excavated soil would be performed onsite, and contaminants in the off-gas would be incinerated. It is assumed that thermal treatment of the excavated soil would remove DNAPL, but the treated soil could still exceed cleanup levels and require containment (such as capping).

Areas where COCs exceed cleanup levels in surface soil would be covered with an engineered cap to prevent direct contact with affected soil.

No active groundwater treatment is included in Alternative 9 because treatment and/or removal of the DNAPL source and contaminated soil is expected to immediately and substantially reduce contaminant concentrations in groundwater and allow for achievement of cleanup levels in groundwater in a reasonable timeframe (25 to 30 years).

Groundwater would be monitored to verify that the remedy is performing as intended (that is, concentrations of COCs are decreasing over time and are expected to reach cleanup levels within the estimated timeframe).

O&M would include cap inspections and groundwater monitoring.

Alternative 9 – In Situ Solidification and Removal/Ex Situ Thermal Treatment of DNAPL and Contaminated Soil, and Soil Capping

Estimated Capital Costs: $218,600,000	Estimated Construction Timeframe: 9.3 years of design/construction
Estimated O&M Costs: $600,000	Estimated Time to Achieve RAOs: Ready in 10 years for anticipated reuse; RAO for groundwater expected to be met in reasonable timeframe since DNAPL and contaminated aquifer materials are addressed
Total Estimated Present Value: $219,200,000	

Alternative 10 – Removal and Ex Situ Thermal Treatment of DNAPL and Contaminated Soil, Soil Capping, and Groundwater Extraction and Treatment

Alternative 10 actively addresses the upland DNAPL source, contaminated soil in the shallow alluvium defined by the extent of MCL exceedances within the groundwater plume, and contaminated groundwater. It includes the following components (Figure 9-5):

- Removal of DNAPL and contaminated soil by excavation to address media causing contamination to both the Shallow Aquifer and Deep Aquifer (14 acres, to a maximum depth of 40 feet bgs).
- Onsite ex situ thermal treatment of the excavated materials (705,000 CY); contaminants in the off-gas would be incinerated.
- Temporary sheet pile, shoring, and dewatering to facilitate the excavation.
- Soil cap where COCs exceed cleanup levels in surface soil, to maintain protectiveness (3 feet thick).
- Groundwater extraction and onsite treatment to address contamination remaining at depth below excavated areas and speed restoration timeframe.
- ICs and monitoring to help ensure the integrity of engineered controls and the effectiveness of the remedy.

DNAPL and contaminated soil removal would be conducted in the dry where practicable to minimize residual contamination. It is assumed that contaminated soil excavation would require extensive shoring and dewatering with the water requiring treatment prior to discharge. Thermal treatment of the excavated soil would be performed onsite and contaminants in the off-gas would be incinerated. It is assumed that thermal treatment would remove DNAPL, but the treated soil could still exceed soil cleanup levels and require containment (such as capping).

Areas where COCs exceed cleanup levels in surface soil would be covered with a cap to prevent direct contact with affected soil.

Groundwater pump-and-treat technology would be implemented to address contamination remaining at depth below the excavated areas after removal of contaminated soils is completed. The objectives of the pump-and-treat system would be to increase flushing of the deeper alluvium and reduce the deep aquifer restoration timeframe. The pump-and-treat system would consist of a groundwater extraction system, an onsite treatment plant, and a means of handling the treated water (e.g., reinjection or discharge to Lake Washington). The addition of deep groundwater extraction and treatment is considered a polishing step and was not shown to have a significant impact since most of the contamination is addressed via removal of the DNAPL source material and contaminated soil.

O&M would consist of pumping and treating groundwater, groundwater monitoring, and cap inspections.

Alternative 10—Removal and Ex Situ Thermal Treatment of DNAPL and Contaminated Soil, Soil Capping, and Groundwater Extraction and Treatment

Estimated Capital Costs: $301,100,000	Estimated Construction Timeframe: 10.8 years of design/construction
Estimated O&M Costs: $8,200,000	Estimated Time to Achieve RAOs: Ready in 12 years for anticipated reuse; RAO for groundwater expected to be met in reasonable timeframe since DNAPL and contaminated aquifer materials are addressed, and pump-and-treat provides a polishing step to accelerate the timeframe
Total Estimated Present Value: $309,300,000	

9.3.1 OU2 Remedial Alternatives

This section describes the offshore alternatives evaluated by EPA. The first three alternatives rely more on capping, while the last two alternatives rely increasingly more on removal (dredging) to address contamination at the Site. All area, depth, and volume estimates are based on information provided in the FS and would be refined in the remedial design.

The O&M costs and the total estimated present-value costs were developed using a 7 percent discount rate. The construction durations presented in this discussion include time for the remedial design, and the time to meet RAOs includes construction time and confirmation monitoring to ensure that the remedies are protective. For Alternatives A through C, it is assumed that 10 years of monitoring (following construction) will be required to confirm that these remedies are protective and that the RAOs are met. Alternatives D and E assume 1 to 2 years of post-construction monitoring will be needed to confirm the remedies are protective.

Alternative 1 – No Action

As required under CERCLA, a “no action” alternative is evaluated to compare cleanup alternatives with baseline Site conditions. Under Alternative 1, no further action would be taken for OU2. Alternative 1 is not considered protective and does not meet ARARs or achieve RAOs.

Alternative 1 – No Action

Estimated Capital Costs: $0	Estimated Construction Timeframe: 0 years
Estimated O&M Costs: $0	Estimated Time to Achieve RAOs: Not applicable
Total Estimated Present Value: $0	

Alternative A – Amended Sand Cap, Reactive Core Mat Cap, Engineered Sand Cap, and Enhanced Natural Recovery

This alternative relies on capping technologies to contain DNAPL and prevent exposure to contaminated sediment. Alternative A includes the following components (Figure 9-6):

- Amended sand cap in DNAPL Area 6 (DA-6) (0.7 acre, 4.5 feet thick) to sorb COCs from DNAPL in upwelling groundwater and prevent exposure to contaminated sediment and porewater.
- RCM caps in remaining DNAPL areas (4.9 acres) to sorb COCs in upwelling groundwater, control DNAPL migration (when present in near surface), and prevent exposure to contaminated sediment and porewater.
- Engineered sand cap (6.2 acres, 1.5 feet thick) to address sediment outside DNAPL areas impacted by upwelling contaminated groundwater (erosion protection requirements determined during remedial design).
- Dredging within 75 feet of the ordinary high-water mark to maintain bathymetry beneath the RCM and engineered sand caps (2,800 CY).

- Onsite dewatering of dredged sediment (2,800 CY) and shipment offsite for disposal.
- ENR (17.6 acres, 6 inches thick) to remediate remaining areas within OU2, beyond the inner harbor zone of upwelling groundwater, where the BTV value is slightly (e.g., less than twice) exceeded.

Under this alternative, DNAPL area DA-6 would be capped with an amended cap, and remaining DNAPL areas would be capped with an RCM cap. An engineered sand cap would be applied to address sediment outside DNAPL areas impacted by upwelling contaminated groundwater. Erosion protection requirements and the need for a demarcation layer would be determined during remedial design. ENR would be applied in the remaining area of OU2.

From the shoreline to approximately 75 feet offshore, sediment would be dredged prior to capping to maintain the existing elevation and profile of the shoreline area. Removal of sediment would likely be conducted using mechanical removal equipment either from a barge or from the shoreline.

This alternative includes a shoreline modification that could be used to offset loss of habitat.

O&M would consist of sediment cap inspections and sampling, and RCM and sand cap shoreline maintenance.

Alternative A – Amended Sand Cap, RCM Cap, Engineered Sand Cap, and ENR

Estimated Capital Costs: $9,430,000	Estimated Construction Timeframe: 1.4 years of design/construction
Estimated O&M Costs: $2,270,000	Estimated Time to Achieve RAOs: 12 years
Total Estimated Present Value: $11,700,000	

Alternative B – Targeted DNAPL Removal (T-Dock DNAPL Area), Amended Sand Cap, RCM Cap, Engineered Sand Cap, and ENR

This alternative relies on a combination of dredging to remove shallow DNAPL and capping to contain DNAPL and prevent exposure to contaminated sediment. Alternative B includes the following components (Figure 9-7):

- Dredging in the T-Dock (DA-1 and DA-2) DNAPL areas (2.7 acres, maximum depth of 2.4 feet below the sediment surface to remove 12,200 CY) to address shallow DNAPL in lake sediments, with placement of a reactive cover over dredged areas to manage residuals, if necessary.
- Amended sand cap in the QP-S (DA-6) DNAPL area (0.7 acre, 4.5 feet thick) to sorb COCs from DNAPL in upwelling groundwater and prevent exposure to contaminated sediment and porewater.
- RCM caps in other sediment DNAPL areas (2.0 acres) to sorb COCs in upwelling groundwater, control DNAPL migration (when present in near surface), and prevent exposure to contaminated sediment and porewater.
- Dredging within 75 feet of the ordinary high-water mark to maintain bathymetry beneath the RCM and engineered sand caps (2,800 CY).
- Onsite dewatering of dredged sediment and shipment offsite for disposal (15,000 CY).
- Engineered sand cap (6.2 acres, 1.5 feet thick) to address sediment outside DNAPL areas impacted by upwelling contaminated groundwater.
- ENR (17.6 acres, 6 inches thick) to remediate remaining areas within OU2.

Alternative B includes dredging of the T-Dock DNAPL areas (DA-1 and DA-2). These T-Dock areas contain near-surface DNAPL deposits that may be potentially disturbed by boating activities such as anchoring, erosional forces from natural events such as wind or following a large seismic event. The FS assumed sediment in the T-Dock DNAPL areas would likely be removed using hydraulic dredging.

Following dredging, a reactive residuals cover (assumed in the FS to be composed of a 6-inch layer of 10 percent organoclay and 90 percent coarse sand by weight) would be placed, and then the dredge areas would be backfilled to original grade.

An amended sand cap would be constructed over the QP-S (DA-6) DNAPL area and RCM caps would be placed in remaining sediment DNAPL areas (DA-3, 4, 5, 7, and 8).

An engineered sand cap would be applied to address sediment outside DNAPL areas impacted by upwelling contaminated groundwater. Actual cap thickness, erosion protection requirements, and the need for a demarcation layer would be determined during remedial design. ENR would be applied in the remaining area of OU2.

Sediment from the shoreline to approximately 75 feet offshore would be removed (dredged) prior to capping to maintain the existing elevation and profile of the shoreline area.

O&M would consist of sediment cap inspections and sampling, and RCM and sand cap shoreline maintenance.

Alternative B – Targeted DNAPL Removal (T-Dock DNAPL Area), Amended Sand Cap, RCM Cap, Engineered Sand Cap, and ENR

Estimated Capital Costs: $15,900,000	Estimated Construction Timeframe: 2.1 years of design/construction
Estimated O&M Costs: $1,100,000	Estimated Time to Achieve RAOs: 13 years
Total Estimated Present Value: $17,000,000	

Alternative C – Targeted DNAPL Removal (T-Dock and QP-S DNAPL Areas), RCM Cap, Engineered Sand Cap, and ENR

This alternative relies on a combination of dredging to remove DNAPL from shallow and moderate depths and capping to contain DNAPL and prevent exposure to contaminants. Alternative C includes the following components (Figure 9-8):

- Dredging in the T-Dock (DA-1 and DA-2) DNAPL areas (2.7 acres, maximum depth of 2.4 feet below the sediment surface to remove 12,200 CY) to address shallow DNAPL in lake sediments, with placement of a reactive cover to manage residuals, if necessary.
- Dredging in the QP-S (DA-6) area (0.7 acre, maximum depth of 8.2 feet below the sediment surface to remove 11,000 CY) to address DNAPL in lake sediments along the shoreline, including temporary sheet pile, and placement of a reactive cover to manage residuals.
- RCM caps in other sediment DNAPL areas (2.0 acres) to sorb COCs in upwelling groundwater, control DNAPL migration (when present in near surface) and prevent exposure to contaminated sediment and porewater.
- Dredging within 75 feet of the ordinary high-water mark to maintain bathymetry beneath the RCM and engineered sand cap (2,700 CY).
- Onsite dewatering of dredged sediment (25,900 CY) and shipment offsite for disposal.
- Engineered sand cap (6.4 acres, 1.5 feet thick) to address sediment outside DNAPL areas impacted by upwelling contaminated groundwater.
- ENR (17.6 acres, 6 inches thick) to remediate remaining areas within OU2.

Alternative C includes dredging of the T-Dock DNAPL area (DA-1 and DA-2) as well as the QP-S (DA-6) area. The FS assumed sediment in the T-Dock area (DA-1 and DA-2) would be removed using hydraulic dredging, and sediment in the QP-S DNAPL area (DA-6) would likely be removed by mechanical dredging. A temporary sheet pile enclosure would be installed around DA-6 to isolate the dredging activities from the lake and to support removal of deep sediments. Removal depths would correspond with observed depths of DNAPL. Removed sediment would be dewatered and disposed of offsite.

Following dredging, a reactive residuals cover (assumed in the FS to be composed of a 6-inch layer of 10 percent organoclay and 90 percent coarse sand by weight) would be placed, and then the dredge areas would be backfilled to original grade.

RCM caps would be used in the remaining sediment DNAPL areas to sorb COCs in upwelling groundwater, control DNAPL migration (when present in near surface), and prevent exposure to contaminated sediment and porewater.

An engineered sand cap would be applied to address sediment outside DNAPL areas impacted by upwelling contaminated groundwater. Actual cap thickness, erosion protection requirements, and the need for a demarcation layer would be determined during remedial design. ENR would be applied in the remaining area of OU2.

Sediment from the shoreline to approximately 75 feet offshore would be removed (dredged) prior to capping to maintain the existing elevation and profile of the shoreline area.

O&M would consist of sediment cap inspections and sampling, and RCM and sand cap shoreline maintenance.

Alternative C – Targeted DNAPL Removal (T-Dock and QP-S DNAPL Areas), RCM Cap, Engineered Sand Cap, and ENR

Estimated Capital Costs: $22,300,000	Estimated Construction Timeframe: 2.8 years of design/construction
Estimated O&M Costs: $700,000	Estimated Time to Achieve RAOs: 13 years
Total Estimated Present Value: $23,000,000	

Alternative D – DNAPL Removal, Engineered Sand Cap, and ENR – Selected Remedy

This alternative relies on a combination of dredging to remove DNAPL from shallow and moderate depths and capping to contain DNAPL and prevent exposure to contaminants. Alternative D includes the following components (Figure 9-9):

- Dredging in the offshore (DA-1 through DA-4) DNAPL areas to address shallow DNAPL in lake sediments (3.3 acres, maximum depth of 3.7 feet below the sediment surface to remove 15,200 CY), with placement of a reactive cover to manage residuals, if necessary.
- Dredging in the DA-5 through DA-8 DNAPL areas to address deep DNAPL in lake sediments along the shoreline (3.1 acres, maximum depth of 14 feet below the sediment surface to remove 41,200 CY), including temporary sheet pile, and placement of a reactive cover to manage residuals.
- Dredging within 75 feet of the ordinary high-water mark, outside of DNAPL areas to maintain bathymetry beneath the engineered sand cap (1,900 CY).
- Onsite dewatering of dredged sediment (58,300 CY) and shipment offsite for disposal.
- Engineered sand cap to address sediment outside DNAPL areas impacted by upwelling contaminated groundwater (5.5 acres, 1.5 feet thick).
- ENR to remediate remaining areas within OU2 (17.6 acres, 6 inches thick).

Alternative D includes dredging of the DA-1 through DA-5 and DA-6 through DA-8 sediment DNAPL areas. The FS assumed offshore sediment removal would likely be performed by hydraulic dredging, and inner harbor sediment removal would be performed by mechanical dredging within a sheet pile enclosure. Removal depths would correspond with observed depths of DNAPL. Removed sediment would be dewatered and disposed of offsite.

Following dredging a reactive residuals cover (assumed in the FS to be composed of a 6-inch layer of 10 percent organoclay and 90 percent coarse sand by weight) would be placed, and then the dredge areas would be backfilled to original grade.

An engineered sand cap would be applied to address sediment outside DNAPL areas impacted by upwelling contaminated groundwater. Actual cap thickness, erosion protection requirements, and the need for a demarcation layer would be determined during remedial design. ENR would be applied in the remaining area of OU2.

Sediment from the shoreline to approximately 75 feet offshore would be removed (dredged) prior to capping to maintain the existing elevation and profile of the shoreline area.

O&M would consist of sediment cap inspections and sampling, and sand cap shoreline maintenance.

Alternative D – DNAPL Removal, Engineered Sand Cap, and ENR – Selected Remedy

Estimated Capital Costs: $39,500,000	Estimated Construction Timeframe: 4.1 years of design/construction
Estimated O&M Costs: $400,000	Estimated Time to Achieve RAOs: 6 years
Total Estimated Present Value: $39,900,000	

Alternative E – DNAPL and Contaminated Sediment Removal, Engineered Sand Cap, and ENR

This alternative relies on dredging to remove offshore DNAPL and contaminated sediment, and additional capping to contain and prevent exposure to contaminants. Alternative E includes the following components (Figure 9-10):

- Dredging in the offshore (DA-1 through DA-4) DNAPL areas (3.3 acres, maximum depth of 5.7 feet below the sediment surface to remove 23,700 CY) to address DNAPL in lake sediments along the former T-Dock and remove additional contaminated sediment, with placement of a reactive cover to manage residuals, if needed.
- Dredging in the inner harbor (NA-5 through NA-8) areas (4.7 acres, maximum depth of 27 feet below the sediment surface to remove 148,600 CY) to address DNAPL in lake sediments along the shoreline and remove additional contaminated sediment. It includes temporary sheet pile, and placement of a reactive cover to manage residuals.
- Dredging within 75 feet of the ordinary high-water mark, outside of DNAPL areas, to maintain bathymetry beneath the engineered sand cap (800 CY).
- Onsite dewatering and ex situ thermal treatment of dredged sediment (173,100 CY). It is assumed that thermal treatment would remove DNAPL and achieve levels protective of groundwater such that it could be placed onsite; however, the treated sediment may still exceed soil cleanup levels and require containment (such as capping).
- Engineered sand cap (3.9 acres, 1.5 feet thick) to address sediment outside DNAPL areas impacted by upwelling contaminated groundwater.
- ENR (17.6 acres, 6 inches thick) to remediate remaining areas within OU2.

Alternative E includes dredging of the offshore (DA-1 through DA-5) areas to 2 feet below the DNAPL and in the inner harbor (DA-6 through DA-8) sediment DNAPL areas, dredging down to 27 feet below sediment surface. Removal depths would correspond with observed depths of DNAPL. Removed sediment would be dewatered and disposed of offsite.

Dredged sediments would be dewatered, and then thermal treatment would be performed onsite and contaminants in the off-gas would be incinerated. It is assumed that thermal treatment would remove DNAPL; however, the treated sediment may still exceed soil cleanup levels and require containment (such as capping).

Following dredging, a reactive residuals cover (assumed in the FS to be composed of a 6-inch layer of 10 percent organoclay and 90 percent coarse sand by weight) would be placed, and then the dredge areas would be backfilled to original grade.

An engineered sand cap would be applied to address sediment outside DNAPL areas impacted by upwelling contaminated groundwater. Actual cap thickness, erosion protection requirements, and the need for a demarcation layer would be determined during remedial design. ENR would be applied in the remaining area of OU2.

Sediment from the shoreline to approximately 75 feet offshore would be removed (dredged) prior to capping to maintain the existing elevation and profile of the shoreline area.

O&M would consist of sediment cap inspections and sampling, and sand cap shoreline maintenance.

Alternative E – DNAPL and Contaminated Sediment Removal, Engineered Sand Cap, and ENR

Estimated Capital Costs: $96,000,000	Estimated Construction Timeframe: 7.6 years of design/construction
Estimated O&M Costs: $400,000	Estimated Time to Achieve RAOs: 9 years
Total Estimated Present Value: $96,400,000	

10 Summary of Comparative Analysis of Alternatives

EPA used the nine criteria required by CERCLA and the NCP (40 CFR Part 300.430[e] [9] iii) to evaluate and select the remedy. The results of those evaluations are used in this section to compare the alternatives by identifying the advantages and disadvantages of each alternative relative to one another, consistent with EPA guidance (EPA 1988).

Summaries of the comparative analyses of the alternatives for OU1 and OU2 are provided in Sections 10.1 and 10.2, respectively.

10.1 Summary of Comparative Analysis of Alternatives for OU1

10.1.1 Overall Protection of Human Health and the Environment

Overall protection of human health and the environment addresses whether each alternative provides adequate protection of human health and the environment and describes how risks posed through each exposure pathway are eliminated, reduced, or controlled, through treatment, engineering controls, and/or ICs.

Alternative 1, the No Action Alternative, does not satisfy the threshold criterion for overall protection of human health and the environment.

The remaining alternatives are expected to be protective of human health and the environment by eliminating, reducing, or controlling risks posed by the Site through treatment or removal of DNAPL, engineering controls, and ICs.

Alternatives 7 through 10 treat or remove DNAPL, the primary source of groundwater contamination. It is expected that these alternatives would achieve cleanup levels within a reasonable amount of time (25 to 30 years). The residual dissolved-phase groundwater plumes (benzene and naphthalene) remaining after source treatment are expected to be reduced by greater than 89 percent by volume.[17] Groundwater monitoring would be conducted to verify that concentrations are declining and that cleanup levels would be met.

Alternative 7 would solidify DNAPL using ISS, which limits leachability, but does not remove or destroy the contaminants. Alternatives 7a through 10 include either in situ thermal destruction (smoldering combustion) in addition to ISS (Alternative 7a) or removal followed by ex situ thermal destruction (Alternatives 8 through 10). Compared with Alternative 7, Alternatives 7a, 8, 9, and 10 would provide greater overall protection due to the destruction or removal of DNAPL versus relying solely on stabilization.

All alternatives would include ICs that specifically limit the use of groundwater as a drinking water source and vapor intrusion assessment or engineering controls for vapor intrusion may be required for any new construction until monitoring demonstrates that it is no longer needed.

10.1.2 Compliance with Applicable or Relevant and Appropriate Requirements

Section 121(d) of CERCLA and NCP §300.430(f)(1)(ii)(B) require that remedial actions at CERCLA sites at least attain legally applicable or relevant and appropriate federal and state requirements, standards, criteria, and limitations, which are collectively referred to as “ARARs,” unless such ARARs are waived under CERCLA Section 121(d)(4).

[17] Based on the estimated remaining plume volume as percent for naphthalene in Table A-7 of the Quendall FS Report (Aspect and Arcadis 2016).

Applicable requirements are those cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under federal environmental or state environmental or facility siting laws that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance found at a CERCLA site. Only those state standards identified by a state in a timely manner and that are more stringent than federal requirements may be applicable.

Relevant and appropriate requirements are those cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under federal environmental or state environmental or facility siting laws that, while not “applicable” to a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site, address problems or situations sufficiently similar to those encountered at the CERCLA site such that their use is well-suited to the particular site. Only those state standards that are identified in a timely manner and are more stringent than federal requirements may be relevant and appropriate.

Compliance with ARARs addresses whether a remedy meets all of the ARARs of other federal and state environmental statutes or provides a basis for invoking a waiver. The chemical-, action-, and location-specific ARARs for OU1 are presented in Tables 10-1 through 10-3, respectively.

Alternative 1, the No Action Alternative, does not satisfy the threshold criterion for compliance with ARARs. All other alternatives have common ARARs associated with the construction of the alternatives, as they share similar remedial technologies. All alternatives would attain the action- and location-specific ARARs.

Alternatives 7 through 10 would satisfy the threshold criterion for compliance with ARARs. EPA expects that when the DNAPL in soil is stabilized, destroyed, or removed, the residual dissolved-phase groundwater plumes (benzene and naphthalene) would be reduced by greater than 89 percent by volume, and groundwater would meet MCLs in 25 to 30 years as a result of remedy implementation. Site groundwater data for COCs, including benzene and cPAHs (COCs with MCLs), indicate a close association of MCL exceedances with the occurrence of DNAPL. EPA expects that when the DNAPL in soil is removed, benzene and cPAHs would largely be addressed. Arsenic is expected to be addressed, as well as the presence of DNAPL in the subsurface allows arsenic to more readily leach from soil (at naturally occurring concentrations) into the groundwater. This is believed to be the primary reason that arsenic is above the MCL in groundwater at the Site. There is no MCL for naphthalene, the other primary COC in groundwater; however, EPA expects that when the DNAPL in soil is removed, the naphthalene plume would also dissipate in a reasonable timeframe (25 to 30 years).

10.1.3 Long-Term Effectiveness and Permanence

Long-term effectiveness and permanence refers to expected residual risk and the ability of a remedy to maintain reliable protection of human health and the environment over time, once cleanup levels have been met. This criterion includes consideration of residual risk that would remain onsite following remediation and the adequacy and reliability of controls.

Each alternative, except the No Action Alternative, provides some degree of long-term protection. The long-term effectiveness and permanence rating is based on consideration of both the magnitude of residual risk associated with any contamination remaining at the Site following implementation of the remedy, and the reliability of controls. The magnitude of residual risk was evaluated in the context of achieving RAOs and considered the total volume of DNAPL removed or treated in each alternative.

A high rating was given to Alternatives 7 through 10, all of which would remove or treat DNAPL. Alternative 7a employs a smoldering combustion technology to destroy significant DNAPL sources in situ. Alternative 7a is more effective and permanent than Alternative 7 because smoldering combustion treatment destroys the DNAPL and is irreversible. There is more uncertainty associated with ISS, as the DNAPL and COCs are immobilized, but still present, and it is possible that dissolved-phase COCs could leach from the solidified soil. Alternatives 9 and 10 remove or treat more contaminated soil, providing the greatest long-term effectiveness and permanence.

All alternatives would require O&M activities and long-term monitoring to ensure that cleanup levels were achieved, and the reliability of caps were maintained. Reviews at least every 5 years, as required, would be necessary to evaluate the effectiveness of any of these alternatives because hazardous substances would remain onsite at concentrations above health-based levels.

10.1.4 Reduction of Toxicity, Mobility, or Volume through Treatment

Reduction of toxicity, mobility, or volume through treatment refers to the anticipated performance of the treatment technologies that may be included as part of a remedy. This criterion addresses the statutory preference for selecting remedial actions that employ treatment technologies that permanently and/or significantly reduce the toxicity, mobility, or volume of hazardous substances as their principal element.

Alternative 1, the No Action Alternative, does not include treatment of the remedy. Therefore, this alternative would not reduce the toxicity, mobility, or volume of hazardous substances at the Site.

Alternatives 7 through 10 include various degrees of treatment to reduce toxicity, mobility, or volume of DNAPL (PTW) and/or contaminated soil. Alternatives 7, 7a, and 9 include ISS; Alternative 7a includes in situ smoldering combustion; and Alternatives 8, 9, and 10 include ex situ thermal treatment of excavated DNAPL and/or contaminated soil. Alternative 10 also includes a groundwater pump-and-treatment system.

Alternatives 7 through 10 received a high rating for this criterion because they all include treatment of DNAPL. Inclusion of treatment by thermal destruction technologies (found in Alternatives 7a, 8, 9, and 10) was rated higher than ISS (found in Alternative 7 and selectively used in Alternatives 7a and 9), because the thermal technologies would reduce toxicity, mobility, and volume through destruction of DNAPL versus ISS, which would not reduce the volume, and would be less effective regarding toxicity and mobility. Alternative 7a provides targeted smoldering combustion destruction of DNAPL and avoids the significant cost of soil excavation required by Alternatives 8, 9, and 10. Alternative 10 would achieve the greatest reduction of DNAPL since it combines ex situ thermal treatment and includes a groundwater pump-and-treat system.

10.1.5 Short-Term Effectiveness

Short-term effectiveness addresses the period of time needed to implement the remedy and any adverse impacts that may be posed to the community, workers, and the environment during construction and operation of the remedy until cleanup levels are achieved.

In general, short-term impacts increase with the volume of contaminated material removed and/or handled. The more the volume of contaminated material handling needed, the greater the potential for short-term impact to occur such as failure of construction equipment and/or protective controls.

The remedial design for each alternative would include measures to minimize impacts to workers, community, and environment during the remedy implementation phase. The primary difference between alternatives is the duration of construction and the potential for exposures if construction equipment and/or protective controls fail.

Alternative 1, the No Action Alternative, would not be an effective alternative in the short-term because current risks from existing contamination would continue to exist.

Alternative 7a receives a high rating for this criterion since it has a relatively short estimated construction duration (2.5 years)[18] and presents the lowest risk to workers, the community, and the environment because DNAPL-containing materials would be treated in place, below the ground surface.

A moderate rating was given to Alternative 7. While it has a slightly shorter estimated construction duration (2.3 years) as compared to Alternative 7a (2.5 years), DNAPL is only addressed through ISS. During ISS, DNAPL-containing materials are brought to the surface during mixing, creating the potential for more short-term exposure impacts relative to Alternative 7a. However, Alternative 7 has fewer short-term impacts than Alternatives 8 through 10 that include excavation and ex situ thermal treatment.

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[18] Construction timeframes cited in this section do not include time for remedial design. Remedial design/construction timeframes are provided in Section 9 for each of the OU1 and OU2 alternatives.

Alternatives 8 through 10 received low ratings for this criterion because, in addition to the greater potential for exposure through a higher level of material handling for these alternatives, the construction periods are also longer, ranging from approximately 2.8 years for Alternative 8 to 6.3 and 7.8 years for Alternatives 9 and 10, respectively.

Air emissions from smoldering combustion (Alternative 7a) and from ex situ thermal treatment (Alternatives 8 through 10) would be addressed by engineering controls to ensure that the emissions meet applicable air emissions standards, mitigating any adverse on- or offsite impacts.

10.1.6 Implementability

Implementability addresses the technical and administrative feasibility of a remedy from design through construction and operation. Factors such as availability of services and materials, administrative feasibility, and coordination with other government entities are also considered.

All alternatives pose technical implementation challenges. All alternatives use proven technologies that have been implemented at other similar sites. Alternatives involving ISS (Alternatives 7, 7a, and 9) would require bench and/or pilot testing of potential amendment mixtures to determine proper mixes to optimize effectiveness, though this is not considered to be an implementability concern. ISS operations would include active vapor management, such as the use of temporary portable enclosures to control nuisance odors and allow for capture and treatment of vapors. Though this is not considered to be an implementability concern, it could have significant cost implications depending on the nature of the controls required.

For Alternative 7a, a laboratory-scale demonstration and field pilot study have both confirmed that DNAPL-impacted soil from the Site can be effectively treated by smoldering combustion (CH2M 2018; Savron 2018).

The deep excavations and ex situ thermal treatment included in Alternatives 8 through 10 would have substantially increased complexity. The excavations would require robust shoring and dewatering systems, including 95-foot-long sheet piles for Alternative 10, which are not readily available and could result in transportation challenges. Alternatives involving onsite thermal treatment of soil (Alternatives 8, 9, and 10) would require treatability testing as well. Onsite thermal treatment would also require air emission controls and extensive air monitoring.

During remedial design, all alternatives would require coordination with numerous federal and state regulatory agencies to ensure that all ARARs, policies, and regulations are met. Alternatives with longer construction durations and/or more construction elements would generally require more administrative coordination and have a greater potential for technical problems and schedule delays.

Alternatives 7 and 7a are rated moderate for implementability. Alternatives 8 through 10 are rated low for implementability due to the significantly greater challenges of shoring and dewatering, excavating extensively, and providing onsite thermal treatment of a large volume of material. Longer durations of construction activities increase the potential for more technical and administrative challenges.

10.1.7 Cost

The estimated present-worth costs for the alternatives, not including the No Action Alternative, range from $66.0 million for Alternative 7 to $309.3 million for Alternative 10. Table 10-7 provides costs for the OU1 alternatives.

10.1.8 Community Acceptance

EPA led a robust community involvement effort associated with the Proposed Plans. These efforts included producing and disseminating information such as fact sheets, establishing information repositories at EPA's Seattle office, the Renton Library, and on EPA's Superfund project website, and participating in community outreach events.

Through the public comment period, EPA received five oral comments during the public meeting and 25 written comments. Many commenters, including those from the public and those identified as PRPs, were concerned with the uncertainties with effectiveness and cost associated with the smoldering combustion technology. Some of the commenters sought more clarity on these concerns. Several comments were related to how the Selected Remedy would impact the community and who would bear the cost burden. Several commenters also expressed support for EPA's Preferred Alternatives.

EPA has addressed these comments in Part 3, the Responsiveness Summary.

10.1.9 State and Tribal Acceptance

The State of Washington and the Muckleshoot Tribe have reviewed the Proposed Plan for OU1 and support EPA's Selected Remedy.

10.2 Summary of Comparative Analysis of Alternatives for OU2

10.2.1 Overall Protection of Human Health and the Environment

Overall protection of human health and the environment addresses whether each alternative provides adequate protection of human health and the environment and describes how risks posed through each exposure pathway are eliminated, reduced, or controlled, through treatment, engineering controls, and/or ICs.

All alternatives, except Alternative 1 (No Action), would protect human health and the environment through combinations of containment and removal of contaminated sediment, and through ICs.

Alternatives A through C would achieve the RAOs for human health that focus on protection of current and future beach users and fish/shellfish consumers, and aquatic and aquatic-dependent wildlife.

However, these alternatives have a heavier reliance on ICs to control exposure to contaminated sediment and would require maintenance in perpetuity to ensure protectiveness.

Alternatives D and E remove DNAPL that is a contaminant source to sediment, and address the remaining areas with lower levels of contamination through capping and ENR. Alternative E further removes contaminated sediment beneath the lake where groundwater exceeds MCLs for benzo(a)pyrene, the most persistent contaminant. Alternatives D and E also include a sand cap in the inner harbor and ENR offshore to reduce concentrations of contamination in sediment and meet sediment cleanup levels within the remainder of OU2. For these alternatives, there would be a lesser reliance on caps because DNAPL is removed from the aquatic environment.

10.2.2 Compliance with Applicable or Relevant and Appropriate Requirements

As discussed in Section 10.1.2, compliance with ARARs addresses whether a remedy would meet all of the ARARs of other federal and state environmental statutes or provides a basis for invoking a waiver. Tables 10-4 through 10-6 present the chemical-, action-, and location-specific ARARs for OU2, respectively.

Alternative 1, the No Action Alternative, does not satisfy the threshold criteria for compliance with ARARs. All other alternatives have common ARARs, which are expected to be met. Alternatives A through E would satisfy the threshold criterion for compliance with ARARs in that chemical-specific ARARs would be met, and ARARs specific to the remediation activities and location of the Site would also be met.

10.2.3 Long-Term Effectiveness and Permanence

Long-term effectiveness and permanence refers to expected residual risk and the ability of a remedy to maintain reliable protection of human health and the environment over time, once cleanup levels have been met. This criterion includes consideration of residual risk that would remain onsite following remediation and the adequacy and reliability of controls.

Each alternative, except the No Action Alternative, provides some degree of long-term protection. The alternatives increase in effectiveness of assuring protection against potential exposure to, and migration of, contaminants as additional treatment components are included, or areas are expanded. Technologies that rely on long-term monitoring to ensure the viability of controls for DNAPL (e.g., amended sand caps and RCM caps) are considered to have a greater risk of failure than technologies that remove DNAPL (dredging). Use of engineered caps and ENR would also require long-term monitoring while contamination is managed in place. Monitoring frequency and specialized monitoring techniques can greatly increase the cost of long-term care of remedies.

Alternatives A through C rely on passive controls to address DNAPL that is left in place. Controls that rely on treatment (e.g., reactive sediment covers, amended caps, and RCM caps) to be effective are considered to have a greater risk of failure than controls that rely on providing a physical barrier, because treatment media can lose effectiveness over time. The long-term effectiveness and sorption capacity of the reactive materials in RCMs or amended caps is also unknown because the nature of the contaminant when it contacts the material (either as NAPL or in the dissolved-phase) influences both sorption and hydraulic conductivity through the RCM or amended sand cap. Additionally, these caps have the potential to be damaged through erosion and activities in Lake Washington, decreasing protectiveness. For these reasons, Alternative A is rated low and Alternatives B and C are rated moderate for this criterion as they remove no DNAPL and some DNAPL, respectively, and the risk for continued contamination of sediment and porewater would remain.

High ratings are given to Alternatives D and E, which would remove DNAPL through dredging. Alternatives that remove DNAPL and contaminated sediment provide a greater degree of long-term effectiveness and permanence. Alternative E removes the most contaminated sediment of the alternatives, providing the greatest long-term effectiveness and permanence.

All alternatives would require O&M activities and long-term monitoring to ensure that cleanup levels were achieved, and the reliability of caps is maintained. Reviews at least every 5 years, as required, would be necessary to evaluate the effectiveness of any of these alternatives because hazardous substances would remain onsite at concentrations above health-based levels.

10.2.4 Reduction of Toxicity, Mobility, or Volume Through Treatment

Reduction of toxicity, mobility, or volume through treatment refers to the anticipated performance of the treatment technologies that may be included as part of a remedy. This criterion addresses the statutory preference for selecting remedial actions that employ treatment technologies that permanently and/or significantly reduce the toxicity, mobility, or volume of hazardous substances as their principal element.

Alternative 1, No Action, does not include treatment of a component of the remedy, and therefore would not reduce the toxicity, mobility, or volume of contamination at the Site.

Alternatives A through C include RCM and/or amended caps in areas where DNAPL is left in place, which immobilize organic COCs through sorption. Alternatives B through E include reactive covers in areas that have been dredged, which also immobilize residual COCs through sorption. Alternative E includes ex situ thermal treatment of dredged sediment, which would remove DNAPL and achieve levels protective of groundwater such that it could be placed onsite; however, the treated sediment may still exceed soil cleanup levels and require containment, such as capping.

Alternative A is rated low with respect to this criterion because it includes only modest treatment and immobilizes but does not reduce volume or toxicity. Alternatives B, C, and D are given moderate ratings as compared to Alternative A as they would include reactive caps or reactive covers in dredged areas.

However, although reactive caps and covers reduce mobility of contaminants, they can lose effectiveness overtime. Alternative E is given a high rating compared to the others because it destroys contaminant mass through thermal treatment, providing the highest reduction of toxicity, mobility, and volume through treatment. Thermal treatment is irreversible.

10.2.5 Short-Term Effectiveness

Short-term effectiveness addresses the period of time needed to implement the remedy and any adverse impacts that may be posed to the community, workers, and the environment during construction and operation of the remedy until cleanup levels are achieved.

The remedial design for each alternative would include measures to minimize impacts to workers, community, and environment during the remedy implementation phase. The primary difference between alternatives is the estimated duration of construction and the potential for exposures if construction equipment and/or protective controls fail, a risk that generally increases with the volume of contaminated material removed or handled.

Alternative 1, the No Action Alternative, would not be an effective alternative because current risks from contamination would continue to exist. Alternatives A and B receive a high rating for this criterion as they have relatively short estimated construction durations (less than 1 year) and present the lowest risk to workers, the community, and the environment due to limited handling of DNAPL materials above ground. The greatest impacts would be expected in the aquatic environment; however, BMPs would be used to minimize water quality impacts, and habitat recovery would be expected to occur relatively quickly following placement of the residuals cover over dredged areas.

A moderate rating is given to Alternatives C and D. These alternatives have estimated construction durations ranging from 1.3 to 1.6 years. Dredged DNAPL is disposed of offsite, which has less short-term impacts relative to the ex situ thermal treatment option for Alternative E, which receives a low rating for this criterion. Alternative E has a greater potential for exposure through a higher level of material handling, air emissions from onsite treatment, and a longer construction time, estimated at 4.6 years.

10.2.6 Implementability

Implementability addresses the technical and administrative feasibility of a remedy from design through construction and operation. Factors such as availability of services and materials, administrative feasibility, and coordination with other government entities are also considered.

In general, implementability decreases with increased complexity of the alternatives. With the exception of the RCM caps, the technologies used by all alternatives are proven technologies that have been implemented at other, similar sites and could be implemented at the Quendall Site.

During remedial design, all alternatives would require coordination with numerous federal and state regulatory agencies to ensure that all ARARs, policies, and regulations are met. EPA, the Muckleshoot Tribe, and natural resource trustees would need to agree on maintenance and monitoring plans, such that access for purposes of installation, operation, and maintenance were acceptable. Alternatives with longer construction durations and/or more construction elements would generally require more administrative coordination and have a greater potential for technical problems and schedule delays.

Alternatives A through C that involve RCM or amended sand caps would require ongoing maintenance and monitoring in perpetuity. Alternatives C through E that include mechanical dredging of DNAPL-containing sediments in the QP-S DNAPL area have increased complexity due to installation and removal of temporary sheet-pile shoring systems and removal of relatively deep sediments. Thermal treatment of sediment under Alternative E would require air emission controls and extensive monitoring.

Alternatives A and B are rated high for implementability, as they involve mostly capping and no mechanical dredging. These alternatives also have the shortest construction period and the fewest construction elements. Alternatives C and D are rated moderate for implementability as they include greater challenges of shoring and dewatering sediments. Alternative E is rated low as it includes removal of significantly more sediment and provides onsite thermal treatment of a large volume of material.

Longer durations of construction activities increase the potential for more technical and administrative challenges.

10.2.7 Cost

The estimated present-worth costs for the alternatives, not including the No Action Alternative, range from $11.7 million for Alternative A to $96.4 million for Alternative E. Table 10-8 shows costs for the OU2 alternatives.

10.2.8 Community Acceptance

EPA led a robust community involvement effort associated with the Proposed Plans (EPA 2019a, 2019b). These efforts included producing and disseminating information such as fact sheets, establishing information repositories at EPA's Seattle office, the Renton Library, and on EPA's Superfund project website, and participating in community outreach events.

Through the public comment period, EPA received five oral comments during the public meeting and 25 written comments. Most comments pertained to the Preferred Alternative for OU1. For OU2, there were several comments regarding EPA's plan to dredge DNAPL-containing sediments. Some were in favor of more dredging, some in favor of less dredging. Several comments were related to how the Selected Remedy would impact the community and who would bear the cost burden. Several commenters also expressed support for EPA's Preferred Alternatives.

EPA has addressed these comments in Part 3, the Responsiveness Summary.

10.2.9 State and Tribal Acceptance

The State of Washington and the Muckleshoot Tribe have reviewed the Proposed Plan for OU2 and support EPA's Selected Remedy.

11 Principal-Threat Waste

The NCP establishes the expectation that treatment will be used to address the principal threats posed by a site whenever practicable (40 CFR 300.430[a] [1] [iii] [A]). PTWs are source materials that include or contain hazardous substances, pollutants, or contaminants that act as a reservoir of contaminants that can migrate to groundwater, surface water, or air, or act as a source for direct exposure. Contaminated groundwater generally is not considered to be a source material; however, NAPLs in soil, groundwater, and sediment would be viewed as source material. PTWs are source materials considered to be highly toxic or highly mobile that generally cannot be reliably contained or would present a significant risk to human health or the environment should exposure occur.

EPA has determined that DNAPL at the Quendall Site, whether in soils or sediments, is to be considered PTW because of the high level of toxicity inherent in the creosote/coal-tar DNAPL. Creosote/coal-tar contaminants present in DNAPL (benzene and naphthalene) are leachable and mobile via groundwater, and DNAPL classified as oil-wetted, may be also be mobile.

The OU1 alternatives described in this ROD include several technologies to address DNAPL in soil. Alternatives 8 and 10 use excavation to remove DNAPL-containing soil; Alternative 7a is a phased approach using smoldering combustion and ISS to destroy and address DNAPL in soil, through treatment; and Alternatives 7 uses ISS to immobilize DNAPL in soil, again through treatment. Alternatives 8, 9, and 10 involve excavation requiring onsite ex situ thermal treatment to remove DNAPL. Alternatives involving ISS would require bench and/or pilot testing of potential amendment mixtures to determine proper mixes to optimize effectiveness for immobilizing DNAPL. Smoldering combustion used in Alternative 7a would destroy DNAPL source material in place.

The OU2 alternatives use dredging to remove DNAPL-contaminated sediment in the lake bed. Dredged materials, including debris would be shipped offsite for disposal at a permitted landfill. Onsite dewatering would be conducted to meet the transportation and disposal requirements and to reduce disposal mass. Following dredging, a reactive residuals cover would be placed, and then the dredged areas would be backfilled to original grade. The composition of the reactive cover may include organoclay or other amendments to reduce the mobility of remaining contaminants. The composition, amount, and placement method for the reactive cover will be determined during remedial design.

12 Selected Remedy

Based on consideration of CERCLA requirements, the detailed analysis of remedial alternatives, and public comments, EPA has selected Alternative 7a, In Situ Smoldering Combustion and/or ISS of DNAPL, and Soil Capping, as the remedy for OU1. EPA has selected Alternative D, DNAPL Removal, Engineered Sand Cap, and ENR, as the remedy for OU2.

This section provides EPA's rationale for the Selected Remedy, a description of the anticipated scope, how the remedy will be implemented, and the expected outcomes.

12.1 Summary of Rationale for the Selected Remedy

The **Selected Remedy for OU1 (Alternative 7a)** meets the threshold criteria and provides the best tradeoffs among the balancing criteria, as compared to other OU1 alternatives. With the incorporation of smoldering combustion, the Selected Remedy will elevate overall protectiveness above that of Alternative 7 (ISS only) because high source-strength contaminants will be permanently destroyed.

Although Alternatives 8 through 10 include removal of DNAPL-contaminated soil, the Selected Remedy is more effective in the short-term as contaminants in thermally treated areas are not brought to the surface, minimizing exposure to Site workers. Alternatives 9 and 10 remove more contaminated soil than Alternative 7a; however, the additional cost for Alternatives 9 and 10 are not commensurate with the additional risk reduction with respect to overall protection of human health and the environment. The Selected Remedy satisfies the statutory preference for treatment and satisfies the requirement that remedial alternatives consider using innovative technology.

Groundwater treatment in the OU1 Selected Remedy will be addressed as part of the DNAPL source area technologies (STAR and ISS). This targeted groundwater remediation will substantially reduce contaminant loading and concentrations and allow for achieving cleanup levels in groundwater in a reasonable timeframe (25 to 30 years). Groundwater will be monitored to verify that the remedy is performing as intended (concentrations of COCs are decreasing over time and are expected to reach cleanup levels within the estimated timeframe). The groundwater decision diagram (Figure 12-4) depicts the logic that will be used to assess progress toward achievement of groundwater cleanup levels.

The **Selected Remedy for OU2 (Alternative D)** meets the threshold criteria and provides the best tradeoffs among the balancing criteria, as compared to other OU2 alternatives. The Selected Remedy will provide a high degree of protectiveness to human health and the environment, and a higher level of long-term effectiveness and permanence than Alternatives A through C, which rely on passive controls (capping) to address DNAPL that is left in place. Fewer engineering controls will be needed to protect contained contamination and less reliance is placed on ICs with Alternative D than with Alternatives A through C because the DNAPL source is removed. Alternative E removes more contaminated sediment than Alternative D; however, the additional cost for Alternative E is not commensurate with the additional risk reduction with respect to overall protection of human health and the environment.

12.2 Description of the Selected Remedy for OU1

The Selected Remedy to address contamination for OU1, shown on Figure 12-1, will consist of the following primary components:

- In situ smoldering combustion treatment of DNAPL to destroy source material causing contamination in both the shallow and deep aquifers (2.3 acres, average depth of 19 feet bgs, for a total of 71,400 to 17,000 CY of which is DNAPL-impacted soil).[19]
- ISS treatment of DNAPL to stabilize remaining source material outside treatment zones identified for in situ smoldering combustion based on pretreatment characterization results (6.7 acres, maximum depth of 36 feet bgs, for a total of 169,600 CY, of which 13,500 CY is DNAPL-impacted soil).
- The actual locations for smoldering combustion versus ISS are expected to be refined and modified and will be based on pretreatment characterization contaminant concentrations as determined during remedial design and refined during remedy implementation. Remedial action implementation will include ongoing evaluation of the technology performance and optimization of the implementation approach.
- A pretreatment HRCS will be conducted to refine the CSM specific to DNAPL distribution and characteristics to support optimization and definition of remedial treatment sectors and the flux-based groundwater treatment performance objectives for each technology.
- A soil cap 3 feet thick where COCs exceed cleanup levels in the top 15 feet of soil.
- ICs and monitoring to help ensure the integrity of engineering controls and the effectiveness of the remedy. This includes any areas where COCs exceed cleanup levels in soil. If redevelopment occurs, any new site construction and structures will require a vapor intrusion assessment, and implementation of mitigation measures (engineering controls) will be required to address unacceptable risks.

Components of smoldering combustion include the following:

- Temporary installation of electrically powered heaters and air injectors to initiate and promote combustion of subsurface DNAPL and propagation of the smoldering combustion front.
- Installation of temporary air injection wells to promote combustion and subsurface propagation of the smoldering combustion front.
- Collection and treatment of soil vapors to minimize the potential for nuisance odor migration or fugitive emissions during treatment and air monitoring to ensure effectiveness.
- Monitoring of subsurface conditions before, during, and after smoldering combustion treatment to assess performance.

Components of ISS include the following:

- Use of a large-diameter shrouded auger to mix Portland cement into coal-tar-contaminated materials.
- Collection of vapors from the auger shroud and treatment with a thermal oxidizer.
- Installation of a temporary enclosure for solidification areas near properties boundaries to control nuisance odors.
- Installation of perimeter real-time air monitoring stations.

The areas shown on Figure 12-1 for smoldering combustion and ISS are conceptual and will be refined prior to treatment implementation.

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19 For the purpose of cost estimating, the Proposed Plan assumed that areas targeted for smoldering combustion would include at least 4 feet of cumulative DNAPL in a single location; the estimate of 17,000 CY of DNAPL-impacted soil for these areas is from FS Table 6-2.

Figure 12-2 provides the DNAPL source treatment implementation process that begins with sitewide pretreatment characterization to update the CSM and delineate separate treatment sector boundaries for smoldering combustion and ISS. Conducting pretreatment characterization to define treatment areas prior to implementation, will decrease the timeframe needed for remedy completion and will allow for more certainty with the treatment approach. In general, soils containing DNAPL with TPH concentrations greater than 3,000 ppm and related application criteria will be candidates for treatment with smoldering combustion.[20]

Areas with soil containing DNAPL with TPH concentrations less than 3,000 ppm (or greater than 3,000 ppm and not meeting the application criteria) would be identified as ISS sectors. Remedial action implementation will include ongoing evaluation of the smoldering technology and optimization of this implementation approach. An adaptive management approach will be used throughout the source treatment process to optimize the implementation and fine-tune the treatment sector boundaries for each technology.

Areas where COCs exceed cleanup levels in the top 15 feet of soil will be covered with a soil cap, 3 feet thick, to prevent direct contact with affected soil.

12.2.1 Pretreatment Characterization

Pretreatment characterization data will be collected to evaluate DNAPL source strength using a HRSC method to be identified in the characterization planning document.

During pretreatment characterization activities, HRSC data (sensor response and stratigraphy), soil TPH concentration data, and visual observations of DNAPL in soil samples will be collected. These data will be used together to develop decision rules associated with HRSC data to define subsurface architecture of DNAPL and soil TPH concentrations. The pretreatment characterization data evaluation will consider the aggregate DNAPL thickness at each location, the areal extent of DNAPL occurrence, and the magnitude of the HRSC measured values. The CSM will be updated with this information and used with associated remedial technology implementation considerations (e.g., the 7-foot radius of influence for smoldering combustion or the 8-foot ISS auger diameter, etc.) to define separate sector boundaries for smoldering combustion treatment and ISS. Details regarding the areal extent, depth, number and spacing of samples, etc., will be determined and documented in pretreatment planning documents that will be approved by EPA.

12.2.2 Phase 1 Technology – Self-Sustaining Smoldering Combustion

Self-sustaining smoldering combustion will be implemented based on the results of the pretreatment characterization completed in areas where DNAPL is observed and concentrations of TPH exceed 3,000 ppm.

Self-sustaining smoldering combustion treatment uses equipment that can be moved around the Site. When “parked” in one location, it can treat a “sector” (a circle with a diameter of about 400 feet, equaling about 125,000 square feet). Combustion treatment implementation by sector and cell is described in Figure 12-3.

Each sector may include approximately 100 cells. A cell will contain 8 IPs spaced at 14 feet apart, covering 1,200 square feet. The 8 IPs in each cell will be activated at the same time. IPs will be installed at the base of each target treatment depth interval identified using real-time field soil core data.

Multiple IPs may be required if the target treatment interval is more than 7 feet thick or if two or more treatment zones are stratigraphically separated by low-permeability materials thicker than 2.5 feet.

After the cell is treated, then the same equipment will be moved to the next cell within the sector for treatment, and so on, until treatment within the sector is complete.

Following combustion treatment of each cell, soil intervals will be resampled to statistically confirm that no individual soil sample exceeds 3,000 ppm TPH. As part of the adaptive management approach, if soil intervals are found that still exceed 3,000 ppm TPH. As part of the adaptive management approach, if soil intervals are found

[20] The 2018 field pilot study at Quendall indicated that a single smoldering combustion ignition point where TPH concentrations are greater than 3,000 ppm has a radius of influence (treatment) of 7 feet (horizontally and vertically).

that still exceed 3,000 ppm after the first round of combustion treatment (e.g., in highly heterogeneous areas), an additional IP may be installed to retreat at that location. The performance of combustion treatment will be evaluated after each sector and will undergo an optimization evaluation before proceeding to the next sector. If combustion treatment is determined to be unsuccessful in any treatment sector, then an evaluation of whether such treatment should continue to other locations or be discontinued will be performed.

The Proposed Plan assumed that smoldering combustion would destroy approximately 60 percent of the significant DNAPL sources, and solidification would be used to treat the remainder. As part of the implementation strategy, the actual areas and depths for smoldering combustion and ISS, will be refined based on evaluation of the pretreatment characterization data (described in Section 12.2.1).

12.2.3 Phase 2 Technology – In Situ Solidification

ISS is the second remedial technology that will be used in the Quendall remediation strategy. ISS would be implemented where significant sources of DNAPL are identified and TPH concentrations are below 3,000 ppm or greater than 3,000 ppm and not meeting the combustion application criteria. The updated CSM will include plan view maps and cross-sections (or 3-dimensional representation) that depict soil and sediment characteristics, DNAPL distribution (saturation, thickness, areal extent, and continuity), and TPH concentrations. The updated CSM will be used to determine the area and volume of soils to be solidified using ISS.

Using ISS, creosote/coal-tar and contaminants in soil are solidified in place. This is done by injecting material very similar to cement into the ground and mixing it with the contaminated soil using large augers or via excavator mixing, depending on depth and area conditions. The augers include a mixing shaft to add amendments such as cement, soda ash, and/or bentonite to the soil. The cement grout and selected additives are pumped through the mixing shaft as the auger advances to create an amended column. Auger locations overlap to create a block of amended soils. Actual amendments and the amendment columns will be determined during remedial design.

As part of design, mix design testing would be performed to determine the optimum reagents, mix ratios, and characteristics of the treated material. Typical reagents include Portland cement, blast furnace slag, and bentonite. The mix design would be evaluated by measuring hydraulic conductivity, unconfined compressive strength, and overall leaching reduction in a series of tests prepared using DNAPL-contaminated soil obtained from the Site. Other test parameters may be identified during remedial design.

ICs will be required to prevent disturbances of the solidified areas (see Section 12.2.6).

12.2.4 Soil Cap

An upland soil cap will be placed in areas where contaminants exceed soil cleanup levels (in the upper 15 feet). The final design for the soil cap will depend on the implementation of smoldering combustion and ISS technologies, and habitat considerations across the Site. The soil cap will consist of the following components:

- A marker fabric layer will be placed across the entire Site to delineate existing soil from the future clean fill and cap material resulting from this action.
- A 3-foot-thick permeable soil cap will be placed over the entire Site where soil cleanup levels are exceeded (in the upper 15 feet). The cap will prevent exposure to contaminated media that remains in place at the Site.

Whether or not a soil cap is necessary for the habitat area will be determined as part of remedial design, and in conjunction with the design for habitat and wetland mitigation. For example, cap designs will need to accommodate grade changes for potential wetlands and include a root zone for plants. The habitat area will consist of a 100-foot-wide corridor along the shoreline.

ICs will be required, including prevention of disturbances of the soil cap and the subsurface soils and may include restrictions on future uses. The soil cap will require ongoing monitoring and maintenance to ensure cap effectiveness and integrity.

12.2.5 Performance Standards

Performance standards relating to the implementation of the Selected Remedy will be fully developed during the remedial design and will be based on environmental media and scientific criteria. The performance standards will be incorporated into all relevant remedial design documents. The standards will promote accountability and ensure that the remedy meets the cleanup levels, Site-specific ARARs, and RAOs.

In Situ Smoldering Combustion Performance Standards

Performance standards are developed to assess the successful implementation of smoldering combustion technology. Each combustion sector will be evaluated against the performance criteria to determine if the combustion treatment for the sector is complete.

The performance standard is based on post-treatment soil TPH concentration remaining in a given treatment cell. The total number of samples collected within each sector will be determined based on the areal extent and vertical distribution of DNAPL in the target treatment area, but will include a minimum of three samples per cell (i.e., a minimum of three samples per 1,200 square feet). For example, if 100 cells are present in a given treatment sector, at least 300 post-treatment characterization samples will be collected in that sector. Post-treatment characterization may also include approved field-screening tools (e.g., TarGOST®) to confirm treatment at a select number of locations (e.g., up to 50 percent of post-treatment characterization locations). The sampling methodology will be refined as part of the remedial design. In general:

- If post-treatment concentrations in the target treatment interval are above 3,000 ppm TPH, retreatment with smoldering combustion will be conducted.
- If concentrations are below 3,000 ppm TPH, smoldering combustion treatment for that cell is complete.

The post-treatment data evaluation will consider the magnitude and areal extent of post-treatment TPH concentrations above 3,000 ppm and a visual evaluation of combustion intervals. This information will be used to assess the residual source strength and to determine if treatment is sufficient to achieve cleanup levels and RAOs.

ISS Performance Standards

The performance standard for ISS will include strength, leachability, and permeability specifications that will be determined during the remedial design. Testing will be performed to confirm that mixing is complete and that permeability, leachability, and strength requirements are achieved.

Groundwater Performance Standards

The groundwater decision diagram (Figure 12-4) depicts the decision logic that will be used to assess progress towards achievement of groundwater cleanup levels. Treatment of the DNAPL source is expected to immediately and substantially reduce contaminant loading and concentrations and allow for achieving cleanup levels in groundwater in a reasonable timeframe (25 to 30 years). Groundwater will be monitored to verify that the remedy is performing as intended (concentrations of COCs are decreasing over time). If groundwater monitoring within the first 5 years following DNAPL treatment indicates that cleanup levels will not be met within 25 to 30 years, then a focused feasibility study will be conducted to identify alternatives to meet groundwater cleanup levels.

12.2.6 Institutional Controls

ICs will be required to help ensure the effectiveness of the engineering controls. ICs that will ensure future uses of the property are consistent with the protectiveness provided by the implemented, and will not impair, interfere with or damage the implemented remedial features include proprietary controls (e.g., MTCA environmental covenants), local zoning or other non-engineering controls. ICs would include prohibitions regarding disturbance of caps and soils with post-treatment concentrations above surface soil cleanup levels. The areas where contaminated soils have been solidified are not expected to require a soil cap but would require prohibitions against any action that may compromise the integrity of the solidified soil. ICs would also be used to control activities in the habitat area. ICs would be needed to prohibit future use of groundwater for drinking or other domestic purposes and construction of wells (other than for remediation or monitoring purposes). A MTCA covenant could be used to restrict future issues and control activities as described above, and to provide access to monitor the effectiveness of the remedy, and to inspect and maintain remedy components such as monitoring wells and caps in perpetuity. ICs will also include the need for vapor intrusion assessments for any redevelopment. Results of this assessment may require engineering controls and ongoing monitoring. The nature and geographic extent of restrictions needed will depend on future uses.

ICs will be established to:

- Protect the final Site caps from disturbance, including future construction actions that would expose workers or the public to contamination left below the cap or compromise the function of the caps.
- Protect areas that will be solidified against any action that may compromise the integrity of the solidified material.
- Prohibit the installation of groundwater wells and use of groundwater on the Site until groundwater beneath the Site meets cleanup levels (Section 8.2).
- Protect any habitat constructed or enhanced as compensatory mitigation for remedial construction impacts.
- Prevent human exposure to vapors present in future structures. If redevelopment occurs, any new site construction and structures require a vapor intrusion assessment, and implementation mitigation measures (engineering controls) will be required to address unacceptable risks.

ICs will be developed as part of the remedial design.

12.2.7 Monitoring Requirements

Monitoring is a crucial part of EPA's Selected Remedy cleanup plan. Monitoring will be conducted to evaluate the short- and long-term effectiveness of the remedy before, during, and after construction. Pretreatment characterization sampling will be conducted prior to implementation of the cleanup to determine existing baseline levels of contamination and to design the remedy specifications. Details of the pretreatment characterization are provided in Section 12.2.1. In addition to providing guidance on remedial implementation, the pretreatment characterization data will serve as a baseline for comparison to post-cleanup data and to aid in the evaluation of source treatment and control effectiveness. Overall, monitoring will aid in determining the effectiveness of the remedy and will ensure the remedy is protective of human health and the environment.

Monitoring During Construction

During active remediation activities (e.g., smoldering combustion, ISS, capping), monitoring will be conducted in the construction area, as appropriate. Air monitoring will be required during remedial actions to ensure contaminants do not exceed worker human-health-based concentrations in air. A construction quality assurance plan will be prepared following remedial design to establish procedures for environmental monitoring during each element of work. If contaminant levels exceed any water or air quality standards, work will be modified and/or additional controls will be taken as needed.

Long-term Monitoring

Following remedy completion, the long-term monitoring program will be designed and implemented. The long-term monitoring program will include sampling of groundwater to demonstrate achievement of groundwater cleanup levels and to ensure the protectiveness of human health and the environment.

Figure 12-4 depicts the decision logic that will be used to assess progress towards achievement of groundwater cleanup levels. Treatment of the DNAPL source is expected to immediately and substantially reduce contaminant loading and concentrations and allow for achieving cleanup levels in groundwater in a reasonable timeframe (25 to 30 years). Groundwater will be monitored to verify that the remedy is performing as intended (concentrations of COCs are decreasing over time). Groundwater monitoring will include assessment of lines of evidence for monitored natural attenuation. If groundwater monitoring within the first 5 years following DNAPL treatment indicates that cleanup levels will not be met within 25 to 30 years, then a focused study will be conducted to identify alternatives to meet groundwater cleanup levels.

Long-term monitoring will also include regular inspections of the entire remedy, including soil caps and covers, to ensure that they are effectively containing migration of contaminants and functioning as intended.

Additional details of long-term monitoring and maintenance, such as performance standards, sampling frequency, benchmarks, and maintenance of the remedy elements, will be provided in a long-term monitoring and maintenance plan to be developed during remedial design.

12.2.8 Remedy Implementation and Timeline

The Selected Remedy for OU1 has an estimated completion timeframe of 5 years, including design and construction activities. The pretreatment characterization and remedy design are expected to take 2.5 years. Following characterization and design, smoldering combustion and ISS can be implemented simultaneously, followed by Site capping and habitat restoration. The sequence of implementation will be defined in the remedial design and construction planning. It is estimated remedy implementation will take 2.5 years.

12.3 Description of the Selected Remedy for OU2

The Selected Remedy to address contamination for OU2, depicted on Figure 12-5, will consist of the following:

- Dredging in the DA-1 through DA-4 DNAPL areas (3.3 acres, maximum depth of 3.7 feet below the sediment surface to remove 15,200 CY) to address shallow DNAPL in lake sediments, with placement of a reactive cover to manage residuals.
- Dredging in the DA-5 through DA-8 DNAPL areas (3.1 acres, maximum depth of 14 feet below the sediment surface to remove 41,200 CY) to address DNAPL in lake sediments along the shoreline, including temporary sheet pile, and placement of a reactive cover to manage residuals.
- Onsite dewatering of dredged sediment (58,300 CY) and shipment offsite for disposal and potential treatment of dewatering water.
- Engineered sand cap (5.5 acres, 1.5 feet thick) to address sediment outside DNAPL areas impacted by upwelling contaminated groundwater.
- Dredging will be included within 75 feet of the ordinary high-water mark, to maintain the pre-cap bathymetry (bathymetry balance) near the shoreline (1,900 CY).
- ENR (17.6 acres, 6 inches thick) to remediate remaining areas within OU2.
- ICs and monitoring to help ensure the integrity of engineering controls and the effectiveness of the remedy.

Components of the Selected Remedy are discussed in more detail in the following sections.

12.3.1 Dredging – DNAPL Removal

Sediment removal can be accomplished by several methods. Sediment removal techniques for the Site will likely include a combination of hydraulic dredging and mechanical dredging:

- **Hydraulic dredging** is most commonly used for environmental dredging, and generally consist of a cutter head or horizontal auger that removes and transports sediment with entrained water as a slurry. Hydraulic dredging generally has greater control of resuspension of sediment and releases than mechanical dredging and would likely be used in areas with relatively shallow target dredge depths, such as DA-1 and DA-2. Hydraulic dredges are not effective at handling debris or larger heavier materials, so any relic offshore structures would be removed prior to dredging.

- **Mechanical dredges** remove bottom sediments through mechanical force, typically using a crane-mounted bucket, such as a clamshell, or fixed-arm articulated backhoe and bucket. A temporary sheet pile enclosure would be installed around the nearshore areas prior to dredging to isolate the dredging activities from the lake and support the dredging depth.

Dredge removal areas were determined based on observed depths of DNAPL. These dredge areas assumed 2 horizontal to 1 vertical (2H:1V) side-slopes to reduce sloughing and failure of adjacent sediments. A shallower slope (3H:1V) may be required in some areas where sediments are relatively soft or in deeper dredge areas. An overdredge allowance of 1-foot deeper than the target dredge depth was included in volume calculations.

The most effective and appropriate method to remove sediment within each area will be determined during the remedial design. The specifications of the hydraulic or mechanical dredging equipment, the extents of those techniques, and BMPs would be determined during the design or bidding, based on the detailed dredge design and in consultation with the services, as appropriate.

Following verification that dredge depths have been met, residuals management and backfilling will be completed. Residuals generated by dredging will be managed using a post-dredge residuals cover. A reactive residuals cover (composed of a 6-inch layer of 10 percent organoclay and 90 percent coarse sand by weight) will be placed in the dredged areas to address anticipated DNAPL and sediment residuals. Following placement of the residuals cover, these areas will be backfilled with sand to the pre-dredge grade. In offshore dredge areas, the need to backfill to existing grade will be further evaluated in design.

12.3.2 Sediment Management and Disposal

Dredged material will be disposed of at an offsite permitted landfill. Based on the review of available sediment data, most of the sediment has concentrations of total PAHs and benzene less than the Washington State Dangerous Waste criteria. It is assumed that dredged materials will be handled as nonhazardous waste. Nonhazardous dredged materials will be disposed of directly at a RCRA Subtitle D facility, in compliance with the acceptance criteria of the receiving facility. If dredged materials fail toxicity characteristic leaching procedure, some materials may be sent to a RCRA Subtitle C landfill.

Given the high moisture content of sediments, onsite dewatering will be conducted to meet the transportation and disposal requirements and reduce the disposal mass. An upland staging area will be used for sediment dewatering prior to loading for offsite transportation and disposal. Dewatering may consist of decanting, gravity dewatering, or additional of a solidification agent, such as cement, lime, or diatomaceous earth. Water generated during the dewatering process will be treated at a temporary onsite water treatment system and discharge to Lake Washington following treatment.

12.3.3 Engineered Sand Cap

For sediment outside DNAPL areas that exceed sediment cleanup levels and are impacted by upwelling contaminated groundwater (approximately 350 feet lakeward from the shoreline, 5.5 acres), a 1.5-foot-thick engineered sand cap will be used to prevent exposure to contaminated sediment and reduce concentrations of COCs entering the lake. Modeling completed during the FS, that considered various chemical and physical processes, indicated that a 1.5-foot thickness would be adequate; however, the actual thickness of the cap would be determined during remedial design.

From the shoreline to approximately 75 feet offshore, approximately 1.5 feet of sediment will be removed prior to capping to maintain the existing elevation and profile of the nearshore area. Removal of sediments would likely be conducted using mechanical removal equipment, as discussed in Section 12.3.1.

The shoreline areas may require erosion protection from wave energy and vessel-generated currents. The FS conservatively assumes that erosion protection will be required in shoreline areas with less than 15 feet of water depth. The FS evaluation indicated that the estimated armor size required will range from 6-inch diameter (riprap) for breaking waves, and 0.6-inch diameter (gravel) for nonbreaking waves. Additional assessment regarding the need for armoring, or the alternative use of biotechnical stabilization, will be conducted during the remedial design.

12.3.4 Enhanced Natural Recovery

For the areas within the OU2 remediation area beyond the inner harbor zone of upwelling groundwater that are not otherwise covered, ENR will be used. For the Selected Remedy, this will include approximately 17.6 acres within OU2. A thin layer of clean sand (approximately 0.5 foot) will be placed over the sediment to accelerate the rate of natural recovery by immediately reducing surface chemical concentrations and facilitating the reestablishment of benthic organisms.

The ENR material will likely consist of fine- to medium-grained sand, which would be applied using either hydraulic washing from the deck of a barge or by window placement from a split-hull hopper dredge.

The nature of the placed material and the application method will be determined during remedial design.

12.3.5 Performance Standards

Performance standards relating to the implementation of the Selected Remedy will be fully developed during the remedial design and will be based on environmental media and scientific criteria. The performance standards will be incorporated into all relevant remedial design documents. The standards will promote accountability and ensure that the remedy meets the RAOs, Site-specific ARARs, and cleanup levels.

Monitoring during and after construction will include environmental monitoring to ensure compliance with cleanup levels and ARARs, and monitoring of physical as-built conditions to ensure compliance with construction standards and project design documents. Construction performance standards will include:

- Verification of the dredge volumes and prisms to ensure as-built conditions meet design requirements.
- Verification of the cap thickness to ensure as-built conditions meet design requirements.
- Bathymetric survey to ensure as-built conditions meet design requirements.
- Post-construction sampling of the upper 10 centimeters of the cap to demonstrate that residual concentrations are at or below cleanup levels (Table 12-5). The total PAH cleanup level will be compared on a point-by-point basis for the protection of benthos. The remaining cleanup levels will be compared to the 95 percent UCL-derived concentration based on a systematic or grid-based sample design, with the sample number derived using statistical considerations appropriate for the objective.

12.3.6 Institutional Controls

ICs will be required to help ensure the effectiveness of the engineering controls (caps and covers). Many types of ICs may be applied at the Site to control human exposure pathways, including government controls, proprietary controls (MTCA environmental covenants), enforcement and permit tools, and informational devices.

ICs would include prohibitions against sediment-disturbing activities in capped areas and limitations on beach access, which would require coordination with both the private aquatic landowners and Washington State Department of Natural Resources for the state-owned aquatic lands. Easements would also be needed to ensure access to remedy components such as caps. ICs will be established to:

- Protect the Site caps from future construction actions that would expose humans or the aquatic species to contamination left below the cap.
- Protect the Site caps from any disturbance that might compromise the function of the cap.
- Protect any habitat constructed or enhanced as compensatory mitigation for remedial construction impacts.
- Restrict land use or access to nearshore areas and river banks to maintain the integrity of caps and/or mitigation areas.

Examples of ICs to protect caps and covers include MTCA environmental covenants and establishment of regulated navigation areas. ICs will be developed as part of the remedial design.

12.3.7 Monitoring Requirements

Monitoring will be conducted to evaluate the short- and long-term effectiveness of the remedy before, during, and after construction. Remedial design sampling will be conducted prior to implementation of the cleanup to determine existing baseline levels of contamination and to design the remedy specifications. The remedial design sampling data will serve as a baseline for comparison to post-cleanup data to evaluate remedy effectiveness in meeting RAOs and to aid in the evaluation of source control effectiveness.

Monitoring During Construction

During active remediation activities (e.g., dredging, capping, placement of clean sediment for ENR), monitoring will be conducted in the construction area (see Section 12.3.5). Remedial construction activities within the lake will require water quality control measures to ensure that water quality standards are met during construction. Air monitoring will be required during remedial actions to ensure contaminants do not exceed worker human-health-based concentrations in air. A construction quality assurance plan will be prepared following remedial design to establish procedures for environmental monitoring during each element of work. If contaminant levels exceed any water or air-quality standards, the work will be modified and/or additional controls will be taken as needed.

Long-term Monitoring

Following remedy completion, long-term monitoring will be completed at the Site. Long-term monitoring will include regular inspections of the entire remedy, including sediment caps and covers, to ensure that they are effectively containing migration of contaminants and functioning as intended.

The details of long-term monitoring and maintenance, such as performance standards, sampling frequency, benchmarks, and maintenance of the remedy elements, will be provided in a long-term monitoring and maintenance plan to be developed during remedial design. Long-term monitoring will include, at a minimum, the following:

- Chemical monitoring of sediments will be conducted to ensure ongoing protectiveness of human health and the environment, to ascertain ongoing attainment of cleanup levels, and to aid in the evaluation of source control effectiveness. Sampling will be conducted to verify concentrations of COC remain at or below cleanup levels.
- Physical monitoring of the caps, covers, and dredged areas will be conducted to ensure the integrity of the remedial action is maintained. At a minimum, the areal coverage of the cap and cover and the thickness will need to be verified. The caps will need to be inspected looking for the presence of NAPL.

At a minimum, it is intended that monitoring be conducted prior to each five-year review to support evaluation of performance and remedial goal attainment.

12.3.8 Remedy Implementation and Timeline

The Selected Remedy for OU1 has an estimated completion timeframe of approximately 5 years, including design and construction activities. The remedy design is expected to take 2.5 years.

The Selected Remedy for OU2 has an estimated completion timeframe of approximately 4 years, including design and construction activities, with design estimated to take 2.5 years. Following design, dredging can be implemented followed by capping and ENR.

The sequence of remedy implementation for both OU1 and OU2 will be defined in the remedial design and construction planning. Because thermal treatment of dredged sediments will be performed onsite, coordination with upland remedial activities will be required.

12.4 Use of Green Remediation Practices

To the extent practicable, the remedial design and action should be carried out consistent with EPA's *Region 10 Clean and Green Policy* (EPA 2009) and the *Superfund Green Remediation Strategy* (EPA 2010), including the following practices:

- Use renewable energy and energy conservation and efficiency approaches, including Energy Star equipment.
- Use cleaner fuels, such as low-sulfur fuel or biodiesel, diesel emissions controls and retrofits, and emission reduction strategies.
- Use water conservation and efficiency approaches, including Water Sense products.
- Use reused or recycled material within regulatory requirements.
- Minimize transportation of materials and use rail rather than truck transport to the extent practicable.

12.5 Summary of Estimated Remedy Costs

The total cost of the remedy is estimated to be $66,100,000 (OU1) and $39,900,000 (OU2), for a total of $106,000,000.

Selected Remedy Costs
Record of Decision for the Quendall Terminals Superfund Site

Selected Alternative	Remedial Construction	Operations and Maintenance Using 7.0 Percent Discount Rate[a]	Total Present Value Using 7.0 Percent Discount Rate	FS-Level Accuracy Range (-30%)	FS-Level Accuracy Range (+50%)
7a (OU1)	65,400,000	700,000	66,100,000	46,300,000	99,200,000
D (OU2)	39,500,000	400,000	39,900,000	27,900,000	59,900,000

Note:
[a] For estimating O&M cost, the cost estimate assumed O&M would be conducted for 100 years.

General assumptions that were used to estimate costs for the Selected Remedy include:

- All unit costs are identical to those presented in the FS (Aspect and Arcadis 2016), except for ISS and for smoldering combustion (see Appendix 2B for cost assumptions specific to smoldering combustion [Self-sustaining Treatment for Active Remediation – STAR]).
- All FS costs, except for ISS and smoldering combustion unit costs are based on 2015 dollars.
- All contingency and mobilization assumptions, and percentages based on construction costs, are identical to those presented in the FS.
- ISS unit costs for 8-inch and 4-inch auger solidification were revised from $70 and $90 per bulk cubic yard (CY) to $129 and $149, respectively, accounting for vapor extraction and treatment and air monitoring during all ISS operations, and subsurface debris removal and temporary enclosure (for odor control) during a portion of the ISS operations.
- Table 12-1 presents the FS-level cost estimate detail for the OU1 Selected Remedy. Costs for smoldering combustion are directly from a vendor. Appendix 2B contains additional details and assumptions for estimation of smoldering combustion costs. For FS-level cost-estimating purposes, it was assumed that smoldering combustion would destroy 17,000 CY of a total of 30,500 CY of DNAPL-impacted soil (approximately 56 percent), and ISS would be used to treat the remainder of the DNAPL-impacted soil. Even though the total area (acres) treated by smoldering combustion (2.3 acres) is less than the area estimated for ISS (6.7 acres), the areas estimated for smoldering combustion contain greater thicknesses of DNAPL than the areas identified for ISS (Figure 12-1).

- Table 12-2 shows the FS-level costs estimate detail for the OU2 Selected Remedy. These costs were taken from the FS.

12.6 Expected Outcomes of the Selected Remedy

The intent of the Selected Remedy is to protect human health and the environment; it is consistent with current and reasonably anticipated future redevelopment. The Selected Remedy will achieve substantial risk reduction by both treating the source materials constituting PTWs at the Site (DNAPL) and providing safe management of remaining material. Treatment of the source material (DNAPL) is consistent with the NCP's expectation that treatment be used to address the principal threats posed by a site, wherever practicable.

The Selected Remedy will achieve substantial risk reduction by destroying or solidifying DNAPL using smoldering combustion in OU1 and by dredging and capping the most contaminated sediments in OU2. Remaining risks will be reduced, to the extent practicable, through soil capping in OU1, sediment capping and ENR in OU2, and ICs. Table 12-3 and 12-4 summarize measures that will be used to determine when the OU1 and OU2 RAOs are met, respectively, and the anticipated timeframe to achieve the RAOs. Table 12-5 summarizes the cleanup levels and where those levels are applied nearshore (delineated by areas covered with 10 feet or less of water – see Figure 12-5) versus sitewide; the basis for the cleanup level, and the RAO achievement measure (e.g., 95 percent UCL in top 10 centimeter of sitewide sediment).

EPA anticipates that cleanup levels will be met for soil and sediment within the areas selected for smoldering combustion, ISS, and soil capping in OU1, and dredging and sediment capping and ENR immediately following construction. Treatment of the DNAPL source is expected to immediately and substantially reduce groundwater contaminant concentrations and allow for achievement of cleanup levels in groundwater in a reasonable timeframe (25 to 30 years). Groundwater will be monitored to verify that the remedy is performing as intended (concentrations of COCs are decreasing over time and are expected to reach cleanup levels within the estimated timeframe).

13 Statutory Determinations

Under CERCLA Section 121(b)(1) and (d) and the NCP Section 300.430(f)(5)(ii), EPA must select remedies that protect human health and the environment, comply with ARARs (unless a statutory waiver is justified), are cost effective, and use permanent solutions and alternative treatment technologies or resource recovery technologies to the maximum extent practicable. In addition, CERCLA includes a preference for remedies that employ treatment that permanently and significantly reduces the volume, toxicity, or mobility of hazardous wastes as a principal element and a bias against offsite disposal of untreated wastes. The following subsections discuss how the Selected Remedy for each OU meets these statutory requirements.

13.1 Protection of Human Health and the Environment

The Selected Remedy is protective of human health and the environment, complies with federal and state requirements that are applicable or relevant and appropriate to the remedial action, is cost effective, and uses permanent solutions and alternative treatment (or resource recovery) technologies to the maximum extent practicable.

The **Selected Remedy for OU1** will protect human health and the environment by treating significant DNAPL sources in the upland area that are currently leading to contamination in both the shallow and deep aquifers. A soil cap also will be installed where COCs exceed cleanup levels in surface soil. Treatment of DNAPL source material and capping the contaminated soil will minimize the exposure to COCs via direct contact or ingestion of contaminated soil. EPA believes the Selected Remedy for OU1 will also restore groundwater to its highest beneficial use (drinking water) in a reasonable timeframe through treatment of the DNAPL source material. The current highest estimated cancer risk associated with the residential pathway (dermal exposure to groundwater) is greater than 8×10^{-1} (Table 7-3). The estimated cancer risk associated with exposure to soil is 3×10^{-2}. Immediately after implementation of the OU1 Selected Remedy, there will no longer be any significant risk from coming into contact with surface soil because the soil cap will prevent direct contact with contaminated soil.

Risks to terrestrial wildlife will also be reduced. For groundwater, additional risk reduction will be achieved over time, with a long-term objective of achieving MCLs.

The **Selected Remedy for OU2** will protect human health and the environment by dredging DNAPL-contaminated sediments from the lake bed, capping sediments that may be impacted by upwelling contaminated groundwater, and applying a thin-layer cap (ENR). These actions will lower COC concentrations in surface sediment to concentrations that are protective for human health and aquatic-dependent wildlife. The current cancer risks associated with fish consumption pathways is 5×10^{-3} (Table 7-4). The estimated risk associated with the recreational beach user (direct exposure to surface sediment) is 3×10^{-4}. Immediately after construction of the OU2 Selected Remedy, people will be safe when coming into contact with surface sediment because removing contaminated sediments and capping residual contamination will prevent direct contact with contaminants. Risks to aquatic and aquatic-dependent receptors will also be reduced. Additional risk reduction is expected for recreational and subsistence fishers.

Substantial reduction in risk following remedy will ultimately result in a remedial action that meets all applicable risk-based criteria, and remaining COCs will be consistent with background concentrations. EPA will evaluate the cleanup during and after the remedial action.

13.2 Compliance with Applicable or Relevant and Appropriate Requirements

Section 121(d) of CERCLA and the NCP §300.430(f)(l)(ii)(B) require that remedial actions at CERCLA sites at least attain legally applicable or relevant and appropriate federal and state requirements, standards, criteria, and limitations, which are collectively referred to as "ARARs," unless such ARARs are waived under CERCLA §121(d)(4). Applicable requirements are those cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under federal environmental or state environmental or facility siting laws that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance found at a CERCLA site. Relevant and appropriate requirements are those cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under federal environmental or state environmental or facility siting laws that, while not "applicable" to a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site, address problems or situations sufficiently similar to those encountered at the CERCLA site that their use is well-suited to the particular site.

Tables 10-1 through 10-3 present the chemical-specific, action-specific, and location-specific ARARs for OU1. Key ARARs for OU1 include the MTCA, the Safe Drinking Water Act, and the CWA. The **Selected Remedy for OU1** will comply with all ARARs. The selected Remedy for OU1 is expected to achieve MCLs for benzene, cPAHs, and arsenic in groundwater in a reasonable timeframe. Based on data indicating a close association of MCL exceedances for benzene and cPAHs with the occurrence of DNAPL, EPA expects that when the DNAPL in soil is destroyed or solidified, the benzene and cPAH mass in groundwater will be significantly reduced. EPA also expects that when the DNAPL in soil is removed, arsenic will be addressed, as the presence of DNAPL in the subsurface allows arsenic to more readily leach from soil (at naturally occurring concentrations) into the groundwater, and is the primary reason that arsenic is above the MCL in groundwater at the Site. There is no MCL for naphthalene, the other primary COC in groundwater; however, EPA expects that when the DNAPL in soil is destroyed or solidified, the naphthalene plume will also dissipate within a reasonable timeframe (25 to 30 years).

Groundwater will be monitored following completion of the OU1 remedy construction and if EPA determines that MCLs will not be met in a reasonable timeframe, a focused feasibility study will be conducted to identify alternatives to meet groundwater cleanup levels.

Tables 10-4 through 10-6 present the chemical-specific, action-specific, and location-specific ARARs for OU2. The **Selected Remedy for OU2** will comply with all ARARs.

The Selected Remedy for each OU will require that some wastes be transported offsite for disposal and, therefore, will need to comply with applicable Washington State Dangerous Waste Regulations (WAC 173-303). Facilities accepting these wastes must be certified to accept the wastes. Land disposal restrictions apply to offsite disposal of dangerous wastes; these restrictions will be determined once the waste is characterized during remedial design.

In addition to ARARs listed in Tables 10-1 through 10-6, worker safety provisions at WAC 296-843, Hazardous Waste Operations, will be observed.

13.3 Cost-Effectiveness

The Selected Remedy for each OU at the Quendall Site is considered cost effective because the costs are proportional to overall effectiveness (see 40 CFR §300.430(f)(l)(ii)(D)). This determination was made by evaluating the overall effectiveness of those alternatives that satisfied the threshold criteria (that is, that protect human health and the environment and comply with all federal and any more stringent state ARARs, or as appropriate, waive ARARs). Overall effectiveness was evaluated by assessing three of the five balancing criteria (long-term effectiveness and permanence; reduction in toxicity, mobility, and volume through treatment; and short-term effectiveness) collectively.

The estimated present-worth cost of the **Selected Remedy for OU1** (Alternative 7a) is $66,100,000. Alternative 7 would immobilize and not remove or destroy the DNAPL source. Alternatives 8, 9, and 10 all include more expansive and costly work that realizes a nominal incremental benefit beyond that provided by Alternative 7a with respect to overall protection of human health and the environment. Alternative 8 would cost more than half than that of Alternative 7a, and while Alternatives 9 and 10 would be expected to result in minimally reduced timeframes to achieve the groundwater MCLs in OU1, the construction duration would nearly double, and the costs would be several times that of Alternative 7a. The relationship of the overall effectiveness of the Selected Remedy for OU1 was therefore determined to be proportional to the costs and hence represents a reasonable value.

The estimated present-worth cost of the **Selected Remedy for OU2** (Alternative D) is $39,900,000. Alternatives A, B, and C are less expensive but would only remove up to about 80 percent of the estimated DNAPL in sediment. Alternative E includes more expansive work that realizes a nominal incremental benefit beyond that provided by Alternative D with respect to overall protection of human health and the environment. Alternative E would cost more than twice that of Alternative D, and the construction duration would more than double. The relationship of the overall effectiveness of the Selected Remedy for OU2 was therefore determined to be proportional to the costs and hence represents a reasonable value for the money to be spent.

13.4 Utilization of Permanent Solutions and Alternative Treatment Technologies to the Maximum Extent Practicable

EPA has determined that the Selected Remedy for each OU at the Quendall Site represents the maximum extent to which permanent solutions and treatment technologies can be used in a practicable manner at the Site. Of those alternatives that are protective of human health and the environment and comply with ARARs, EPA has determined that the Selected Remedy provides the best balance of tradeoffs in terms of the five balancing criteria, while also considering the statutory preference for treatment as a principal element and bias against offsite treatment and disposal while considering state, tribal, and community acceptance.

The **Selected Remedy for OU1** treats the source materials constituting principal threats in the uplands at the Site. It includes a phased approach where alternative treatment technologies are used to treat sources with different source strength. The Phase 1 technology, smoldering combustion, will be used to destroy DNAPL with TPH concentrations greater than 3,000 ppm, while the Phase 2 technology, ISS, will be used to immobilize DNAPL source material outside of sectors defined for combustion treatment. Treatment of the DNAPL source material is expected to achieve significant reductions in COC concentrations in soil and ultimately groundwater, leading to groundwater restoration to its highest beneficial use (drinking water) in a reasonable timeframe. The Selected

Remedy satisfies the criteria for long-term effectiveness by destroying or immobilizing the DNAPL source in the uplands. The addition of a soil cap will effectively reduce the potential for direct contact with soil contaminants remaining onsite. The Selected Remedy presents fewer short-term risks than the other alternatives as contaminants with the highest source strength are not brought to the surface during mixing, and vapors are controlled. All alternatives evaluated are considered implementable with no major elements that distinguish one alternative over another.

The **Selected Remedy for OU2** removes the source materials constituting principal threats in the sediment in the Lake Washington portion of the Site. It also includes capping to address contaminated sediment outside DNAPL areas impacted by upwelling of contaminated groundwater, and ENR to remediate remaining areas within OU2 with low levels of COC contamination. The Selected Remedy satisfies the criteria for long-term effectiveness by removing the DNAPL source in the lake sediments and addressing remaining areas within OU2 with either a sand cap or ENR. The addition of a sediment cap will effectively reduce the potential for direct contact with contaminants remaining in surface sediment. The Selected Remedy presents slightly more short-term risk than Alternatives A and B, but significantly fewer short-term risks as compared to Alternative E. All alternatives evaluated are considered implementable. Alternatives A and B involve mostly capping with no dredging. Alternative C is similar to the Selected Remedy in that it would include the need for shoring and dewatering of sediments; however, the Selected Remedy is more easily implementable than Alternative E, which includes removal of significantly more sediment and onsite thermal treatment of a large volume of material.

13.5 Preference for Treatment as a Principal Element

The NCP establishes the expectation that treatment will be used to address the principal threats posed by a site whenever practicable (40 CFR 300.430[a] [1] [iii] [A]). As discussed in Section 11, EPA determined that soil and sediment contaminated with oily creosote DNAPL are PTW.

This remedy satisfies the statutory preference for treatment as a principal element of the remedy (i.e., reduces the toxicity, mobility, or volume of hazardous substances, pollutants, or contaminants as a principal element through treatment).

The **Selected Remedy for OU1** includes treatment of DNAPL-containing soil using smoldering combustion and/or ISS, satisfying the statutory preference for remedies that employ treatment as a principle element. Additional treatment to immobilize or destroy contaminants in soil, evaluated in Alternatives 8, 9, and 10, was deemed to be impractical due to high cost and adverse short-term impacts, with little improvement in long-term effectiveness. The Selected Remedy for OU1 will use treatment to address principal threats to the extent practicable.

The **Selected Remedy for OU2** includes dredging and offsite disposal of DNAPL-containing sediment. Once dredged, DNAPL-containing sediment will be dewatered, and the oil/water will be treated. The sediment will also be stabilized as needed before it is transported to offsite disposal. Stabilization will reduce DNAPL mobility and toxicity, but it will not destroy the contaminants or reduce contaminant volume. Residuals generated by dredging would be managed using a post-dredge reactive residuals cover. Further treatment of dredged sediment was determined to be less cost effective than offsite disposal. Additional removal and thermal treatment of contaminated sediment, evaluated in Alternative E, was determined to be impractical due to high cost, adverse short-term impacts, and implementation challenges. Although the Selected Remedy will not satisfy the preference for treatment as a principal element, it will remove DNAPL from the shallow and deeper lakebed. The Selected Remedy for OU2 will achieve substantial risk reduction by both removing the DNAPL source materials constituting principal threats at the Site and providing safe management of remaining material.

13.6 5-Year Review Requirements

Section 121(c) of CERCLA and the NCP §300.430(f)(5)(iii)(C) provide the statutory and legal bases for conducting five-year reviews. Because the OU1 and OU2 remedies will result in hazardous substances, pollutants, or contaminants remaining onsite above levels that allow for unlimited use and unrestricted exposure, a statutory review will be conducted within 5 years after initiation of remedial action to ensure that the remedy is, or will be, protective of human health and the environment.

14 Documentation of Significant Changes to the Selected Remedy

14.1 Documentation of Significant Changes to the Selected Remedy for OU1

The Proposed Plan for OU1 was released for public comment in September 2019. The Proposed Plan identified Alternative 7a, In Situ Smoldering Combustion and/or In Situ Solidification of DNAPL, and Soil Capping, as the Preferred Alternative for OU1.

In response to comments received on the Proposed Plan, EPA has refined some aspects of the Preferred Alternative (Alternative 7a) in formulating the Selected Remedy for OU1. The following is a brief description of the refinements, which are discussed in more detail in Sections 8 and 12:

- **Cleanup Levels for Soil.** The ROD provides clarification concerning the applicability of cleanup levels in soil. The ROD clarifies that the soil cleanup levels apply to soil (upper 15 feet). Areas where COCs exceed cleanup levels in the top 15 feet of soil will be covered with a soil cap to prevent direct contact with contaminated soil. The goal of smoldering combustion in subsurface soil is to achieve the action levels and performance criteria specified below.
- **Action Levels and Performance Criteria.** The approach for implementing the Selected Remedy for OU1 in the ROD has been slightly refined from what was presented in the Proposed Plan. Metrics have been defined for deciding which areas of the Site will be targeted for smoldering combustion and which areas will be targeted for ISS treatment, how the success of smoldering combustion will be determined, and the path forward for groundwater monitoring and assessment following source treatment.

  As presented in Section 12.2.1, pretreatment characterization data will be collected to evaluate DNAPL source strength using an HRSC method. This information will be used to delineate separate treatment sector boundaries for smoldering combustion and ISS. In general, HRSC values indicating the presence of DNAPL with TPH concentrations greater than 3,000 ppm would be treated with smoldering combustion. HRSC values indicating significant sources of DNAPL with TPH less than 3,000 ppm would be identified as potential ISS sectors. Remedial action implementation will include ongoing evaluation of the smoldering technology and optimization of the implementation approach. An adaptive management approach will be used throughout the source treatment to optimize the implementation and fine-tune sector boundaries for each technology. The use of pretreatment characterization data to define treatment areas prior to implementation will decrease the timeframe needed for remedy completion and will allow for more certainty with the source treatment approach. Further, the implementation strategy has been refined to provide clarity regarding the intent to allow flexibility and optimization during source treatment.

These refinements do not significantly change the Selected Remedy, nor do they change the expected accuracy of the costs (-30 percent to +50 percent).

14.2 Documentation of Significant Changes to the Selected Remedy for OU2

The Proposed Plan for OU2 was released for public comment in September 2019. The Proposed Plan identified Alternative D, DNAPL Removal, Engineered Sand Cap, and Enhanced Natural Recovery, as the Preferred

Alternative for OU2. EPA reviewed all written and verbal comments submitted during the public comment period. It was determined that no significant changes to the remedy, as originally identified in the Proposed Plan, were necessary or appropriate.

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Tables

Table 5-1. Contaminant Concentrations in Soil, Operable Unit 1

Record of Decision for the Quendall Terminals Superfund Site

Contaminant of Concern	PRG (mg/kg)	PRG Source	Number of Detections/ Samples	Number of Detects Exceeding PRGs	Number of Non-detects Exceeding PRGs	Average Detected Concentration (mg/kg)	Maximum Detected Concentration (mg/kg)
Metals							
Arsenic	7.3	Ecology 1994[a]	44/81	21	2	12	110
Chromium	51	ERA RBC HQ=1	10/10	2	--	35	65.3
Lead	37	ERA RBC HQ=1	50/66	17	--	106	1,120
Polycyclic Aromatic Hydrocarbons							
2-Methylnaphthalene	240	HHRA RBC HQ=1	63/106	6	--	166	5,200
Benz(a)anthracene	1.1	HHRA RBC 10^{-6}	81/106	47	2	70	1,500
Benzo(a)pyrene	0.11	HHRA RBC 10^{-6}	81/106	76	3	97	2,100
Benzo(b)fluoranthene	1.1	HHRA RBC 10^{-6}	82/106	48	2	74	1,700
Benzo(k)fluoranthene	11	HHRA RBC 10^{-6}	80/106	29	1	58	1,400
Chrysene	110	HHRA RBC 10^{-6}	85/106	9	--	106	2,500
Dibenz(a,h)anthracene	0.11	HHRA RBC 10^{-6}	53/106	44	14	16	190
Indeno(1,2,3-c,d)pyrene	1.1	HHRA RBC 10^{-6}	73/106	43	3	53	1,500
Naphthalene	3.8	HHRA RBC 10^{-6}	80/117	38	1	308	11,000
Total cPAHs	0.11	HHRA RBC 10^{-6}	85/106	80	1	119	2,751
Total HPAHs	3.7	ERA RBC HQ=1	88/106	62	--	904	21,955
Total LPAHs	65	ERA RBC HQ=1	93/106	31	--	704	25,820
Volatile Organics							
Ethylbenzene	5.8	HHRA RBC 10^{-6}	15/46	4	--	9.9	92

Notes:

Based on soil data to depths of 15 feet or less.

[a] Washington State Department of Ecology. 1994. *Natural Background Soil Metals Concentrations in Washington State*. Publication 94-115. October.

cPAH = carcinogenic PAH – calculated based on benzo(a)pyrene equivalents

ERA RBC HQ=1 = Ecological Risk Assessment Risk-Based Concentration, based on noncancer hazard quotient of 1

HHRA RBC 10^{-6} = Human Health Risk Assessment Risk-Based Concentration based on cancer risk of 1×10^{-6}

HHRA RBC HQ=1 = Human Health Risk Assessment Risk-Based Concentration based on noncancer hazard quotient of 1

HPAH = high-molecular-weight PAH (benz[a]anthracene, benzo[a]pyrene, benzo[b]fluoranthene, benzo[k]fluoranthene, benzo[g,h,i]perylene, chrysene, dibenz[a,h]anthracene, indeno[1,2,3-c,d]pyrene, fluoranthene, and pyrene)

LPAH = low-molecular-weight PAH (acenaphthylene, acenaphthene, anthracene, fluorene, naphthalene, and phenanthrene)

mg/kg = milligram per kilogram

PAH = polynuclear aromatic hydrocarbon

PRG = preliminary remediation goal

Table 5-2. Contaminant Concentrations in Groundwater, Operable Unit 1

Record of Decision for the Quendall Terminals Superfund Site

Contaminant of Concern	PRG (µg/L)	PRG Source	Number of Detections/ Samples	Number of Detects Exceeding PRGs	Number of Non-detects Exceeding PRGs	Average Detected Concentration (µg/L)	Maximum Detected Concentration (µg/L)
Metals							
Arsenic	10	MCL	25/25	10	--	32	389
Polycyclic Aromatic Hydrocarbons							
2-Methylnaphthalene	36	HHRA RBC HQ=1	25/25	13	--	278	2,200
Acenaphthene	530	HHRA RBC HQ=1	21/25	--	--	103	390
Benz(a)anthracene	0.03	HHRA RBC 10^{-6}	5/25	4	20	41	170
Benzo(a)pyrene	0.2	MCL	3/25	3	12	97	290
Benzo(b)fluoranthene	0.25	HHRA RBC 10^{-6}	4/25	2	12	53	210
Benzo(k)fluoranthene	2.5	HHRA RBC 10^{-6}	4/25	1	9	53	210
Chrysene	25	HHRA RBC 10^{-6}	4/25	1	5	68	270
Dibenz(a,h)anthracene	0.025	HHRA RBC 10^{-6}	1/25	1	23	0.13	0.13
Fluoranthene	800	HHRA RBC HQ=1	9/25	--	--	61	250
Fluorene	290	HHRA RBC HQ=1	18/25	--	--	55	290
Indeno(1,2,3- c,d)pyrene	0.25	HHRA RBC 10^{-6}	1/25	1	13	0.45	0.45
Naphthalene	0.17	HHRA RBC 10^{-6}	27/28	26	1	2,637	16,000
Pyrene	120	HHRA RBC HQ=1	10/25	2	--	86	330
Total cPAHs	0.2	MCL	6/25	5	10	65	362
Semivolatile Organics							
Dibenzofuran	7.9	HHRA RBC HQ=1	15/25	12	--	44	180
Volatile Organics							
Benzene	5	MCL	15/28	13	--	3,337	31,000
Ethylbenzene	700	MCL	15/28	4	--	694	2,900
Total Xylenes	10,000	MCL	16/28	1	--	1,433	10,600

Notes:

Based on data collected during the 2008/2009 Remedial Investigation (RI).

µg/L = micrograms per liter

cPAH = carcinogenic PAH – calculated based on benzo(a)pyrene equivalents

HHRA RBC 10^{-6} = Human Health Risk Assessment Risk-Based Concentration based on cancer risk of 1 x 10^{-6}

HHRA RBC HQ=1 = Human Health Risk Assessment Risk-Based Concentration based on noncancer hazard quotient of 1

MCL = maximum contaminant level

PAH = polynuclear aromatic hydrocarbon

PRG = preliminary remediation goal

Table 5-3. Contaminant Concentrations in Nearshore Sediment, Operable Unit 2
Record of Decision for the Quendall Terminals Superfund Site

Contaminant of Concern	PRG (mg/kg)	PRG Source	Number of Detections/ Samples	Number of Detects Exceeding PRGs	Number of Non-detects Exceeding PRGs	Average Detected Concentration (mg/kg)	Maximum Detected Concentration (mg/kg)
Polycyclic Aromatic Hydrocarbons							
Benz(a)anthracene*	0.98	HHRA RBC 10^{-6}	10/10	5	--	2.5	8.2
Benzo(a)pyrene*	0.098	HHRA RBC 10^{-6}	10/10	9	--	6.8	23
Benzo(b)fluoranthene*	0.98	HHRA RBC 10^{-6}	10/10	4	--	7.8	29
Benzo(k)fluoranthene*	9.83	HHRA RBC 10^{-6}	10/10	3	--	4.9	17
Chrysene*	98.3	HHRA RBC 10^{-6}	10/10	--	--	5.2	19
Dibenz(a,h)anthracene*	0.098	HHRA RBC 10^{-6}	9/10	9	--	1.5	4.8
Indeno(1,2,3-c,d)pyrene*	0.98	HHRA RBC 10^{-6}	10/10	4	--	3.9	17
Total 10 of 16 HPAH (U = 1/2)	29	EcoRA RBC HQ=1	10/10	3	--	47	171
Total 16 PAH (U = 1/2)	17	Ecology SMS	10/10	5	--	56	231
Total cPAHs	0.098	HHRA RBC 10^{-6}	10/10	10	--	192	578

Notes:

Field duplicates processed using the maximum detected result or lowest method detection limit if applicable. Samples represented in this table were collected from areas with water depths of less than 10 feet.

cPAH = carcinogenic PAH(s) – calculated based on benzo(a)pyrene equivalents (indicated by asterisk)

EcoRA RBC HQ=1 = Ecological Risk Assessment Risk-Based Concentration, based on noncancer hazard quotient of 1

Ecology SMS = Washington State Department of Ecology Sediment Management Standards (WAC 173-205-563, Table VI, Sediment Cleanup Objective)

HHRA RBC 10^{-6} = Human Health Risk Assessment Risk-Based Concentration, based on cancer risk of 1 x 10^{-6}

HPAH = high-molecular-weight PAH (benz[a]anthracene, benzo[a]pyrene, benzo[b]fluoranthene, benzo[k]fluoranthene, benzo[g,h,i]perylene, chrysene, dibenz[a,h]anthracene, indeno[1,2,3-c,d]pyrene, fluoranthene, and pyrene)

mg/kg = milligrams per kilogram

PAH = polycyclic aromatic hydrocarbon

PRG = preliminary remediation goal

U=1/2 = undetected chemicals were included as one-half the detection limit

Table 5-4. Contaminant Concentrations in Sitewide Sediment, Operable Unit 2
Record of Decision for the Quendall Terminals Superfund Site

Contaminant of Concern	PRG (mg/kg)	PRG Source	Number of Detections/ Samples	Number of Detects Exceeding PRGs	Number of Non-detects Exceeding PRGs	Average Detected Concentration (mg/kg)	Maximum Detected Concentration (mg/kg)
Polycyclic Aromatic Hydrocarbons							
Benz(a)anthracene*	5.35	HHRA RBC 10^{-6}	98/100	13	--	7.9	260
Benzo(a)pyrene*	1.62	HHRA RBC 10^{-6}	98/100	44	--	7.7	140
Benzo(b)fluoranthene*	16.2	HHRA RBC 10^{-6}	99/100	12	--	7.9	130
Benzo(k)fluoranthene*	162	HHRA RBC 10^{-6}	99/100	--	--	6.0	130
Chrysene*	530	HHRA RBC 10^{-6}	99/100	--	--	9.6	340
Dibenz(a,h)anthracene*	0.48	HHRA RBC 10^{-6}	93/100	37	--	1.2	17
Indeno(1,2,3-c,d)pyrene*	10.5	HHRA RBC 10^{-6}	99/100	9	--	3.0	34
Total 10 of 16 HPAH (U = 1/2)	29	EcoRA RBC HQ=1	100/100	25	--	79	2,004
Total 16 PAH (U = 1/2)	17	Ecology SMS	100/100	39	--	113	2,948
Total cPAHs	1.62	HHRA RBC 10^{-6}	99/100	97	1	185	2,910

Notes:

Field duplicates processed using the maximum detected result or lowest method detection limit if applicable.

cPAH = carcinogenic PAH(s) – calculated based on benzo(a)pyrene equivalents (indicated by asterisk)

EcoRA RBC HQ=1 = Ecological Risk Assessment Risk-Based Concentration, based on noncancer hazard quotient of 1

Ecology SMS = Washington State Department of Ecology Sediment Management Standards (WAC 173-205-563, Table VI, Sediment Cleanup Objective)

HHRA RBC 10^{-6} = Human Health Risk Assessment Risk-Based Concentration, based on cancer risk of 1 x 10^{-6}

HPAH = high-molecular-weight PAH (benz[a]anthracene, benzo[a]pyrene, benzo[b]fluoranthene, benzo[k]fluoranthene, benzo[g,h,i]perylene, chrysene, dibenz[a,h]anthracene, indeno[1,2,3-c,d]pyrene, fluoranthene, and pyrene)

mg/kg = milligrams per kilogram

PAH = polycyclic aromatic hydrocarbon

PRG = preliminary remediation goal

U=1/2 = undetected chemicals were included as one-half the detection limit

Table 5-5. Contaminant Concentrations in Surface Water and Porewater, Operable Unit 2

Record of Decision for the Quendall Terminals Superfund Site

Contaminant of Concern	PRG (µg/L)	PRG Source	Number of Detections/ Samples	Number of Detects Exceeding PRGs	Number of Non-detects Exceeding PRGs	Average Detected Concentration (µg/L)	Maximum Detected Concentration (µg/L)
Polycyclic Aromatic Hydrocarbons							
Acenaphthene	30	40 CFR 131.45	49/96	10	--	36	266
Anthracene	100	40 CFR 131.45	41/96	--	--	2.9	25
Benz(a)anthracene*	0.00016	40 CFR 131.45	25/96	25	71	0.33	1.4
Benzo(a)pyrene*	0.000016	40 CFR 131.45	31/96	31	65	0.11	0.59
Benzo(b)fluoranthene*	0.00016	40 CFR 131.45	35/96	35	61	0.11	0.56
Benzo(k)fluoranthene*	0.016	40 CFR 131.45	33/96	28	63	0.11	0.58
Chrysene*	0.016	40 CFR 131.45	37/96	28	28	0.19	0.87
Dibenz(a,h)anthracene*	0.000016	40 CFR 131.45	8/96	8	88	0.032	0.092
Fluoranthene	6	40 CFR 131.45	46/96	7	--	3.6	54
Fluorene	10	40 CFR 131.45	46/96	8	--	15	170
Indeno(1,2,3-c,d)pyrene*	0.00016	40 CFR 131.45	16/96	16	80	0.051	0.15
Pyrene	8	40 CFR 131.45	50/96	5	--	2.2	29
Total cPAH	0.000016	40 CFR 131.45	52/96	52	44	0.11	0.83
Volatile Organics							
Benzene	0.44	NTR	16/54	16	30	159	1,200
Toluene	57	Section 304(a)	11/54	--	--	5.9	16

Notes:

Data include both surface water and porewater.

Field duplicates processed using the maximum detected result or lowest method detection limit if applicable.

µg/L = micrograms per liter

40 CFR 131.45 = 40 *Code of Federal Regulations* 131.45, Revisions of certain federal water quality criteria applicable to Washington (water and organisms)

cPAH = carcinogenic PAH(s) – calculated based on benzo(a)pyrene equivalents (indicated by asterisk)

NTR = National Toxics Rule, human health criteria based on risk of 1 x 10-6 (for water and organisms) per Washington Administrative Code (WAC) 173-201A.

PAH = polycyclic aromatic hydrocarbon

PRG = preliminary remediation goal

Section 304(a) = Clean Water Act 33 *United States Code* 1314 (Section 304[a]) National Recommended Water Quality Criteria, human health criteria based on risk of 1×10^{-6} (for water and organisms)

Table 7-1. Reasonable Maximum Exposure Assumptions
Record of Decision for the Quendall Terminals Superfund Site

Exposure Parameter	Units	Occupational Worker	Source	Construction/ Excavation Worker	Source	Resident	Source	Beach User	Source	Fish Consumer	Source
Exposure Concentration (soil/sediment)	mg/kg-dry	95% UCL of mean	calc.	95% UCL of mean	calc.	95% UCL of mean	calc.	95% UCL of mean	calc.	--	--
Exposure Concentration (groundwater/surface water)	µg/L	--	--	Sitewide maximum	a	Well-specific	b	Sitewide maximum	c	--	--
Exposure Concentration (indoor air/trench air)	µg/m³	--	--	Sitewide maximum	calc.	Well-specific	calc.	--	--	--	--
Exposure Concentration (fish tissue)	mg/kg-wet	--	--	--	--	--	--	--	--	95% UCL of mean	d
Adult Body Weight	kg	70	e	70	e	70	e	70	e	70	e
Child Body Weight	kg	--	--	--	--	15	e	15	e	--	--
Exposure Frequency	days/yr	250	e	250	e	350	e	94	f	350/39/65	g
Adult Exposure Duration	yrs	25	e	1	h	24	e	24	e	30	e
Subsistence Fish Consumption Exposure Duration	yrs	--	--	--	--	--	--	--	--	70	k
Child Exposure Duration	yrs	--	--	--	--	6	e	6	e	--	--
Inhalation Exposure Time Fraction	unitless	0.33	i	0.33	i	1.0	i	--	--	--	--
Carcinogenic Averaging Time	yrs	70	e	70	e	70	e	70	e	70	e
Noncarcinogenic Averaging Time	yrs	25	e	1	h	30	e	30	e	30	e
Adult Incidental Soil/Sediment Ingestion Rate	mg/day	100	e	330	j	100	e	100	e	100	e
Child Incidental Soil/Sediment Ingestion Rate	mg/day	--	--	--	--	200	e	200	e	--	--
Adult Water Ingestion Rate	L/day	--	--	--	--	2	e	0.05	k	--	--
Child Water Ingestion Rate	L/day	--	--	--	--	1	k	0.05	k	--	--
Recreator Fish Consumption Rate	g/day-wet	--	--	--	--	--	--	--	--	17.37	l
Subsistence Fish Consumption Rate	g/day-wet	--	--	--	--	--	--	--	--	143.4	l
Adult Skin Surface Area (soil)	cm²	3,300	m	3,300	m	5,700	m	5,700	m	1,980	n
Child Skin Surface Area (soil)	cm²	--	--	--	--	2,800	m	2,800	m	--	--
Adult Skin Surface Area (water)	cm²	--	--	3,300	m	18,000	m	18,000	m	--	--
Child Skin Surface Area (water)	cm²	--	--	--	--	6,600	m	6,600	m	--	--
Dermal Absorption Fraction (from soil/sediment)	unitless	Chemical-specific	m	Chemical-specific	m	Chemical-specific	m	Chemical-specific	m	Chemical-specific	m,n
Dermal Permeability Coefficient (water)	cm/hr	--	--	Chemical-specific	m	Chemical-specific	m	Chemical-specific	m	--	--
Adult Event Duration (water)	hr/event	--	--	1.0	o	0.58	m	1.0	o	--	--
Child Event Duration (water)	hr/event	--	--	--	--	1.0	m	1.0	o	--	--
Adult Soil-to-Skin Adherence Factor	mg/cm²	0.2	m	0.3	m	0.07	m	0.3	m,p	0.3	m,p

Table 7-1. Reasonable Maximum Exposure Assumptions
Record of Decision for the Quendall Terminals Superfund Site

Exposure Parameter	Units	Occupational Worker	Source	Construction/ Excavation Worker	Source	Resident	Source	Beach User	Source	Fish Consumer	Source
Child Soil-to-Skin Adherence Factor	mg/cm^2	--	--	--	--	0.2	m	3.3	m,p	--	--
Particulate Emission Factor	m^3/kg	1.32E+09	q	1.32E+09	q	1.32E+09	q	--	--	--	--
Volatilization Factor	m^3/kg	Chemical-specific	q	Chemical-specific	q	Chemical-specific	q	--	--	--	--

Notes:

[a] Based on Sitewide maximum groundwater concentration from RI (2008-2009).

[b] Based on Sitewide highest well-specific groundwater concentration from RI (2008-2009).

[c] Based on Sitewide maximum surface water concentration.

[d] Based on average (sediment 95% UCL x BSAF x Lipid fraction) of three fish groups.

[e] Risk Assessment Guidance for Superfund, Volume 1, Human Health Evaluation Manual. Supplemental Guidance: Standard Default Exposure Factors (EPA 1991).

[f] Professional judgment. Assumes recreational use occurs for an average of about 3 months per year.

[g] Exposure frequencies listed for fish consumption/recreational angler sediment contact/subsistence angler sediment contact. Assumes 3 and 5 days per week over the entire year for in-water recreational and subsistence fishing, respectively. Assumes fishing near the Site occurs 25 percent of total fishing days.

[h] Professional judgment. Assumes that construction work occurs over a one-year period.

[i] Fraction of exposure time applied to calculation of inhalation risk (worker equates to 8 hr/day, recreational user equates to 4 hr/day).

[j] Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites (EPA 2002e).

[k] Risk Assessment Guidance for Superfund, Volume 1, Human Health Evaluation Manual (Part A), Interim Final (EPA 1989).

[l] Based on the 90th percentile for recreational fishing and the 99th percentile for subsistence fishing from Estimated Per Capita Fish Consumption in the United States (EPA 2002b).

[m] Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment) Final (EPA 2004).

[n] Average surface area for hands and forearms of men (EPA 1997a).

[o] Professional judgment. Assumes a one-hour swimming or contact event per day.

[p] From Exhibit 3-3 in EPA 2004. Value for residential adults as gardeners and value for children playing in wet soil.

[q] Soil Screening Guidance: Users Guide (EPA 1996).

BSAF = biota-sediment accumulation factor

cm^2 = square centimeter

days/yr = days per year

kg = kilogram

m^3/kg = cubic meters per kilogram

calc. = calculated value

UCL = upper confidence limit

mg/cm^2 = milligrams per square centimeter

mg/day = milligrams per day

mg/kg = milligrams per kilogram

mg/L= milligrams per liter

yrs = years

EPC = exposure point concentration

Table 7-2. Toxicity Values Used for the Baseline Human Health Risk Assessment
Record of Decision for the Quendall Terminals Superfund Site

Analyte	CASRN	Mutagen (Y/N)	Water Permeability Constant (Kp) (cm/hr)	Volatilization Factor (m^3/kg)	Dermal Absorption Fraction	GI Absorption Fraction	Oral Slope Factor $(mg/kg\text{-}day)^{-1}$	Source	Inhalation Unit Risk (µg/m^3)	Source	Oral Reference Dose (mg/kg-day)	Source	Inhalation Reference Concentration (RfC) (mg/m^3)	Source
2,4-Dimethylphenol	105-67-9	N	1.1E-02	--	0.1	1	--	--	--	--	2.0E-02	I	--	--
2-Methylnaphthalene	91-57-6	N	9.2E-02	6.34E+04	0.1	1	--	--	--	--	4.0E-03	I	--	--
2-Methylphenol (o-Cresol)	95-48-7	N	7.7E-03	--	0.1	1	--	--	--	--	5.0E-02	I	--	--
4-Methylphenol	106-44-5	N	7.5E-03	--	0.1	1	--	--	--	--	5.0E-03	H	--	--
Acenaphthene	83-32-9	N	8.6E-02	1.52E+05	0.13	1	--	--	--	--	6.0E-02	I	--	--
Anthracene	120-12-7	N	1.4E-01	5.64E+05	0.13	1	--	--	--	--	3.0E-01	I	--	--
Arsenic	7440-38-2	N	1.6E-03	--	0.03	1	1.5E+00	I	4.3E-03	I	3.0E-04	I	1.5E-05	C
Benzene	71-43-2	N	1.5E-02	3.80E+03	0.1	1	5.5E-02	I	7.8E-06	I	4.0E-03	I	3.0E-02	I
Benzo(a)anthracene	56-55-3	Y	5.0E-01	--	0.13	1	7.3E-01	C	1.1E-04	C	--	--	--	--
Benzo(a)pyrene	50-32-8	Y	7.1E-01	--	0.13	1	7.3E+00	C	1.1E-03	C	--	--	--	--
Benzo(b)fluoranthene	205-99-2	Y	4.2E-01	--	0.13	1	7.3E-01	C	1.1E-04	C	--	--	--	--
Benzo(k)fluoranthene	207-08-9	Y	6.9E-01	--	0.13	1	7.3E-01	C	1.1E-04	C	--	--	--	--
bis(2-Ethylhexyl)phthalate	117-81-7	N	1.1E+00	--	0.1	1	1.4E-02	I	2.4E-06	C	2.0E-02	I	--	--
Cadmium (soil)	7440-43-9	N	--	--	0.001	0.025	--	--	1.8E-03	I	1.0E-03	I	2.0E-05	C
Cadmium (water)	7440-43-9	N	--	--	0.001	0.05	--	--	1.8E-03	I	5.0E-04	I	2.0E-05	C
Carbon disulfide	75-15-0	N	--	1.24E+03	0.1	1	--	--	--	--	1.0E-01	I	7.0E-01	I
Chloroform	67-66-3	N	6.83E-03	2.85E+03	0.1	1	3.1E-02	C	2.3E-05	I	1.0E-02	I	9.8E-02	A
Chromium III	7440-47-3	N	--	--	--	0.013	--	--	--	--	1.5E+00	I	--	--
Chrysene	16065-83-1	Y	6.0E-01	--	0.13	1	7.3E-02	C	1.1E-05	C	--	--	--	--
Copper	7440-50-8	N	--	--	--	1	--	--	--	--	4.0E-02	H	--	--
Dibenz(a,h)anthracene	53-70-3	Y	2.2E+00	--	0.13	1	7.3E-01	C	1.1E-04	C	--	--	--	--
Dibenzofuran	132-64-9	N	9.8E-02	2.13E+05	0.1	1	--	--	--	--	1.0E-03	X	--	--
Ethylbenzene	100-41-4	N	4.9E-02	6.18E+03	0.1	1	1.1E-02	C	2.5E-06	C	1.0E-01	I	1.0E+00	I
Fluoranthene	206-44-0	N	3.1E-01	--	0.13	1	--	--	--	--	4.0E-02	I	--	--
Fluorene	86-73-7	N	1.1E-01	3.06E+05	0.13	1	--	--	--	--	4.0E-02	I	--	--
Indeno(1,2,3-c,d)pyrene	193-39-5	Y	1.2E+00	--	0.13	1	7.3E-01	C	1.1E-04	C	--	--	--	--
Iron	7439-89-6	N	--	--	--	1	--	--	--	--	7.0E-01	P	--	--
Methylene chloride	75-09-2	N	--	2.40E+03	0.1	1	7.5E-03	I	4.7E-07	I	6.0E-02	I	1.0E+00	A
Naphthalene	91-20-3	N	4.7E-02	5.04E+04	0.15	1	--	--	3.4E-05	C	2.0E-02	I	3.0E-03	I
Nickel	7440-02-0	N	--	--	--	0.04	--	--	2.6E-04	C	2.0E-02	I	9.0E-05	A

Table 7-2. Toxicity Values Used for the Baseline Human Health Risk Assessment

Record of Decision for the Quendall Terminals Superfund Site

Analyte	CASRN	Mutagen (Y/N)	Water Permeability Constant (Kp) (cm/hr)	Volatilization Factor (m^3/kg)	Dermal Absorption Fraction	GI Absorption Fraction	Oral Slope Factor $(mg/kg\text{-}day)^{-1}$	Source	Inhalation Unit Risk (µg/m^3)	Source	Oral Reference Dose (mg/kg-day)	Source	Inhalation Reference Concentration (RfC) (mg/m^3)	Source
N-Nitrosodiphenylamine	86-30-6	N	--	--	0.1	1	4.9E-03	I	2.6E-06	C	--	--	--	--
Pentachlorophenol	87-86-5	N	--	--	0.25	1	4.0E-01	I	5.1E-06	C	5.0E-03	I	--	--
Phenol	108-95-2	N	--	--	0.1	1	--	--	--	--	3.0E-01	I	2.0E-01	C
Pyrene	129-00-0	N	2.0E-01	2.56E+06	0.13	1	--	--	--	--	3.0E-02	I	--	--
Styrene	100-42-5	N	3.7E-02	1.02E+04	0.1	1	--	--	--	--	2.0E-01	I	1.0E+00	I
Toluene	108-88-3	N	3.1E-02	4.65E+03	0.1	1	--	--	--	--	8.0E-02	I	5.0E+00	I
Xylenes, Total	1330-20-7	N	--	6.33E+03	0.1	1	--	--	--	--	2.0E-01	I	1.0E-01	I
Zinc	7440-66-6	N	--	--	--	1	--	--	--	--	3.00E-01	I	--	--

Notes:

CASRN = Chemical Abstract System Registry Number Sources:

A = Agency for Toxic Substances and Disease Registry (ATSDR)

I = Integrated Risk Information System (IRIS)

C = California Environmental Protection Agency (CAEPA)

P = Provisional Peer-Reviewed Toxicity Values (PPRTV)

E = Environmental Criteria and Assessment Office (ECAO)

X = PPRTV Appendix H - Health Effects Assessment Summary Tables (HEAST)

Kp values from the EPA Estimation Program Interface (EPI) Suite database. EPA May 2011 regional screening levels (RSLs) and volatilization factors (VFs).

Cancer slope factors and inhalation unit risks (IURs) for carcinogenic polycyclic aromatic hydrocarbons (PAHs) were weighted according to their respective benzo(a)pyrene toxicity equivalency factors (TEFs) using the scheme of CAEPA (2009).

µg/m^3 = micrograms per cubic meter

m^3/kg = cubic meters per kilogram

mg/kg = milligrams per kilogram

mg/m^3 = milligrams per cubic meter

Table 7-3. Summary of Risk and Hazard Estimates for Human Exposure Scenarios, Operable Unit 1
Record of Decision for the Quendall Terminals Superfund Site

		Human Exposure Scenarios					
		Residential		Occupational Worker		Construction/Excavation Worker	
Exposure Medium	**Exposure Route**	**HI**	**ELCR**	**HI**	**ELCR**	**HI**	**ELCR**
Soil (0 to 15 feet bgs)	Ingestion	1	2×10^{-2}	0.4	1×10^{-3}	1	1×10^{-4}
	Dermal	0.5	7×10^{-3}	0.3	8×10^{-4}	0.4	5×10^{-5}
	Inhalation	6	3×10^{-4}	1	5×10^{-5}	1	2×10^{-6}
	Total	8	3×10^{-2}	2	2×10^{-3}	3	2×10^{-4}
Groundwater	Ingestion	602	8×10^{-1}	--	--	--	--
	Dermal	175	5×10^{-4}	--	--	0.00001	1×10^{-5}
	Inhalation	7,218	3×10^{-1}	--	--	--	--
	Total	7,995	$>8 \times 10^{-1}$	--	--	0.00001	1×10^{-5}
Indoor Air	Inhalation	280	2×10^{-2}	--	--	--	--
Trench Vapor	Inhalation	--	--	--	--	486	8×10^{-4}

Notes:
bgs = below ground surface
ELCR = excess lifetime cancer risk
HI = hazard index

Table 7-4. Summary of Risk and Hazard Estimates for Human Exposure Scenarios, Operable Unit 2
Record of Decision for the Quendall Terminals Superfund Site

Exposure Medium	**Exposure Route**	**Recreational Beach User**		**Recreational Fishing**		**Subsistence Fishing**	
		HI	**ELCR**	**HI**	**ELCR**	**HI**	**ELCR**
Nearshore Sediment	Ingestion	0.004	2×10^{-4}	--	--	--	--
	Dermal	0.01	9×10^{-5}	--	--	--	--
	Total	0.02	3×10^{-4}	--	--	--	--
Sitewide Sediment	Ingestion	--	--	0.008	2×10^{-5}	0.01	4×10^{-5}
	Dermal	--	--	0.005	2×10^{-5}	0.01	3×10^{-5}
	Total	--	--	0.01	4×10^{-5}	0.02	6×10^{-5}
Site Surface Water	Ingestion	0.007	2×10^{-6}	--	--	--	--
	Dermal	0.02	2×10^{-6}	--	--	--	--
	Total	0.03	3×10^{-6}	--	--	--	--
Site Fish/Shellfish	Ingestion	--	--	0.4	2×10^{-4}	3	5×10^{-3}

Notes:

bgs = below ground surface

ELCR = excess lifetime cancer risk

HI = hazard index

Table 7-5. Contaminants of Potential Concern for Ecological Receptors
Record of Decision for the Quendall Terminals Superfund Site

COI	Soil		Surface Water		Sediment		
	COPC?	Rationale	COPC?	Rationale	COPC?	Rationale	Bioaccumulative?
2,4-Dimethylphenol	Y	Max. detect > SL	NA	Not a SW COI	NA	Not a sed. COI	
2-Methylnaphthalene	Y	Max. detect > SL	Y	Max. detect > SL	Y	Max. detect > SL	
4-Methylphenol (p-Cresol)	NA	Not a soil COI	NA	Not a SW COI	N	Max. detect < SL	
Acenaphthene	N	Max. detect < SL	Y	Max. detect > SL	Y	Max. detect > SL	Y
Acenaphthylene	NA	Not a soil COI	NA	Not a SW COI	Y	Max. detect > SL	Y
Anthracene	N	Max. detect < SL	Y	Max. detect > SL	Y	Max. detect > SL	Y
Arsenic	Y	Max. detect > SL	Y	Max. detect GW > SL	Y	QA1- DL > SL; Indicator	Y
Benzene	N	All ND; DL < SL	Y	Max. detect > SL	NA	Not a sed. COI	
Benzo(a)anthracene	Y	Max. detect > SL	Y	Max. detect > SL	Y	Max. detect > SL	Y
Benzo(a)pyrene	Y	Max. detect > SL	Y	Max. detect > SL	Y	Max. detect > SL	Y
Benzo(b)fluoranthene	Y	Max. detect > SL	Y	No SL	NA	Not a sed. COI	Y
Benzo(g,h,i)perylene	Y	Max. detect > SL	NA	Not a SW COI	Y	Max. detect > SL	Y
Benzo(k)fluoranthene	Y	Max. detect > SL	Y	No SL	NA	Not a sed. COI	Y
Cadmium	N	QA1- Max. < BKGD	NA	Not a SW COI	N	QA1-	Y
Carbon disulfide	NA	Not a soil COI	NA	Not a SW COI	N	QA1-	
Chromium	Y	QA1- max. > SL; Indicator	NA	Not a SW COI	Y	QA1- max. > SL; Indicator	
Chrysene	Y	Max. detect > SL	Y	No SL	Y	Max. detect > SL	Y
Copper	NA	Not a soil COI	NA	Not a SW COI	Y	QA1- max. > SL; Indicator	Y
Dibenz(a,h)anthracene	Y	Max. detect > SL	Y	No SL	Y	Max. detect > SL	Y
Dibenzofuran	Y	No SL	NA	Not a SW COI	Y	Max. detect > SL	
Ethylbenzene	N	Max. detect < SL	Y	Max. detect > SL	N	QA1- max. < BKGD	
Fluoranthene	Y	Max. detect > SL	Y	Max. detect > SL	Y	Max. detect > SL	Y
Fluorene	Y	Max. detect > SL	Y	Max detect > SL	Y	Max. detect > SL	Y
Indeno(1,2,3-c,d)pyrene	Y	Max. detect > SL	Y	No SL	Y	Max. detect > SL	Y
Lead	Y	Max. detect > SL	NA	Not a SW COI	N	QA1-	Y
m,p-Xylene	N	Max. det. total xylenes < SL	Y	Max. detect > SL	NA	Not a sed. COI	
Mercury	NA	Not a soil COI	NA	Not a SW COI	N	Not a sed. COI	Y
Naphthalene	Y	Max. detect > SL	Y	Max. detect > SL	Y	Max. detect > SL	

Table 7-5. Contaminants of Potential Concern for Ecological Receptors

Record of Decision for the Quendall Terminals Superfund Site

COI	Soil		Surface Water		Sediment		
	COPC?	**Rationale**	**COPC?**	**Rationale**	**COPC?**	**Rationale**	**Bioaccumulative?**
Nickel	N	QA1-	NA	Not a SW COI	N	QA1-	Y
o-Xylene	N	Max. det. total xylenes < SL	NA	Not a SW COI	NA	Not a sed. COI	
Pentachlorophenol	Y	All ND; DL > SL	NA	Not a SW COI	NA	Not a sed. COI	Y
Phenanthrene	Y	Max. detect > SL	Y	Max. detect > SL	Y	Max. detect > SL	Y
Phenol	NA	Not a soil COI	NA	Not a SW COI	N	Max. detect < SL	Y
Pyrene	Y	Max. detect > SL	Y	Max. detect > SL	Y	Max. detect > SL	Y
Sulfide	NA	Not a soil COI	NA	Not a SW COI	N	QA1-	
Toluene	N	Max. detect < SL	Y	Max. detect > SL	NA	Not a sed COI	
Total 10 of 16 HPAHs (U=1/2)	Y	Max. detect > SL	NA	Not a SW COI	Y	Max. detect > SL	Y
Total 16 PAHs (U=1/2)	NA	Not a soil COI	NA	Not a SW COI	Y	Max. detect > SL	Y
Total 6 of 16 LPAHs (U=1/2)	Y	Max. detect > SL	NA	Not a SW COI	Y	Max. detect > SL	Y
Total PCB Aroclors (U=1/2)	Y	QA1- max. > SL; Indicator	NA	Not a SW COI	NA	Not eco COI	Y
Total cPAH TEQs (7 minimum) (U=1/2)	NA	Not eco COI	NA	Not eco COI	NA	Not eco COI	Y
Total Organic Carbon	NA	Not a soil COI	NA	Not a SW COI	Y	Max. detect > SL	
Total PAH ESBQs (U=1/2)	NA	Not a soil COI	Y	Max. detect > SL	Y	Max. detect > SL	
Total Xylenes (U=1/2)	N	Max. detect < SL	Y	Max. detect > SL	NA	Not a sed COI	

Notes:

All ND; DL > SL = All non-detects; detection limit exceeds screening level.

Max. detect > SL = Maximum detected concentration exceeds screening level.

QA1- max. > SL; Indicator = Maximum value of QA1 – quality exceeds screening level; indicator chemical.

QA1 – DL > SL; Indicator = Analyte not detected, detection limit exceeds screening level; indicator chemical.

Max. detect total xylenes < SL = Total xylenes (used as surrogate for individual isomers) do not exceed screening level.

Details supporting the COPC screening for the ecological risk assessment are provided in Appendix J-8.

The samples included:

Soil – all surface soil samples (0-5 feet) in risk data set.

Surface Water – groundwater, porewater (undiluted), and surface water samples in risk data set.

Sediment – all surface sediment samples (0-4 inches) in risk data set.

COI = contaminants of interest

COPC = contaminant of potential concern

cPAH TEQ = carcinogenic PAH toxicity equivalency quotient

ESBQ = equilibrium partitioning sediment benchmark quotient

HPAH = high-molecular-weight PAH

LPAH = low-molecular-weight PAH

PAH = polynuclear aromatic hydrocarbon

Table 7-6. Ecological Pathways of Concern

Record of Decision for the Quendall Terminals Superfund Site

Exposure Scenario/Receptors	Exposure Media	Exposure Routes	Assessment Endpoint	Measurement Endpoint
Soil Invertebrates and Terrestrial Plants	Soil and surface water	Direct contact and ingestion of soil (surface water exposure insignificant relative to soil exposure)	Probability of reduced survival, growth, and reproduction of soil invertebrate communities and plants	Soil: Bulk soil concentrations compared to ecological soil screening guidelines.
Terrestrial Birds	Soil, surface water, and soil biota	Direct contact and ingestion of soil (surface water exposure insignificant relative to soil exposure) Ingestion of soil biota	Probability of reduced survival, growth, and reproduction of terrestrial bird populations	Soil: Bulk soil concentrations compared to ecological soil quality screening guidelines. Dietary Total Daily Intake: Estimated based on modeled plant and soil invertebrate tissue data and incidental soil and surface water uptake.
Terrestrial Mammals	Soil, surface water, and soil biota	Direct contact and ingestion of soil (surface water exposure insignificant relative to soil exposure) Ingestion of soil biota	Probability of reduced survival, growth, and reproduction of terrestrial mammal populations	Soil: Bulk soil concentrations compared to ecological soil screening guidelines. Dietary Total Daily Intake: Estimated based on modeled plant, soil invertebrate and small mammal data and incidental soil and surface water uptake.
Aquatic Macrophytes	Surface water	Direct contact and ingestion of surface water	Probability of reduced survival, growth, and reproduction of aquatic plants	Porewater: Porewater and modeled surface water concentrations compared directly to AWQC or TRVs.
Benthic Invertebrates	Surface water and sediment	Direct contact and ingestion of soil (surface water exposure insignificant relative to soil exposure)	Probability of reduced survival, growth, and reproduction of benthic invertebrate communities	Porewater: Porewater and modeled surface water concentrations compared directly to PAH ESB model FCVs and AWQC or other TRVs. Bulk sediment: Bulk sediment concentrations compared to benchmarks. Bioassays: Results of Site co-located COPC concentrations and bioassay results compared with background and controls. Wood debris: Results of wood debris analysis correlated with chemistry.

Table 7-6. Ecological Pathways of Concern

Record of Decision for the Quendall Terminals Superfund Site

Exposure Scenario/Receptors	Exposure Media	Exposure Routes	Assessment Endpoint	Measurement Endpoint
Fish/Shellfish	Surface water, sediment, and fish/invertebrates	Direct contact and ingestion	Probability of reduced survival, growth, and reproduction of fish or shellfish populations	Porewater: Porewater and modeled surface water concentrations compared directly to PAH model FCVs and AWQC or other TRVs. Tissue Residue: Fish tissue estimated based on BSAF- modeled concentrations compared to tissue-based TRVs. Dietary Intake: Fish tissue estimated based on BSAF- modeled concentrations compared to dietary TRVs.
Aquatic-Dependent Birds	Surface water, sediment, and fish/shellfish	Direct contact and ingestion of sediment (surface water exposure insignificant relative to soil exposure) Ingestion of fish/shellfish prey	Probability of reduced survival, growth, and reproduction of aquatic-dependent bird populations	Dietary Total Daily Intake: Estimated based on BSAF- modeled fish and shellfish tissue data and, depending on species, incidental surface water and sediment.
Aquatic-Dependent Mammals	Surface water, sediment, and fish/shellfish	Direct contact and ingestion of sediment (surface water exposure insignificant relative to soil exposure) Ingestion of fish/shellfish prey	Probability of reduced survival, growth, and reproduction of piscivorous mammal populations	Dietary Total Daily Intake: Estimated based on BSAF- modeled fish and shellfish tissue data and, depending on species, incidental surface water and sediment.

Notes:

AWQC = ambient water quality criteria

BSAF = biota-sediment accumulation factor

COPC = contaminant of potential concern

EPA Eco-SSLs = U.S. Environmental Protection Agency Ecological Soil Screening Levels

FCV = final chronic value

ORNL = Oak Ridge National Laboratory

PAH ESB = polynuclear aromatic hydrocarbon equilibrium partitioning sediment benchmark

TRV = toxicity reference value

Table 7-7. Summary of Hazard Estimates for Ecological Receptors

Record of Decision for the Quendall Terminals Superfund Site

Ecological COPC	Terrestrial Receptors						Aquatic-Dependent Receptors				
	Bulk Soil Screening HQs				TDI Assessment NOAEL HQs (Maximum HQs for Birds and Mammals)		Surface Water Screening HQs		Fish Diet LOAEL HQs	TDI Assessment NOAEL HQs (Maximum HQs for Birds and Mammals)	
	Plant	**Invert.**	**Avian**	**Mammal**	**Robin**	**Racoon**	**Aq. Plant**	**Fish**	**Benthivore**	**Sandpiper**	**Otter**
2,4-Dimethylphenol	NTRV	NTRV	NTRV	NTRV	<1	<1	NCOPC	NCOPC	NCOPC	NCOPC	NCOPC
2-Methylnaphthalene	PAHs	PAHs	PAHs	PAHs	PAHs	PAHs	**1**	<1	PAHs	PAHs	PAHs
Acenaphthene	NCOPC	NCOPC	NCOPC	NCOPC	NCOPC	NCOPC	**1.6**	<1	PAHs	PAHs	PAHs
Acenaphthylene	NCOPC	NCOPC	NCOPC	NCOPC	NCOPC	NCOPC	NCOPC	NCOPC	PAHs	PAHs	PAHs
Anthracene	PAHs	PAHs	PAHs	PAHs	PAHs	PAHs	**42**	**14**	PAHs	PAHs	PAHs
Arsenic	<1	NTRV	<1	<1	<1	<1	<1	<1	NBSAF	<1	<1
Benzene	NCOPC	NCOPC	NCOPC	NCOPC	NTRV	<1	<1	<1	NCOPC	NCOPC	<1
Benzo(a)anthracene	PAHs	PAHs	PAHs	PAHs	PAHs	PAHs	**15**	**11.1**	PAHs	PAHs	PAHs
Benzo(a)pyrene	NTRV	NTRV	NTRV	NTRV	**110**	**24**	**50**	**53**	<1	**11**	<1
Benzo(b)fluoranthene	PAHs	PAHs	PAHs	PAHs	PAHs	PAHs	NTRV	<1	NCOPC	PAHs	PAHs
Benzo(g,h,i)perylene	PAHs	PAHs	PAHs	PAHs	PAHs	PAHs	NCOPC	NCOPC	PAHs	PAHs	PAHs
Benzo(k)fluoranthene	PAHs	PAHs	PAHs	PAHs	PAHs	PAHs	NTRV	NTRV	NCOPC	PAHs	PAHs
Chromium	NTRV	NTRV	**2.2**	**1.7**	<1	<1	NCOPC	NCOPC	NB	**1.3**	--
Chrysene	PAHs	PAHs	PAHs	PAHs	PAHs	PAHs	NTRV	NTRV	PAHs	PAHs	PAHs
Copper	NCOPC	NCOPC	NCOPC	NCOPC	NCOPC	NCOPC	NCOPC	NCOPC	NBSAF	<1	--
Dibenz(a,h)anthracene	PAHs	PAHs	PAHs	PAHs	PAHs	PAHs	NTRV	NTRV	PAHs	PAHs	PAHs
Dibenzofuran	NTRV	NTRV	NTRV	NTRV	NTRV	NTRV	NCOPC	NCOPC	NB	--	--
Ethylbenzene	NCOPC	NCOPC	NCOPC	NCOPC	NTRV	<1	<1	<1	NCOPC	NCOPC	<1
Fluoranthene	PAHs	PAHs	PAHs	PAHs	PAHs	PAHs	**49**	**1.03**	PAHs	PAHs	PAHs
Fluorene	PAHs	PAHs	PAHs	PAHs	PAHs	PAHs	**1.7**	<1	PAHs	PAHs	PAHs
Indeno(1,2,3-c,d)pyrene	PAHs	PAHs	PAHs	PAHs	PAHs	PAHs	NTRV	<1	PAHs	PAHs	PAHs
Lead	**5.3**	<1	**58**	**11.4**	**11.9**	**2.00**	NCOPC	NCOPC	NCOPC	NCOPC	NCOPC
m,p-Xylene	NCOPC	NCOPC	NCOPC	NCOPC	Xylenes	Xylenes	Xylenes	Xylenes	NCOPC	Xylenes	Xylenes
Naphthalene	PAHs	PAHs	PAHs	PAHs	PAHs	PAHs	**123**	**10.4**	PAHs	PAHs	PAHs
Pentachlorophenol	--	--	**34**	**25**	ND	**4.4**	NCOPC	NCOPC	NCOPC	NCOPC	NCOPC

Table 7-7. Summary of Hazard Estimates for Ecological Receptors

Record of Decision for the Quendall Terminals Superfund Site

Ecological COPC	Terrestrial Receptors						Aquatic-Dependent Receptors				
	Bulk Soil Screening HQs				TDI Assessment NOAEL HQs (Maximum HQs for Birds and Mammals)		Surface Water Screening HQs		Fish Diet LOAEL HQs	TDI Assessment NOAEL HQs (Maximum HQs for Birds and Mammals)	
	Plant	Invert.	Avian	Mammal	Robin	Racoon	Aq. Plant	Fish	Benthivore	Sandpiper	Otter
Phenanthrene	PAHs	PAHs	PAHs	PAHs	PAHs	PAHs	**13**	**1.4**	PAHs	PAHs	PAHs
Pyrene	PAHs	PAHs	PAHs	PAHs	PAHs	PAHs	**62**	**5.2**	PAHs	PAHs	PAHs
Toluene	NCOPC	NCOPC	NCOPC	NCOPC	NTRV	<1	**1.6**	<1	NCOPC	NCOPC	<1
Total 10 of 16 HPAHs (U=1/2)	NTRV	**226**	NTRV	**3,692**	**55**	**1101**	NCOPC	NCOPC	**1.3**	**7**	**6**
Total 16 PAHs(U=1/2)	NCOPC	NCOPC	NCOPC	NCOPC	NCOPC	NCOPC	NCOPC	NCOPC	<1	**10**	**9**
Total 6 of 16 LPAHs (U=1/2)	NTRV	**47**	NTRV	**14**	**21**	**2.3**	NCOPC	NCOPC	<1	**5.2**	<1
Total PCBs (U=1/2)	NTRV	NTRV	NTRV	NTRV	<1	<1	NCOPC	NCOPC	NCOPC	NCOPC	NCOPC
Total Xylenes (U=1/2)	NCOPC	NCOPC	NCOPC	NCOPC	<1	<1	<1	<1	NCOPC	<1	<1
PAH ESBQ TUs	NCOPC	NCOPC	NCOPC	NCOPC	NCOPC	NCOPC	NCOPC	**26.5**	NCOPC	NCOPC	NCOPC

Notes:

PAHs summarized via benzo(a)pyrene and PAH totals.

Boldface without highlighting = HQ greater than 1

Boldface with highlighting = HQ greater than 10

-- = No COPC data in exposure data set.

COPC = contaminant of potential concern

ESBQ TU = equilibrium partitioning sediment benchmark quotient toxic unit

HPAH = high-molecular-weight PAH

HQ = hazard quotient

LOAEL = lowest observed adverse effects level

LPAH = low-molecular-weight PAH

NB = not sediment bioaccumulative

Xylenes summarized via total xylenes.

U=1/2 = Non-detects included at 1/2 the method detection limit.

NBSAF = no BSAF available

NCOPC = Not a COPC for exposure media evaluated for receptor

NOAEL = no observed adverse effects level

NTRV = No tissue TRV available

PAH = polynuclear aromatic hydrocarbon

PCB = polychlorinated biphenyl

TDI = total dietary intake

TRV = toxicity reference value

Table 7-8. Summary of Lines of Evidence, Baseline Ecological Risk Assessment

Record of Decision for the Quendall Terminals Superfund Site

Ecological Receptor Group	Line(s) of Evidence	Weight	Risk Characterization Summary	Uncertainty
Soil Invertebrates and Terrestrial Plants	Comparison of Site data with soil screening values for single chemicals or chemical groups	Primary	Lead exceeds the plant Eco-SSL; HPAHs and LPAHs exceed the invertebrate Eco-SSL.	High uncertainty because of lack of Site-specificity. Future remediation will require a soil cap; therefore, uncertainty is acceptable, and estimates are conservative.
Terrestrial Birds and Mammals	Multi-media exposure model calculations and comparisons with single-chemical toxicity data	Primary	LOAEL HQs >1 for at least one chemical or chemical group for each receptor. Highest HQs for HPAHs for the short-tailed shrew and the raccoon.	Moderate conservative uncertainty in models. More Site- specificity than Eco-SSLs.
	Comparison of Site data with soil screening values for single chemicals or chemical groups	Secondary	Chromium, lead, and pentachlorophenol exceeded the avian Eco-SSLs. Chromium, lead, pentachlorophenol, HPAHs, and LPAHs exceeded the mammal Eco-SSLs. HPAHs had the highest HQ, consistent with the primary line of evidence.	Higher uncertainty than multi-media model because of lack of Site-specificity. Results from this line of evidence support the primary line of evidence.
Aquatic Macrophytes	Comparison of Site data with surface water screening values for single chemicals or chemical groups	Primary	Individual PAHs HQs (including naphthalene) and PAH ESBQ TU >1.	Moderate uncertainty due to generic nature of screening levels; however, the overall risk to aquatic macrophytes was reasonably addressed with the PAH ESB approach.
Benthic Invertebrates	Site-specific sediment bioassays using amphipods and midges with Site and statistical comparisons with reference sediment tests	Primary	Midge and amphipod bioassay results indicate toxicity in samples associated with elevated hydrocarbons.	Because bioassays are a direct measure of toxicity, this line of evidence is primary.
	Comparison of Site data with porewater screening values or benchmarks for single chemicals or chemical groups	Secondary	Sediment porewater PAH ESBQ TU values were elevated in areas associated with hydrocarbon releases. Toxicity was observed where porewater TU values were greatest, corroborating the primary line of evidence.	Because sediment porewater is a direct measure of exposure to benthos, this line of evidence is secondary. Results from this line of evidence support the primary line of evidence.
	Comparison of Site data with bulk sediment screening values or benchmarks for single chemicals or chemical groups	Tertiary	Bulk sediment PAH ESBQ TU values were elevated in areas associated with hydrocarbon releases. Toxicity was observed where bulk sediment TU values were greatest, corroborating the primary line of evidence.	Because bulk sediment is an indirect measure of exposure to benthos, this line of evidence is tertiary. Results from this line of evidence support the primary line of evidence.

Table 7-8. Summary of Lines of Evidence, Baseline Ecological Risk Assessment
Record of Decision for the Quendall Terminals Superfund Site

Ecological Receptor Group	Line(s) of Evidence	Weight	Risk Characterization Summary	Uncertainty
Fish and Shellfish	Comparison of Site data with surface water and sediment porewater screening values or benchmarks for single chemicals or chemical groups	Primary	Individual PAHs HQs (including naphthalene) and PAH ESBQ TU >1.	Because surface water and porewater are direct measures of exposure to fish and shellfish, this line of evidence is primary.
	Dietary exposure model calculations and comparisons with single-chemical toxicity data	Secondary	Only one LOAEL (HPAH) HQ>1.	Dietary exposure models for PAHs and fish are highly uncertain given the lack of Site-specific data.
	Modeled tissue residue values for single chemicals or chemical groups	Tertiary	Risk was not characterized for this line of evidence.	Because PAHs are metabolized and there are a paucity of effects data, this line of evidence could not be evaluated.
Aquatic-dependent Birds and Mammals	Multi-media exposure model calculations and single-chemical toxicity data	Primary	LOAEL HQs >1 only for spotted sandpiper. Highest NOAEL HQs were for PAHs for the river otter and spotted sandpiper. Bald Eagle and great blue heron NOAEL HQs <1.	Moderately conservative uncertainty in models. This is the sole line of evidence for these receptors.

Notes:

Eco-SSL = Ecological Soil Screening Level
ESBQ TU = equilibrium partitioning sediment benchmark quotient toxic unit
HPAH = high-molecular-weight PAH
HQ = hazard quotient
LOAEL = lowest observed adverse effects level
LPAHs = low-molecular-weight PAHs
NOAEL = no observed adverse effects level
PAH = polynuclear aromatic hydrocarbon

Table 8-1. Remedial Action Objective Achievement Measures for Operable Unit 1
Record of Decision for the Quendall Terminals Superfund Site

Remedial Action Objective	Measures Used to Determine When the RAO Has Been Met
RAO 1—Reduce migration of COCs from DNAPL to groundwater to levels that allow restoration of groundwater to drinking water standards.	Depending on how DNAPL is addressed with each alternative, this RAO will be met when: (1) total petroleum hydrocarbon concentrations in thermally treated areas are below 3,000 parts per million, (2) solidification performance goals (to be determined in remedial design) are met in solidified areas; or (3) DNAPL-containing soil has been removed and treated or disposed.[a]
RAO 2—Restore groundwater in the shallow alluvium and deeper alluvium aquifers to drinking water standards to achieve its highest beneficial use (drinking water) within a reasonable timeframe.	This RAO will be met when the concentration of COCs in Site monitoring wells, are at or below MCLs or cleanup levels for the protection of human health (Table 8-3). Groundwater COC concentrations are expected to significantly decline following active remedial measures that treat or remove DNAPL in soil. Institutional controls would prohibit use of groundwater for drinking water purposes and construction of wells for any purpose, including domestic uses (e.g., inhalation while showering) until the RAO is met.
RAO 3—Reduce to acceptable levels the risk to future residents from direct contact or incidental ingestion of COCs in surface and subsurface soil.	This RAO will be met when the 95UCL concentration of COCs in the top 15 feet of soil, is at or below cleanup levels for the protection of human health (Table 8-3), or direct contact is prevented with a minimum 3-foot soil cap and institutional controls to prevent contact.
RAO 4—Reduce to acceptable levels the risk to terrestrial wildlife from direct contact or incidental ingestion of COCs in soils or soil invertebrates.	This RAO will be met when the 95UCL concentration of COCs in the top 5 feet of soil, is at or below cleanup levels for the protection of ecological receptors (Table 8-3), or direct contact is prevented with a minimum 3-foot soil cap and institutional controls.
RAO 5—Reduce to acceptable levels the human health risk from inhalation of vapors from groundwater and/or soils contaminated with COCs.	This RAO will be met when vapors are at acceptable levels, concentrations in groundwater and soils are at or below cleanup levels for the protection of human health (Table 8-3), or vapors are controlled to acceptable levels by a soil cap and institutional controls. Institutional controls would require that any future use that results in human occupation in enclosed spaces will require an assessment for potential vapor intrusion risks and, if necessary, require engineering controls to eliminate exposure to vapors. If engineering controls are implemented, indoor air monitoring and maintenance of vapor control devices would be required until the RAO is met.

[a] For determining areas for either smoldering combustion, ISS treatment, or excavation, evaluation of pre-remediation HRSC data will take into account the aggregate DNAPL thickness at each location, the areal extent of DNAPL occurrence, and the magnitude of the HRSC measured value.

ARAR = applicable or relevant and appropriate requirement

COC = contaminant of concern

DNAPL = dense nonaqueous phase liquid

HRSC = high-resolution site characterization

ISS = in situ solidification

MCL = maximum contaminant level

RAO = Remedial Action Objective

95UCL = 95 percent upper confidence limit on the mean

Table 8-2. Remedial Action Objective Achievement Measures for Operable Unit 2
Record of Decision for the Quendall Terminals Superfund Site

Remedial Action Objective	Measures Used to Determine When the RAO Has Been Met
RAO 1—Reduce migration of COCs from DNAPL to sediment to levels that allow restoration of sediment to acceptable levels.	This RAO will be met when DNAPL-containing sediment has been removed and treated or disposed of offsite.[a]
RAO 2—Reduce to acceptable levels the risk to adults and children from ingestion of resident fish and shellfish taken from the Site.	This RAO will be met when the 95UCL concentrations of COCs in the top 10 centimeters of sitewide sediment are at or below cleanup levels for the protection of human health (Table 8-4). Actions to minimize the release of COCs from the upland area to Lake Washington, in combination with active remedial measures in the lake, will reduce COC concentrations in sediment and in porewater. These reductions are expected to result in declining contaminant concentrations in fish and shellfish tissue.
RAO 3—Reduce to acceptable levels the risk to future beach users from playing or wading in shallow water near shore resulting in incidental ingestion or/and dermal exposure to contaminated sediments.	This RAO will be met when the 95UCL concentrations of COCs in the top 10 centimeters of nearshore sediment (areas where water depths are at or below 10 feet) are at or below cleanup levels for the protection of human health (Table 8-4).
RAO 4—Reduce to acceptable levels the risk to aquatic organisms (benthos, aquatic plants, and fish) and aquatic-dependent wildlife (sediment-probing birds and piscivorous mammals) from direct contact and/or incidental ingestion of COCs in sediment, surface water/porewater, and prey.	This RAO will be met when: (1) the concentration of total PAHs in the top 10 centimeters of sediment, on a point-by-point basis, are at or below cleanup levels for the protection of benthic organisms (Table 8-4); and (2) the 95UCL concentrations of COCs, other than PAHs, in the top 10 centimeters of sitewide sediment, are at or below cleanup levels for the protection of other aquatic life (Table 8-4).

[a] For determining areas for dredging, evaluation of pre-remediation data will take into account the aggregate DNAPL thickness at each location and the areal extent of DNAPL occurrence.

ARAR = applicable or relevant and appropriate requirement

COC = contaminant of concern

DNAPL = dense nonaqueous phase liquid

RAO = Remedial Action Objective

95UCL = 95 percent upper confidence limit on the mean

Table 8-3. Cleanup Levels for Soil and Groundwater, Operable Unit 1

Record of Decision for the Quendall Terminals Superfund Site

Contaminant of Concern	Soil (mg/kg)	Basis	Groundwater (µg/L)	Basis
2-methylnaphthalene	240	HHRA RBC HQ=1	36	HHRA RBC HQ=1
Acenaphthene	--	--	530	HHRA RBC HQ=1
Arsenic	7.3	Ecology 1994[a]	10	MCL
Benzene	--	--	5	MCL
Benz(a)anthracene*	1.1	HHRA RBC 10^{-6}	0.03	HHRA RBC 10^{-6}
Benzo(a)pyrene*	0.11	HHRA RBC 10^{-6}	0.2	MCL
Benzo(b)fluoranthene*	1.1	HHRA RBC 10^{-6}	0.25	HHRA RBC 10^{-6}
Benzo(k)fluoranthene*	11	HHRA RBC 10^{-6}	2.5	HHRA RBC 10^{-6}
Chromium	51	ERA RBC HQ=1	--	--
Chrysene*	110	HHRA RBC 10^{-6}	25	HHRA RBC 10^{-6}
Dibenz(a,h)anthracene*	0.11	HHRA RBC 10^{-6}	0.025	HHRA RBC 10^{-6}
Dibenzofuran	--	--	7.9	HHRA RBC HQ=1
Ethylbenzene	5.8	HHRA RBC 10^{-6}	700	MCL
Fluoranthene	via HPAH	ERA RBC HQ=1	800	HHRA RBC HQ=1
Fluorene	via LPAH	ERA RBC HQ=1	290	HHRA RBC HQ=1
Indeno(1,2,3-c,d)pyrene*	1.1	HHRA RBC 10^{-6}	0.25	HHRA RBC 10^{-6}
Lead	37	ERA RBC HQ=1	--	--
Naphthalene	3.8	HHRA RBC 10^{-6}	0.17	HHRA RBC 10^{-6}
Phenanthrene	via LPAH	ERA RBC HQ=1	--	--
Pyrene	via HPAH	ERA RBC HQ=1	120	HHRA RBC HQ=1
Total cPAHs	0.11	HHRA RBC 10^{-6}	0.2	MCL
Total HPAHs	3.7	ERA RBC HQ=1	--	--
Total LPAHs	65	ERA RBC HQ=1	--	--
Total Xylenes	--	--	10,000	MCL

Notes:

[a] Washington State Department of Ecology. 1994. *Natural Background Soil Metals Concentrations in Washington State*. Publication 94-115. October.

-- = not a contaminant of concern for medium listed

µg/L = microgram(s) per liter

*cPAH = carcinogenic PAH – calculated based on benzo(a)pyrene equivalents.

HPAH = high-molecular-weight PAH (benzo[a]anthracene, benzo[a]pyrene, benzo[b]fluoranthene, benzo[k]fluoranthene, benzo[g,h,i]perylene, chrysene, dibenz[a,h]anthracene, indeno[1,2,3-c,d]pyrene, fluoranthene, and pyrene)

LPAH = low-molecular-weight PAH (acenaphthylene, acenaphthene, anthracene, fluorene, naphthalene, and phenanthrene)
mg/kg = milligram per kilogram

PAH = polynuclear aromatic hydrocarbon PRG = preliminary remediation goal

HHRA RBC 10^{-6} = Human Health Risk Assessment Risk-Based Concentration based on cancer risk of 1 x 10^{-6}

HHRA RBC HQ=1 = Human Health Risk Assessment Risk-Based Concentration based on noncancer hazard quotient of 1. Cleanup levels for COCs with similar noncarcinogenic toxic effects will also meet an HI of 1.
ERA RBC HQ=1 = Ecological Risk Assessment Risk-Based Concentration, based on noncancer hazard quotient of 1

MCL = maximum contaminant level

Table 8-4. Cleanup Levels for Sediment, Operable Unit 2
Record of Decision for the Quendall Terminals Superfund Site

Contaminant of Concern	Nearshore Sediment (mg/kg)	Basis	Sitewide Sediment (mg/kg)	Basis
Benz(a)anthracene*	0.98	HHRA RBC 10^{-6}	5.35	HHRA RBC 10^{-6}
Benzo(a)pyrene*	0.098	HHRA RBC 10^{-6}	1.62	HHRA RBC 10^{-6}
Benzo(b)fluoranthene*	0.98	HHRA RBC 10^{-6}	16.2	HHRA RBC 10^{-6}
Benzo(k)fluoranthene*	9.83	HHRA RBC 10^{-6}	162	HHRA RBC 10^{-6}
Chrysene*	98.3	HHRA RBC 10^{-6}	530	HHRA RBC 10^{-6}
Dibenz(a,h)anthracene*	0.098	HHRA RBC 10^{-6}	0.48	HHRA RBC 10^{-6}
Indeno(1,2,3-c,d)pyrene*	0.98	HHRA RBC 10^{-6}	10.5	HHRA RBC 10^{-6}
Total cPAHs	0.098	HHRA RBC 10^{-6}	1.62	HHRA RBC 10^{-6}
Total HPAHs	29	ERA RBC HQ=1	--	--
Total PAHs	17	SMS	17	SMS

Notes:

Cleanup Levels (CULs) for sediment and surface water were identified based on the most stringent applicable or relevant and appropriate requirement (ARAR). For sediment, if no ARAR is available, the lowest risk-based concentration (RBC) based on either carcinogenic effects or noncarcinogenic effects was selected.

Nearshore sediment is delineated by areas covered with 10 feet or less of water.

-- = not a contaminant of concern for medium listed

mg/kg = milligrams per kilogram

*cPAH = carcinogenic PAH(s) – calculated based on benzo(a)pyrene equivalents

ERA RBC HQ=1 = Ecological Risk Assessment (ERA) Risk-Based Concentration, based on otter (Hazard Quotient = 1, back-calculated from ERA)

HHRA RBC 10^{-6} = Human Health Risk Assessment Risk-Based Concentration, based on risk of 1 x 10^{-6}

HPAH = high-molecular-weight PAH (benz[a]anthracene, benzo[a]pyrene, benzo[b]fluoranthene, benzo[k]fluoranthene, benzo[g,h,i]perylene, chrysene, dibenz[a,h]anthracene, indeno[1,2,3-c,d]pyrene, fluoranthene, and pyrene)

PAH = polycyclic aromatic hydrocarbon

SMS = Washington State Sediment Management Standards (WAC 173-204-563, Table VI, Sediment Cleanup Objective)

Table 10-1. Chemical-Specific Applicable or Relevant and Appropriate Requirements, Operable Unit 1

Record of Decision for the Quendall Terminals Superfund Site

Regulatory Citation	Description of Regulatory Requirement	Rationale for Including	Application
Soil			
Model Toxics Control Act (MTCA) (RCW 70.105D; WAC 173-340)	WAC 173-340 is the Washington State regulation that requires investigation and remediation of contaminated sites. The cleanup levels developed will meet following MTCA requirements: • Total excess cancer risk is less than 1 x 10^{-5} cumulatively for all COCs • Excess cancer risk for individual COCs is less than or equal to 1 x 10^{-6}, except where below background • Noncancer hazard index is less than or equal to 1	**Applicable** where substantive MTCA requirements are more stringent than the Comprehensive Environmental Response, Compensation, and Liability Act of 1980.	EPA-developed Site cleanup levels meet the MTCA risk thresholds.
Groundwater			
Federal: Primary Drinking Water Standards -40 CFR 141 Subpart G, Maximum Contaminant Levels (MCLs) and Maximum Residual Disinfectant Levels (MRDLs) State: Drinking Water Standards – MCLs and MRDLs, WAC 246-290-310	Establishes drinking water standards for public water systems to protect human health. Includes standards for the following Site COCs: arsenic, benzene, and benzo(a)pyrene. The National Contingency Plan states that MCLs, not MCL goals, are ARARs for usable aquifers.	**Applicable** for groundwater that could potentially be used for drinking water, where the water will be provided directly to 25 or more people or will be supplied to 15 or more service connections.	The RI states that the groundwater beneath the Site and Lake Washington are considered potable water supplies. The remedial goals consider these standards.
Federal: Secondary Drinking Water Standards - 40 CFR 143, Secondary MCLs	Establishes drinking water standards for public water systems to achieve the aesthetic qualities of drinking water (secondary MCLs).	**To Be Considered** for groundwater that could potentially be a drinking water source (i.e., achieved as practicable).	The RI states that the groundwater beneath the Site and Lake Washington are considered potable water supplies. The remedial goals consider these standards.
Model Toxics Control Act (MTCA) (RCW 70.105D; WAC 173-340)	WAC 173-340 is the Washington State regulation that requires investigation and remediation of contaminated sites. The cleanup levels developed will meet following MTCA requirements: • Total excess cancer risk is less than 1 x 10^{-5} cumulatively for all COCs • Excess cancer risk for individual COCs is less than or equal to 1 x 10^{-6}, except where below background • Noncancer hazard index is less than or equal to 1	**Applicable** where substantive MTCA requirements are more stringent than the Comprehensive Environmental Response, Compensation, and Liability Act of 1980.	EPA-developed Site cleanup levels meet the MTCA risk thresholds.

ARAR = applicable or relevant and appropriate requirement
CFR = *Code of Federal Regulations*
COC = contaminant of concern
EPA = U.S. Environmental Protection Agency
MCL = maximum contaminant level
MTCA = Model Toxics Control Act
RCW = Revised Code of Washington
RI = Remedial Investigation
WAC = Washington Administrative Code

Table 10-2. Action-Specific Applicable or Relevant and Appropriate Requirements, Operable Unit 1

Record of Decision for the Quendall Terminals Superfund Site

Regulatory Citation	Description of Regulatory Requirement	Rationale for Including	Application
Contaminated Site Remediation			
Washington Model Toxics Control Act (MTCA), WAC 173-340	WAC 173-340 is the Washington State regulation that requires investigation and remediation of contaminated sites. Applicable sections include: • 173-340-400 Implementation of the cleanup action • 173-340-420 Periodic review • 173-340-600 Public notice and participation	**Applicable.** The CERCLA process is equivalent to the substantive requirement of MTCA process and implementation of the selected remedy pursuant to CERCLA and the NCP provides the same level of protection as MTCA.	Remedial actions will be implemented per this Record of Decision followed by CERCLA Five- Year Reviews.
Minimum Standards for Construction and Maintenance of Wells, WAC 173-160	Establishes minimum standards for construction of wells, including monitoring well design, construction, development, and abandonment. Also provides technical standards by which well cuttings and development water are handled.	**Applicable** for wells constructed to support remediation and monitoring.	Would apply to wells constructed as part of the smoldering combustion treatment system (air/heat injection and soil vapor extraction) and groundwater monitoring wells.
Wetlands Disturbance			
CWA Section 404(b)(1) (33 *United States Code* 1344[b][1]) Guidelines 40 CFR 230, Guidelines for Specification of Disposal Sites for Dredged or Fill Material 33 CFR 330, Nationwide General Permit Program U.S. Army Corps of Engineers Nationwide Permit 38 – Cleanup of Hazardous and Toxic Waste	CWA Section 404 regulates the discharge of dredged or fill material into waters of the U.S. including return flows from such activity. This program is implemented through regulations set forth in the Section 404(b)(1) guidelines found in 40 CFR Part 230. Specific requirements include: 40 CFR 230.7 – General Permits may be authorized to address 40 CFR 230 requirements, 40 CFR 230.11 – factual determinations on short- term and long-term effects of a proposed discharge of dredged or fill material on the physical, chemical, and biological components of the aquatic environment in light of 40 CFR 230 Subparts C through F, 40 CFR 230.41 – potential impacts to wetlands, and 40 CFR 230 Subpart J provides the standards and criteria for the use of compensatory mitigation when the response action will result in unavoidable impacts to the aquatic environment, including wetlands.	CWA Section 404 requirements are **Applicable** to construction activities, including treatment of contaminated wetlands and riparian habitat adjacent to the shoreline. A Section 404 permit is not needed because this is a CERCLA site.	FS information indicates that the remedy can be implemented in compliance with Section 404 requirements. However, more detailed remedial design information will be required to fully assess impacts and specify requirements and controls to minimize impacts on wetlands. Also, through the Section 404 analysis in remedial design, exact amounts of compensatory mitigation for unavoidable loss of habitat will be determined and mitigation plans developed.
State: WAC 220-660, Hydraulic Code Rules WAC 220-660-110, Authorized Work Times in Freshwater Areas WAC 220-660-120, Common Freshwater Construction Provisions	Requires consultation with WDFW, although no Hydraulic Project Approval permit is required because this is a CERCLA site. Specific technical requirements include: WDFW will determine when work can occur in freshwater areas based on fish life stages to minimize impact on fish (WAC 220-660-110) Conduct activities that cause the least impacts to fish life (WAC 220-660-120), including, but not limited to: • Establish staging areas to prevent migration of contaminants to state waters • Limit removal of native vegetation • Use equipment that reduces ground pressure if wet or muddy conditions exist • Use environmentally acceptable lubricants if equipment is used near the shore • Restore riparian zones to as close as possible to pre-project conditions at the end of the project unless otherwise indicated in planning documents	The definition of "freshwater area" in WAC 220-660-100 states "Freshwater areas also include all lakes, ponds, and tributary streams and surface-water-connected wetlands that provide or maintain habitat that supports life. This definition does not include irrigation ditches, canals, stormwater treatment, and conveyance systems, or other entirely artificial watercourses, except where they exist in a natural watercourse that has been altered by humans." The wetlands and riparian habitat along the shoreline at the Site appear to meet this definition, so this regulation would be **Applicable** to remediation in the wetland areas. A Hydraulic Project Approval permit is not needed because this is a CERCLA site.	Would apply to wetlands and riparian areas that are subject to smoldering combustion, ISS, or capping as part of the remedy.
Stormwater Discharge During Construction			
State: WAC 173-201A- 510(3)(a), (b), and (c), Nonpoint source and stormwater pollution	Requires the use of BMPs to prevent water quality violations caused by stormwater.	These regulations are **Relevant and Appropriate** for managing stormwater generated during construction.	Construction stormwater BMPs are discussed in Ecology's Construction Stormwater General Permit (expiration date 12/31/2020), which references Ecology's Stormwater Management Manual for Western Washington (draft 2019 update). Stormwater management BMPs will need to be included in the remedial design.
Wastewater Discharge			
Local: King County Pretreatment Standards, King County Code Title 28: Rules and Regulations for the Disposal of Industrial Waste into the Metropolitan Sewerage System Chapter 28.84.060, Industrial Waste rules and regulations	Limits the concentrations of contaminants and heat in wastewater discharged to the sanitary sewer.	Part of the smoldering combustion remediation is collecting the vapors that are generated by heating the soil. **Applicable** if moisture from the vapor stream can be discharged to the King County sanitary sewer.	
Discharge of Polluting Matters into Waters			
State: Water Pollution Control Act, RCW 90.48.080, Discharge of Polluting Matter into Waters Prohibited	RCW 90.48.080 prohibits the discharge of polluting matter into state waters.	These requirements are **Applicable** to any discharge of water that may go to Lake Washington during construction	Actions will be taken during remedy implementation to minimize the potential for discharge outside the remedial construction area. These actions will be discussed in the work plan for the remedy

Table 10-2. Action-Specific Applicable or Relevant and Appropriate Requirements, Operable Unit 1
Record of Decision for the Quendall Terminals Superfund Site

Regulatory Citation	Description of Regulatory Requirement	Rationale for Including	Application
Air Emissions			
State: General Regulations for Air Pollution Sources (WAC 173-400); and Controls for New Sources of Toxic Air Pollutants (WAC 173-460) Regional: PSCAA, Regulations I and III (PSCAA has been delegated authority by U.S. Environmental Protection Agency and Ecology)			
State: WAC 173-400-040, General Standards for Maximum Emissions	All sources and emission units are required to meet the general emission standards unless a specific source standard is available. General standards apply to visible emissions, fallout, fugitive emissions, odors, emissions detrimental to persons and property, sulfur dioxide, concealment and masking, and fugitive dust.	State regulations defining methods of control to be employed to minimize the release of contaminants associated with fallout are **Relevant and Appropriate** to remedial actions that may generate fallout	PSCAA regulations also address other potential releases of contaminants, such as fugitive dust and odor, which are listed below and are applicable.
State: WAC 173-460-150, Toxic Air Pollutants (as adopted by PSCAA Regulation I Section 1.07), Regional: PSCAA Regulation III Section 2.07	Lists Washington State TAPs, which is a larger list than the federal hazardous air pollutant list. Includes ASILs (in micrograms per cubic meter), small quantity emission rate (in pounds per averaging period specified), and de minimis (in pounds per averaging period specified) emissions values.	**Applicable**, if a TAP may be emitted from the remediation project (e.g., the smoldering combustion technology).	Of the 21 specific compounds listed as soil or groundwater contaminants of concern, 16 are included on the TAP list.
Regional: PSCAA Regulation I Section 6.03(c)(93), soil and groundwater treatment exemption definition PSCAA Regulation III, Section 2.07, Calculating the impacts of toxic air contaminants Section 1.05(c), Best available control technology (BACT)	Soil and groundwater remediation projects involving ≥15 pounds per year of benzene and ≥1,000 pounds per year of toxic air contaminants are subject to PSCAA NOC submittal requirements. Regulation I states that a TAP is also known as a toxic air contaminant. Regulation III says that if an NOC is required, the owner/operator of a source shall quantify toxic air contaminant emissions that may be discharged to the atmosphere after applying the required control technology, and determine if the potential TAP concentrations emitted are below ASILs. The required control technology for toxic air contaminant emissions is BACT.	An NOC submittal is administrative; however, calculation of TAPs emissions and use of BACT controls are **Applicable**, if a TAP may be emitted from the remediation project (e.g., vapor collection and emissions controls on the smoldering combustion technology).	Potential emissions of TAPs will be calculated during remedial design. TAPs may be emitted to the air during the smoldering combustion process and during ISS. If necessary, the design will include the use of BACT to control TAP emissions from the remediation.
PSCAA Regulation 1, Section 5.06(c), O&M plans	The owner/operator of sources subject to PSCAA regulation will develop and implement an O&M plan to ensure continuous compliance with Regulations I, II, and III. The plan shall reflect good industrial practice and shall include, but not be limited to, the following: (1) Periodic inspection of all equipment and control equipment; (2) Monitoring and recording of equipment and control equipment performance; (3) Prompt repair of any defective equipment or control equipment; (4) Procedures for start-up, shut down, and normal operation; (5) The control measures to be employed to ensure compliance with Section 9.15 of this regulation; and (6) A record of all actions required by the plan. The plan shall be reviewed by the source owner.	**Applicable**, if a TAP may be emitted from the remediation project (e.g., vapor collection on the smoldering combustion technology), and emissions controls are installed.	An O&M Plan will be developed during remedial design that will include emissions control.
PSCAA Regulation I, Section 9.11, Emission of air contaminant: detriment to person or property	Air contaminants may not be emitted in sufficient quantities and of such characteristics and duration as is, or is likely to be, injurious to human health, plant or animal life, or property, or which unreasonably interferes with enjoyment of life and property.	**Applicable,** because remediation activities may generate odors or air contaminants.	Precautions to minimize odors and air emissions will be taken during construction and considered during remedial design.
PSCAA Regulation I, Section 9.15, Fugitive dust control measures	Reasonable precautions need to be taken to minimize visible fugitive dust emissions.	**Applicable,** because dust may be generated as part of ISS activities.	Precautions to minimize fugitive dust could include practices such as wetting (misting) of materials while stockpiled, covering stockpiles, or minimizing stockpiling time to avoid drying out of solidification materials.
PSCAA Regulation I, Section 9.20, Maintenance of Equipment	Equipment and air emissions control equipment must be maintained in good working order. Equipment is defined as any part of a stationary source or source that emits or would have the potential to emit any pollutant subject to regulation (Regulation 1, Section 1.07).	**Applicable**, because equipment and air emissions control equipment will be used during the remedial action.	An O&M Plan will be developed during remedial design that will include emissions control.
Solid and Dangerous Waste Generation			
State: Solid Waste Regulations, WAC 173-350 WAC 173-350-025, Owner responsibilities for solid waste WAC 173-350-040, Performance standards WAC 173-350-300, Onsite storage, collection, and transportation standards WAC 173-350-900, Remedial action	Establishes minimum functional performance standards for the proper handling and disposal of solid waste, not otherwise excluded. Provides requirements for the proper handling of solid waste materials originating from residences, commercial, agricultural, and industrial operations, and other sources, and identifies those functions necessary to ensure effective solid waste handling programs at both the state and local level.	Requirements are **Applicable** for covered solid waste generated during implementation of remedial actions. The remedial action will generate solid waste such as personal protective equipment and construction debris (e.g., during installation of the smoldering combustion system, ISS, or installation of monitoring wells).	Remedial actions that generate covered solid waste will meet standards.

Table 10-2. Action-Specific Applicable or Relevant and Appropriate Requirements, Operable Unit 1
Record of Decision for the Quendall Terminals Superfund Site

Regulatory Citation	Description of Regulatory Requirement	Rationale for Including	Application
WAC 173-303-016, Identifying Solid Waste	Identifies those materials that are and are not solid wastes and identifies those materials that are and are not solid wastes when recycled.	Solid waste identification requirements are **Applicable** to solid wastes generated during remedial actions.	Standards will be met for remediation activities
WAC 173-303-070, Designation of Dangerous Waste	Establishes the requirements for determining whether a solid waste is a dangerous waste (or an extremely hazardous waste), for making quantity determinations and for small quantity generators.	Dangerous waste characterization and determination is **Applicable** to wastes generated during remedial actions, such as soil and groundwater well purge water, that will be disposed of offsite.	According to the FS, the following hazardous/dangerous wastes may be generated during remediation: Listed hazardous waste K035 – soil located above the water table within the footprint of the north and south sumps Characteristic hazardous waste D0018 and/or Washington criteria dangerous waste WP01 – principal-threat waste soils (soils contaminated with dense nonaqueous phase liquid)
WAC 173-303-140(1) through (4), Land Disposal Restrictions (which reference 40 CFR 268)	Establishes land disposal restrictions, including waste and applicable treatment standards determinations, and storage and disposal prohibitions.	**Applicable** to onsite management of dangerous waste generated during remedial action.	Contaminated soils may need to be treated to meet land disposal restrictions before disposal in Washington (or another state).
WAC 173-303-170, Requirements for Generators of Dangerous Waste	This regulation establishes the requirements for dangerous waste generators. Requirements for Generators of Dangerous Waste (WAC 173-303-170[3]) includes the substantive provisions of Accumulating Dangerous Waste On Site (WAC 173-303-200) by reference.	This regulation **is Applicable** to remedial actions that may generate dangerous wastes.	Remediation wastes (for example, contaminated soil, PPE) may be dangerous waste and will be managed in accordance with these requirements.
WAC 173-303-200, Conditions for Exemption for a Large Quantity Generator that Accumulates Dangerous Waste	This regulation establishes the requirements for accumulating wastes onsite and includes certain substantive standards from Use and Management of Containers (WAC 173-303-630) and Tank Systems (WAC 173-303-640) by reference. Includes standards for secondary containment and closure of accumulation areas (WAC 173-303-200[3])	State rules establishing requirements for accumulating dangerous waste onsite are **Applicable** for managing remediation wastes generated at the Site including contaminated soils, contaminated debris, used PPE, and treatment chemicals.	Management of remediation wastes that are dangerous waste will comply with these requirements.
WAC 173-303-630, Use and Management of Containers	This regulation establishes requirements for management of dangerous waste in containers.	This standard is **Applicable** to remedial actions that involve management of dangerous waste in containers that are subject to this standard.	Remedial actions that produce or manage containers of dangerous waste will be managed to meet standards.
WAC 173-303-280(6), General requirements for dangerous waste management facilities: Requirements for cleanup only facilities	This regulation establishes requirements for the protection of public safety and worker safety at hazardous waste cleanup sites, including measures to prevent exposure by members of the general public, worker safety training, accident prevention, management of surface impoundments and waste piles, and construction quality assurance planning.	This rule is **Relevant** and **Appropriate** to construction activities on shoreline, and soil remediation and capping activities; and to dangerous waste treatment and handling before offsite transport.	Cleanup activities will comply with these standards.

ASIL = Acceptable Source Impact Level
BACT = best available control technology
BMP = best management practice
CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act of 1980
CFR = *Code of Federal Regulations*
CWA = Clean Water Act
Ecology = Washington State Department of Ecology
FS = Feasibility Study
ISS = in situ solidification
MTCA = Model Toxics Control Act
NOC = notice-to-construct
O&M = operations and maintenance
PPE = personal protective equipment
PSCAA = Puget Sound Clean Air Agency
TAP = toxic air pollutant
U.S. = United States
WAC = Washington Administrative Code
WDFW = Washington State Department of Fish and Wildlife

Table 10-3. Location-Specific Applicable or Relevant and Appropriate Requirements, Operable Unit 1
Record of Decision for the Quendall Terminals Superfund Site

Regulatory Citation	Description of Regulatory Requirement	Rationale for Including	Application
Archaeologically or Historically Sensitive Resources			
Federal: Native American Graves Protection and Repatriation, 25 U.S.C. 3001-3013, 43 CFR 10	Requires federal agencies and museums which have possession of or control over Native American cultural items (including human remains, associated and unassociated funerary items, sacred objects, and objects of cultural patrimony) to compile an inventory of such items. Prescribes when such federal agencies and museums must return Native American cultural items.	This requirement is **Applicable** if Native American human remains or cultural items associated with human remains are present and discovered during the course of remedial construction. Such a discovery at the Site is unlikely but possible.	The Muckleshoot Tribe will be consulted if remains or cultural items are present and discovered.
Federal: National Historic Preservation Act (NHPA), 16 U.S.C. 470 et seq. 36 CFR Part 800	Requires the identification of historic properties potentially affected by the agency undertaking, and assessment of the effects on the historic property and seek ways to avoid, minimize or mitigate such effects. Historic property is any district, Site, building, structure, archaeological Site, traditional cultural landscape, traditional cultural property, or object included in or eligible for the National Register of Historic Places, including artifacts, records, and material remains related to such a property.	**Applicable** if historic properties are potentially affected by remedial activities. No historic properties have been identified at the Site to date, but could potentially be identified during remedial design.	EPA will consult with the Washington SHPO, and DAHP before the start of remedial construction and will work to avoid, minimize, or mitigate the impacts of construction on any historic properties.
Federal: Archaeological and Historic Preservation Act, 16 U.S.C. 469a-1	Provides for the preservation of historical and archaeological data that may be irreparably lost as a result of a federally approved project and mandates only preservation of the data.	**Applicable** if historical and archaeological data may be irreparably lost by implementation of the remedial activities.	EPA will consult with the Washington SHPO and DAHP before the start of remedial construction and will preserve data as required, should there be any historical or archaeological features within the construction area.
Sensitive Habitats and Protected Species			
Federal: Migratory Bird Treaty Act. 16 U.S.C. 703 and 50 CFR 10.12	This act makes it unlawful to pursue, hunt, take, capture, or kill any migratory bird, part, nest, egg, or product. All but a few bird species naturally occurring in the United States are protected under this act.	Applicable - may require mitigation measures to deter nesting by migratory birds on, around, or within remedial action areas and methods to protect occupied bird nests.	Remedial actions will use best management practices for observing and avoiding contact with migratory birds during construction of the remedy.
Federal: Bald and Golden Eagle Protection Act, 16 U.S.C. 668, 50 CFR 22.11, General Requirements	Protects bald and golden eagles from take, possession or transportation without a permit	Applicable if bald and golden eagles or their habitat would be affected during remediation activities, based on the biological assessment (to be performed during design).	If needed, remedial action work plans will include measures to minimize disturbances to bald eagles.
Coast and Shoreline			
Federal: Coastal Zone Management Act, 16 U.S.C. 1451 et seq.) State: Shoreline Management Act of 1971, Revised Code of Washington (RCW) 90.58 and Washington Administrative Code (WAC) 173-27 City: Renton Shoreline Master Program: Renton Municipal Code 4-3-090, Shoreline Master Program Regulations, subsections 04-3-090.D.2.d.iv(c) and (d); 04-2-090.D.2.d.vi and d.vii; and 04-3- 090.D.2.d.x(d)	Establishes regulations, enforcement procedures, and policies for protecting and developing Washington and Renton's shoreline areas.	Policies and regulations for Renton shorelines and wetlands are **Relevant and Appropriate** for remedial activities within 200 feet of the ordinary high-water mark.	Design and construction in habitat zone at the shoreline and other wetlands at the Site will comply with Shoreline Master Program requirements and include mitigation for unavoidable impacts. The City of Renton is in the process of reviewing the Shoreline Master Program and will submit the revisions to the Washington State Department of Ecology by June 2019.
Critical Areas			
City: Renton Critical Areas Program: Renton Municipal Code 4-3-050, Critical Areas Regulations	Establishes regulations, enforcement procedures, and policies for protecting Renton's critical areas, including wetlands. No net loss of wetlands is allowed. Wetland mitigation must meet certain requirements.	Policies and regulations for Renton wetlands are **To Be Considered** for remedial activities. Renton's mapping of critical areas includes the habitat area along the shoreline and wetlands interior to the Site.	Design and construction in Renton critical areas, including the habitat zone at the shoreline and other wetlands at the Site, will comply with critical area requirements and include mitigation for unavoidable impacts.

CFR = *Code of Federal Regulations*
DAHP = Washington State Department of Archaeology and Historic Preservation
EPA = U.S. Environmental Protection Agency
SHPO = State Historic Preservation Officer
U.S.C. = *United States Code*

Table 10-4. Chemical-Specific Applicable or Relevant and Appropriate Requirements, Operable Unit 2

Record of Decision for the Quendall Terminals Superfund Site

Regulatory Citation	Description of Regulatory Requirement	Rationale for Including	Application
Surface Water			
Clean Water Act (CWA) 33 U.S.C. 1313 and 1314 (Sections 303 and 304). Most recent Section 304(a) list of recommended water quality criteria, as updated to issuance of the Record of Decision	Under CWA Section 304(a), EPA develops recommended water quality criteria for water quality programs established by states. Two kinds of water quality criteria are developed: one for protection of human health, and one for protection of aquatic life. CWA Section 303 requires states to develop water quality standards based on federal water quality criteria to protect existing and attainable use or uses (for example, recreation, public water supply) of the receiving waters.	The most recent Section 304(a) recommended water quality criteria are **Relevant and Appropriate** as criterion to apply to short-term impacts from dredging and capping if more stringent than promulgated state criteria.	Contaminants could be released to Lake Washington during in-water remedy implementation activities including sediment dredging and capping activities.
40 CFR 131.36(b)(1) as applied to Washington, 40 CFR 131.36(d)(14), Toxics Criteria for Those States Not Complying with Clean Water Act	Establishes numeric water quality criteria for priority toxic pollutants for the protection of human health and aquatic organisms which supersede criteria adopted by the state, except where the state criteria are more stringent than the federal criteria.	These requirements are **Applicable** for any discharge of water generated during construction.	Would apply to any discharges of water during construction, for example, if porewater drained from dredged sediments is discharged to Lake Washington.
WAC 173-201A; Water Quality Standards for Surface Waters of the State of Washington Fresh Water Designated Uses and Criteria (WAC 173-201A- 200) Fresh Water Use Designations (WAC 173-201A-600 and 602)	Establishes chemical water quality standards for surface waters of the State of Washington for protection of aquatic life. The Site is located in Lake Washington. Lake Washington is listed in WAC 173-201A-602 for aquatic life, recreational, water supply, and miscellaneous uses. WAC 173-201A-210 also includes limits for more traditional pollutants, including temperature, turbidity, dissolved oxygen, and pH, based on the fresh water use.	State standards that are more stringent than federal standards are **Relevant and Appropriate** as criterion to short-term impacts and to any new point source discharges that may occur in implementing the remedy.	Specific actions taken to minimize turbidity and other limits in the area outside the immediate dredge area will be evaluated and addressed in the work plan, based on selected construction methods during design and implementation of the remedy. Potential actions could include use of turbidity curtains around the dredge area, or similar.
Surface Water Quality Standards, Toxic Substances (WAC 173-201A-240)	Ecology is authorized by EPA to administer the CWA in Washington State. WAC 173-201A-240: Toxic substances shall not be introduced above natural background levels in waters of the state which have the potential either singularly or cumulatively to adversely affect characteristic water uses, cause acute or chronic toxicity to the most sensitive biota dependent upon those waters, or adversely affect public health. Substances may not exceed specified standards for parameters such as inorganics, hydrocarbons, and toxic substances.	State standards that are more stringent than federal standards are **Relevant and Appropriate** as criterion to short-term impacts during construction and to any new point source discharges that may occur in implementing the remedy.	Contaminants could be released to Lake Washington during in-water construction activities including sediment dredging and capping activities. Specific actions taken to comply with these applicable or relevant and appropriate requirements will be evaluated and addressed, based on results of sediment chemical testing and selected construction methods during design and implementation of the remedy.
Water Pollution Control Act RCW 90.48.080, Discharge of Polluting Matter into Waters Prohibited	RCW 90.48.080 prohibits the discharge of polluting matter into state waters.	These requirements are **Applicable** to any discharge of water that may go to Lake Washington during remedy implementation.	Actions will be taken during remedy implementation to minimize the potential for discharge outside the remedial construction area. These actions will be discussed in the work plan for the remedy.
Sediment			
Model Toxics Control Act (MTCA) (RCW 70.105D; WAC 173-340)	WAC 173-340 is the Washington State regulation that requires investigation and remediation of contaminated sites. The cleanup levels developed will meet following MTCA requirements: • Total excess cancer risk is less than 1 x 10-5 cumulatively for all COCs • Excess cancer risk for individual COCs is less than or equal to 1 x 10^{-6}, except where below background • Noncancer hazard index is less than or equal to 1	These requirements are **Applicable** where substantive MTCA requirements are more stringent than the Comprehensive Environmental Response, Compensation, and Liability Act.	EPA-developed Site cleanup levels meet the MTCA risk-based thresholds.
Washington Sediment Management Standards (SMS) WAC 173-204 WAC 173-204-120, Antidegradation and designated use policies	The Antidegradation Policy states that existing beneficial uses shall be maintained and protected, and no further degradation shall be allowed. The Designated Use Policy states that waste discharges and sediment quality shall be managed to protect existing beneficial uses and move towards attainment of designated beneficial uses as specified in section 101 (a)(2) of the federal CWA (33 U.S.C. 1251, et seq.) and WAC 173-201A, Water Quality Standards for Surface Waters of the State of Washington (see above discussion of WAC 173-201A).	These requirements are **Applicable** to dredging activities.	Applicable to Alternative D, where sediment will be dredged, as contaminated sediments may be exposed as part of the dredging activities. The 2018 Dredge Material Management Program (DMMP) User Manual Section 12.3 states: DMMP (2008a) *[6/10/2008 DMMP Clarification Paper: Quality of Post-dredge Sediment Surfaces (Updated)]* should be referenced for more detail, but the following guidelines are expected to cover the majority of antidegradation evaluations for sediment projects: • If the post-dredge sediment meets the SMS Sediment Quality Standards (SQS), it is generally also compliant with the antidegradation policy. Exceptions include chemicals without numeric SQS values, such as dioxin and tributyltin. • Post-dredge sediment may not exceed the SMS Cleanup Screening Levels or DMMP maximum levels unless they pass bioassays. • If chemical concentrations are higher in the Z-samples than in the overlying dredged material and exceed SQS (or screening level [SL] for COCs with no numeric SQS), then bioassays might be required to evaluate the material for toxicity. Toxicity would need to be below SQS in order to meet the antidegradation guidelines. • If chemical concentrations are lower in the Z-samples than in the overlying dredged material, but still exceed SQS (or SL for COCs with no numeric SQS) and/or bioaccumulation trigger, the

Regulatory Citation	Description of Regulatory Requirement	Rationale for Including	Application
			DMMP agencies will review the bioassay and/or bioaccumulation results from the overlying dredged material before requiring the Z- samples to be tested biologically. • Antidegradation guidelines for freshwater projects are similar to those for marine projects, with the SCO (SL1) replacing SQS. Dioxin will be addressed on a case-by-case basis. • If a project, either marine or freshwater, is within an EPA or MTCA cleanup site, further coordination on antidegradation will be required.
WAC 173-204-310, Sediment Quality Standards Designation Procedure WAC 174-204-340, Freshwater Sediment Quality Standards WAC 173-204-560, Sediment Cleanup Levels, General Requirements	The SMS lists the SQS, below which sediments are designated as having no adverse effect on biological resources and not posing a significant health threat to humans (WAC 173-204-310). WAC 173-204-340, Freshwater Sediment Quality Standards shall be determined on a case-by-case basis as determined by Ecology. WAC 173-204-560 specifies methods for establishing sediment cleanup standards for sites where there has been a release or threatened release of contaminants to sediment. Requires that the point of compliance be established within the biologically active zone but may be established at a different location to protect human health.	Washington SMS requirements for setting cleanup levels are **To Be Considered** for determining sediment cleanup levels.	EPA-developed Site cleanup levels meet SMS risk-based thresholds.
WAC 173-204-561, Sediment cleanup levels based on protection of human health	Sets forth requirements for human health risk- based cleanup levels set at the sediment cleanup objective. For human health noncarcinogenic effects, the sediment cleanup objective shall result in a hazard quotient of 1 and a cumulative hazard index 1 for multiple contaminants and/or exposure pathways. For individual carcinogens, the sediment cleanup objective cleanup level shall result in an estimated lifetime excess cancer risk of 1×10^{-6}. For multiple carcinogens and/or exposure pathways exceeding 1×10^{-5} lifetime excess cancer risk, the sediment cleanup objectives shall be adjusted downward to 1×10^{-5}.	**To Be Considered** for determining human health-based sediment cleanup levels.	EPA-developed cleanup levels for direct contact (dermal contact and incidental ingestion) were based on a subsistence fishing scenario as the reasonable maximum exposure. Cleanup levels for multiple carcinogens are based on an estimated lifetime cancer risk of 1×10^{-6}.
WAC 173-204-563, Sediment cleanup levels based on protection of the benthic community in freshwater sediment	Sets forth chemical and biological criteria for the protection of benthic invertebrates.	**To Be Considered** for determining sediment cleanup levels for the protection of benthic invertebrates.	The selected levels for protection of the benthic community are the SMS sediment cleanup objective levels.
WAC 173-204-410(7), Dredged material and fill discharge activities	WAC 173-204-410(a) states: (a) Requirements for dredging activities and disposal sites shall be established by the department using best available dredged material management guidelines and applicable federal and state rules. These guidelines shall include the Puget Sound dredged disposal analysis (PSDDA) dredged material testing and disposal requirements. The regulation then goes on to cite example guidance, as updated, that should be followed.	**Applicable** for dredging activities in freshwater.	Applicable to Alternative D, where sediment will be dredged. The sediment requirements are implemented through the DMMP, including the *Dredged Material Evaluation and Disposal Procedures User Manual* (DMMP 2018) (listed below).
Dredged Material Evaluation and Disposal Procedures User Manual (DMMP 2018)	The User Manual addresses how dredge materials need to be characterized in order to be appropriately managed during dredging and after removal.	These requirements are **Applicable** because the document is cited in WAC 173-204- 410(7).	Dredged sediment needs to be characterized to determine whether the sediment needs to be disposed of or can be released back into the dredged area with no restrictions (i.e., reuse of the material). • If the dredged sediment is below the SMS SQS, then it can be reused (DMMP User Manual Section 14 "Beneficial Use"). • If the dredged material is unsuitable for reuse, then it may still be suitable for some other unconfined in-water disposal or it may require other confined in-water disposal or upland disposal. • The DMMP User Manual should be consulted to determine specific requirements. Other agencies may need to be consulted to determine whether beneficial use is possible.

CFR = *Code of Federal Regulations*
COC = contaminant of concern
CWA = Clean Water Act
DMMP = Dredge Material Management Program
Ecology = Washington State Department of Ecology
EPA = U.S. Environmental Protection Agency
MTCA = Model Toxics Control Act
RCW = Revised Code of Washington
SQS = sediment quality standards
SMS = Sediment Management Standards
U.S.C. = *United States Code*
WAC = Washington Administrative Code

Table 10-5. Action-Specific Applicable or Relevant and Appropriate Requirements, Operable Unit 2

Record of Decision for the Quendall Terminals Superfund Site

Regulatory Citation	Description of Regulatory Requirement	Rationale for Including	Application
Surface Water			
CWA, Section 404, 33 U.S.C. 1344 and Section 404(b)(1) Guidelines, 40 CFR Part 230, Guidelines for Specification of Disposal Sites for Dredged or Fill Material 33 CFR 330, Nationwide General Permit Program	CWA Section 404 regulates the discharge of dredged or fill material into waters of the United States including return flows from such activity. This program is implemented through regulations set forth in the Section 404(b)(1) guidelines found in 40 CFR Part 230. Specific requirements include: • 40 CFR 230.7 – General Permits may be authorized to address 40 CFR 230 requirements, • 40 CFR 230.10 – restrictions on dredged or fill materials discharge, • 40 CFR 230.11 – factual determinations on short- term and long-term effects of a proposed discharge of dredged or fill material on the physical, chemical, and biological components of the aquatic environment in light of 40 CFR 230 Subparts C through F, • 40 CFR 230. 12 – findings of compliance for dredge material disposal with the 40 CFR 230 restrictions, and • 40 CFR 230 Subpart J provides the standards and criteria for the use of compensatory mitigation when the response action will result in unavoidable impacts to the aquatic environment.	CWA Section 404 requirements are **Applicable** to in-water construction activities, including dredging and capping. A Section 404 permit is not needed because this is a CERCLA site.	Remedial design information will be required to fully assess impacts and specify all requirements and controls that will need to be placed on dredging and placing backfill materials to minimize or avoid impacts. The results of the pre- and post-dredge sampling results will be used during the remedial design to establish procedures to mitigate the potential spread of contamination from dredging activities. Also, through the Section 404 analysis in remedial design, exact amounts of compensatory mitigation for unavoidable loss of aquatic habitat will be determined and mitigation plans developed.
33 U.S.C. 403: Section 10 of the Rivers and Harbor Appropriation Act of 1899	Any obstruction or change to a channel must be authorized by Congress or the U.S. Army Corps of Engineers if it will affect a navigable channel; this includes dredging and disposal of dredged material.	These requirements will be **Applicable** if dredging will result in a change to the navigable area at the Site.	Applicable to Alternative D, which includes dredging and capping in Lake Washington. The remedy will address the substantive requirements of Nationwide Permit 38, which should address this ARAR.
33 CFR 154, Facilities Transferring Oil and Hazardous Material in Bulk	Provides specific planning and equipment requirements for transfer of hazardous materials between a vessel and a shore facility.	**Relevant and Appropriate**, since the sediment being dredged, transferred to the shore for treatment, and disposed of upland, may fail a hazardous waste characteristic and may need to be managed as hazardous waste.	The remedy will address the substantive requirements of transfer to shore, such as providing containment/booming for the transfer point and immediate shutdown of transfer if a spill occurs.
33 CFR 156, Oil and Hazardous Material Transfer Operations	Provides specific instructions on how to perform a hazardous material transfer between a vessel and a shore facility.		
Air			
State: Regulations for Air Pollution Sources (WAC 173 400); and Controls for New Sources of Toxic Air Pollutants (WAC 173 460) Regional: PSCAA, Regulations I and III (PSCAA has been delegated authority by U.S. Environmental Protection Agency and Washington State Department of Ecology)			
WAC 173-400-040, General Standards for Maximum Emissions	All sources and emission units are required to meet the general emission standards unless a specific source standard is available. General standards apply to visible emissions, fallout, fugitive emissions, odors, emissions detrimental to persons and property, sulfur dioxide, concealment and masking, and fugitive dust.	State regulations defining methods of control to be employed to minimize the release of contaminants associated with fugitive emissions are **Relevant and Appropriate** to remedial actions that may generate fugitive emissions.	PSCAA regulations address other potential releases of contaminants, such as fugitive dust and odor, which are listed below and are applicable.
PSCAA Regulation 1, Section 5.06(c), O&M plans	The owner/operator of sources subject to PSCAA regulation will develop and implement an operations and maintenance plan to ensure continuous compliance with Regulations I, II, and III. The plan shall reflect good industrial practice and shall include, but not be limited to, the following: • Periodic inspection of all equipment and control equipment; • Monitoring and recording of equipment and control equipment performance; • Prompt repair of any defective equipment or control equipment; • Procedures for start-up, shut down, and normal operation; • The control measures to be employed to ensure compliance with Section 9.15 of this regulation; and • A record of all actions required by the plan. The plan shall be reviewed by the source owner.	These requirements will be **Applicable** if a toxic air pollutant may be emitted from the remediation project (e.g., during dredging) and emissions controls are installed.	--
PSCAA Regulation I, Section 9.11, Emission of air contaminant: detriment to person or property	Air contaminants may not be emitted in sufficient quantities and of such characteristics and duration as is, or is likely to be, injurious to human health, plant or animal life, or property, or which unreasonably interferes with enjoyment of life and property.	These requirements are **Applicable** because remediation activities may generate odors or air contaminants.	Precautions to minimize odors and air emissions will be taken during construction and considered during remedial design.
PSCAA Regulation I, Section 9.15, Fugitive dust control measures	Reasonable precautions need to be taken to minimize visible fugitive dust emissions.	These requirements are **Applicable** because dust may be generated as part of dredging or capping activities.	Precautions to minimize fugitive dust could include practices such as wetting (misting) of materials while stockpiled, covering stockpiles, or minimizing stockpiling time.

Table 10-5. Action-Specific Applicable or Relevant and Appropriate Requirements, Operable Unit 2
Record of Decision for the Quendall Terminals Superfund Site

Regulatory Citation	Description of Regulatory Requirement	Rationale for Including	Application
PSCAA Regulation I, Section 9.20, Maintenance of Equipment	Equipment and air emissions control equipment must be maintained in good working order. Equipment is defined as any part of a stationary source or source that emits or would have the potential to emit any pollutant subject to regulation (Regulation 1, Section 1.07).	These requirements are **Applicable** because equipment and air emissions control equipment will be used during the remedial action.	--
Solid and Dangerous Waste			
State: Solid Waste Regulations, WAC 173-350 WAC 173-350-025, Owner responsibilities for solid waste WAC 173-350-040, Performance standards WAC 173-350-300, Onsite storage, collection, and transportation standards WAC 173-350-900, Remedial action	Establishes minimum functional performance standards for the proper handling and disposal of solid waste, not otherwise excluded. Provides requirements for the proper handling of solid waste materials originating from residences, commercial, agricultural and industrial operations, and other sources, and identifies those functions necessary to ensure effective solid waste handling programs at both the state and local level.	The remedial action will generate solid waste such as PPE and construction debris (e.g., during dredging or capping). These requirements are **Applicable** to solid wastes generated during remedial actions.	Remedial actions that generate covered solid waste will meet standards.
WAC 173-303-016, Identifying Solid Waste	Identifies those materials that are and are not solid wastes and identifies those materials that are and are not solid wastes when recycled.	Solid waste identification requirements are **Applicable** to solid wastes generated during remedial actions.	Standards will be met for remediation activities.
WAC 173-303-070, Designation of Dangerous Waste	Establishes the requirements for determining whether a solid waste is a dangerous waste (or an extremely hazardous waste), for making quantity determinations and for small quantity generators	Dangerous waste characterization and determination is **Applicable** to wastes generated during remedial actions, such as soil and groundwater well purge water, that will be disposed of offsite.	According to the FS, dredged sediment would not designate as a Washington State Dangerous Waste.
WAC 173-303-140 (1) through (4), Land Disposal Restrictions (which reference 40 CFR 268)	Establishes land disposal restrictions, including waste and applicable treatment standards determinations, and storage and disposal prohibitions.	These requirements are **Applicable** to onsite management of dangerous waste that may be generated during dredging activities.	Potential ARAR for sediments dredged from the Site for offsite disposal. Contaminated sediments may need to be treated to meet land disposal restrictions before disposal in Washington (or another state).
WAC 173-303-170, Requirements for Generators of Dangerous Waste	This regulation establishes the requirements for dangerous waste generators. Requirements for Generators of Dangerous Waste (WAC 173-303-170[3]) includes the substantive provisions of Accumulating Dangerous Waste On Site (WAC 173-303-200) by reference.	This regulation is **Applicable** to remedial actions that may generate dangerous wastes.	Remediation wastes (for example, contaminated sediment, PPE, recovered nonaqueous phase liquid) may be dangerous waste and will be managed in accord with these requirements.
WAC 173-303-200, Accumulating Dangerous Waste Onsite	This regulation establishes the requirements for accumulating wastes onsite. Accumulating Dangerous Waste On Site (WAC 173-303-200) includes certain substantive standards from Use and Management of Containers (WAC 173-303-630) and Tank Systems (WAC 173-303-640) by reference.	State rules establishing requirements for accumulating dangerous waste onsite are **Applicable** for managing remediation wastes generated at the Site including contaminated sediments, contaminated debris, and used PPE.	Management of remediation wastes that are dangerous waste will comply with these requirements.
WAC 173-350-025, Owner Responsibilities for Solid Waste WAC 173-350-040, Performance Standards WAC 173-350-300, Onsite Storage, Collection, and Transportation Standards WAC 173-350-900, Remedial Action	Establishes minimum functional performance standards for the proper handling and disposal of solid waste, not otherwise excluded. Provides requirements for the proper handling of solid waste materials originating from residences, commercial, agricultural and industrial operations, and other sources, and identifies those functions necessary to ensure effective solid waste handling programs at both the state and local level.	Requirements are **Applicable** for covered solid waste generated during implementation of remedial actions. Remedial actions that generate covered solid waste will meet standards.	Remedial actions that generate covered solid waste will meet standards.
Sediment Cleanup			
Washington Model Toxics Control Act (MTCA), WAC 173-340 173-340-400, Implementation of the Cleanup Action 173-340-420, Periodic Review 173-340-600, Public Notice and Participation 173-340-760 Sediment Cleanup Standards	WAC 173-340 is the Washington State regulation that requires investigation and remediation of contaminated sites.	These requirements are **Applicable**. The CERCLA process is equivalent to the MTCA process.	Remedial actions will be implemented per this Record of Decision followed by CERCLA Five- Year Reviews. WAC 173-340-760 states that sediment cleanup actions must also comply with the requirements of WAC 173-204. Specifics regarding applicability of WAC 173-204 requirements are found in this table and in Table 10-4.
WAC 173-204-570, Selection of cleanup actions	Sediment cleanup actions must comply with the sediment cleanup standards, use permanent solutions to the maximum extent practicable, provide for a reasonable restoration time frame, and shall not rely exclusively on monitored natural attenuation or institutional controls and monitoring where implementing a more permanent cleanup action is possible.	Washington Sediment Management Standards requirements for selection of cleanup actions related to cleanup of sediments are **Applicable**.	The Selected Remedy for sediments includes dredging, capping, and enhanced natural recovery to achieve cleanup levels.
WAC 220-660, Hydraulic Code Rules WAC 220-660-110 Authorized work times in freshwater areas WAC 220--660-120, Common freshwater construction provisions WAC 110-660-170, Dredging in freshwater Areas	Requires consultation with WDFW, although no Hydraulic Project Approval permit is required because this is a CERCLA site. Specific technical requirements include: • WDFW will determine when work can occur in freshwater areas based on fish life stages to minimize impact on fish (WAC 220-660-110)	The definition of "freshwater area" in WAC 220-660-100 states "Freshwater areas also include all lakes, ponds, and tributary streams and surface-water-connected wetlands that provide or maintain habitat that supports life. This definition does not include irrigation ditches, canals, stormwater treatment, and conveyance systems, or other entirely artificial watercourses, except where	Applicable to Alternative D for work within Lake Washington.

Table 10-5. Action-Specific Applicable or Relevant and Appropriate Requirements, Operable Unit 2
Record of Decision for the Quendall Terminals Superfund Site

Regulatory Citation	Description of Regulatory Requirement	Rationale for Including	Application
	• Conduct activities that cause the least impacts to fish life (WAC 220-660-120), including, but not limited to: • Establish staging areas to prevent migration of contaminants to state waters • Limit removal of native vegetation • Use equipment that reduces ground pressure if wet or muddy conditions exist • Use environmentally acceptable lubricants if equipment is used near the shore • Restore riparian zones to as close as possible to pre-project conditions at the end of the project unless otherwise indicated in planning documents	they exist in a natural watercourse that has been altered by humans." Lake Washington meets the freshwater area definition, so this regulation would be **Applicable** to remediation within the Site, which extends into the sediments of Lake Washington. A Hydraulic Projects Approval permit is not needed because this is a CERCLA site.	
Dredged Material Evaluation and Disposal Procedures User Manual (DMMP 2016)	The User Manual addresses how dredging should be appropriately coordinated and scheduled and how dredge material should be managed during dredging and after removal (e.g., Section 13 Dredging and Disposal).	Dredging procedures are **Applicable** for implementation of the remedy. These requirements are **Applicable** because the document is cited in WAC 173-204- 410(7).	Applicable to Alternative D, the selected alternative.
Wood Waste Cleanup (2013)	Wood Waste Cleanup provides guidance on the cleanup of wood waste pursuant to the Sediment Management Standards, WAC 173-204. The guidance provides recommendations and best management practices for wood waste cleanup in marine and freshwater environments.	The guidance is **To Be Considered** to the area of wood waste in the water at the Site.	The guidance will be considered to identify, assess, and remediate wood waste areas during the remedy implementation.

ARAR = applicable or relevant and appropriate requirement
CFR = *Code of Federal Regulations*
CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act
CWA = Clean Water Act
MTCA = Model Toxics Control Act
PPE = personal protective equipment
PSCAA = Puget Sound Clean Air Agency
U.S.C. = *United States Code*
WAC = Washington Administrative Code
WDFW = Washington State Department of Fish and Wildlife

Table 10-6. Location-Specific Applicable or Relevant and Appropriate Requirements, Operable Unit 2

Record of Decision for the Quendall Terminals Superfund Site

Regulatory Citation	Description of Regulatory Requirement	Rationale for Including	Application
Archaeologically or Historically Sensitive Resources			
Federal: Native American Graves Protection and Reparation Act, 25 U.S.C. 3001 through 3013 and 43 CFR 10	Requires federal agencies and museums which have possession of or control over Native American cultural items (including human remains, associated and unassociated funerary items, sacred objects and objects of cultural patrimony) to compile an inventory of such items. Prescribes when such federal agencies and museums must return Native American cultural items.	This requirement is **Applicable** if Native American human remains or cultural items associated with human remains are present and discovered during the course of remedial construction. Such a discovery at the Site is unlikely but possible.	The Muckleshoot Tribe will be consulted if remains or cultural items are present and discovered.
Federal: National Historic Preservation Act, 16 U.S.C. 470 et seq., 36 CFR 800	Requires the identification of historic properties potentially affected by the agency undertaking, and assessment of the effects on the historic property and seek ways to avoid, minimize or mitigate such effects. Historic property is any district, site, building, structure, archaeological site, traditional cultural landscape, traditional cultural property, or object included in or eligible for the National Register of Historic Places, including artifacts, records, and material remains related to such a property.	**Applicable** if historic properties are potentially affected by remedial activities. No historic properties have been identified at the Site to date, but could potentially be identified during remedial design.	EPA will consult with the Washington SHPO, and DAHP before the start of remedial construction and will work to avoid, minimize, or mitigate the impacts of construction on any historic properties.
Federal: Archaeological and Historic Preservation Act, 16 U.S.C. 469a-1	Provides for the preservation of historical and archaeological data that may be irreparably lost as a result of a federally approved project and mandates only preservation of the data.	**Applicable** if historical and archaeological data may be irreparably lost by implementation of the remedial activities.	Consultation will occur with the Washington SHPO and DAHP before the start of remedial construction and will preserve data as required, should there be any historical or archaeological features within the construction area.
Sensitive Habitats and Protected Species			
50 CFR 17.11 and 17.12 or designation of critical habitat of such species listed in 50 CFR 17.95; Interagency Cooperation for the Endangered Species Act, 50 CFR 402	Actions authorized, funded, or carried out by federal agencies may not jeopardize the continued existence of threatened or endangered species or result in the adverse modification of species' critical habitat. Agencies are to avoid jeopardy or take appropriate mitigation measures to avoid jeopardy.	Applicable to remedial actions that may impact endangered or threatened species or critical habitat that are present at the Site. Listed species that may use the Site include Chinook salmon, steelhead, and bull trout. The area of the lake adjacent to the Site is considered prime habitat for rearing juvenile salmonid stocks.	EPA will consult with the NMFS and U.S. Fish and Wildlife Service regarding actions to be taken, their impacts on listed species, and measures that will be taken to reduce, minimize, or avoid such impacts so as not to jeopardize the continued existence or adversely modify critical habitat. If take cannot be avoided, take permission from the services will be obtained before construction.
Federal: Magnuson-Stevens Fishery Conservation and Management Act. 50 CFR 600.920	Requires federal agencies consult with NMFS on actions that may adversely affect EFH, defined as "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity."	**Applicable** because Lake Washington is within the Puget Sound Basin, designated as EFH for various life stages of groundfish and three species of salmon.	Dredging may affect EFH and water quality during implementation of the remedy. EPA will consult with the NMFS regarding actions to be taken, their impacts on EFH, and measures that will be taken to eliminate impacts on essential habitat.
Federal: Fish and Wildlife Coordination Act. 16 U.S.C. 662 and 663, 50 CFR 6.302(g)	Requires federal agencies to consider effects on fish and wildlife from projects that may alter a body of water and mitigate or compensate for project-related losses, which includes discharges of pollutants to water bodies.	**Applicable** to remedial actions in the shoreline, which may disturb fish and wildlife habitat.	Remedial action will be designed to minimize impacts to fish and wildlife and disturbance of sensitive habitats.
Federal: Migratory Bird Treaty Act. 16 U.S.C. 703	This act makes it unlawful to pursue, hunt, take, capture, or kill any migratory bird, part, nest, egg, or product. All but a few bird species naturally occurring in the United States are protected under this act.	**Applicable** and may require mitigation measures to deter nesting by migratory birds on, around, or within remedial action areas and methods to protect occupied bird nests.	Best management practices will be used for observing and avoiding contact with migratory birds during construction of the remedy.
Federal: Bald and Golden Eagle Protection Act 16 U.S.C. 668, 50 CFR 22	Protects bald and golden eagles from take, possession or transportation without a permit.	**Applicable** if bald and golden eagles or their habitat would be affected during remediation activities.	If needed, remedial action work plans will include measures to minimize disturbances to bald eagles.
State: Bald Eagle Protection Rules (WAC 232-12-292) Habitat Buffer Zone for Bald Eagles – Rules (RCW 77.12.655)	Protects eagle habitat to maintain eagle populations so the species are not classified as threatened, endangered, or sensitive in Washington State.	**Applicable** and may require mitigation for any adverse impacts to eagle habitat.	If needed, remedial action work plans will include measures to protect eagle habitat.
Coast and Shoreline			
Federal: Coastal Zone Management Act, 16 U.S.C. 1451 et seq.) State: Shoreline Management Act of 1971, RCW 90.58 and WAC 173-27	Establishes regulations, enforcement procedures, and policies for protecting and developing Washington shoreline areas.	Policies and regulations for the shorelines of Lake Washington are **Relevant and Appropriate** for dredging and capping components and any remedial activities within 200 feet of the ordinary high-water mark.	Design and construction in shoreline sediments will comply with shoreline management requirements and include mitigation for unavoidable impacts to shoreline resources.

Regulatory Citation	Description of Regulatory Requirement	Rationale for Including	Application
Critical Areas			
City: Renton Critical Areas Program: Renton Municipal Code 4-3-050, Critical Areas Regulations	Establishes regulations, enforcement procedures, and policies for protecting Renton's critical areas, including wetlands. No net loss of wetlands is allowed. Wetland mitigation must meet certain requirements.	Policies and regulations for Renton wetlands are To Be Considered for remedial activities. Renton's mapping of critical areas includes the habitat area along the shoreline at the Site.	Design and construction in Renton critical areas, including the habitat zone at the shoreline at the Site, will comply with critical area requirements and include mitigation for unavoidable impacts.

CFR = *Code of Federal Regulations*
DAHP = Washington State Department of Archaeology and Historic Preservation
EFH = Essential Fish Habitat
EPA = U.S. Environmental Protection Agency
NMFS = National Marine Fisheries Service
RCW = Revised Code of Washington
SHPO = State Historic Preservation Officer
U.S.C. = *United States Code*
WAC = Washington Administrative Code

Table 10-7. Costs for the Operable Unit 1 Alternatives
Record of Decision for the Quendall Terminals Superfund Site

Alternative	Remedial Construction	Operations and Maintenance Using 7.0 Percent Discount Rate[a]	Total Present Value Using 7.0 Percent Discount Rate	FS-Level Accuracy Range (-30%)	FS-Level Accuracy Range (+50%)
7	65,300,000	700,000	66,000,000	46,200,000	99,000,000
7a	65,400,000	700,000	66,100,000	46,300,000	99,200,000
8	99,400,000	600,000	100,000,000	70,000,000	150,000,000
9	218,600,000	600,000	219,200,000	153,400,000	328,800,000
10	301,100,000	8,200,000	309,300,000	216,500,000	464,000,000

Notes:

[a] For estimating operations and maintenance cost, the FS cost estimate assumed operations and maintenance would be conducted for 100 years.

Table 10-8. Costs for the Operable Unit 2 Alternatives
Record of Decision for the Quendall Terminals Superfund Site

Alternative	Remedial Construction	Operations and Maintenance Using 7.0 Percent Discount Rate[a]	Total Present Value Using 7.0 Percent Discount Rate	FS-Level Accuracy Range (-30%)	FS-Level Accuracy Range (+50%)
A	9,430,000	2,270,000	11,700,000	8,200,000	17,600,000
B	15,900,000	1,100,000	17,000,000	11,900,000	25,500,000
C	22,300,000	700,000	23,000,000	16,100,000	34,500,000
D	39,500,000	400,000	39,900,000	27,900,000	59,900,000
E	96,000,000	400,000	96,400,000	67,400,000	144,000,000

Notes:

[a] For estimating operations and maintenance cost, the FS cost estimate assumed operations and maintenance would be conducted for 100 years.

Table 12-1. Cost Estimate Detail for OU1 Selected Remedy
Record of Decision for the Quendall Terminals Superfund Site

	Item	Quantity	Unit	Unit Cost	Total Cost
Capital Construction Costs					
Upland Soil Excavation and Capping					
	Mobilization/Demobilization[1]	1	LS	$388,439	$388,439
	Site Preparation	22	acre	$6,900	$149,040
	Geotextile marker layer	104,544	SY	$2	$158,907
	Import Fill - Permeable Cap	104,544	BCY	$30	$3,136,320
	Compaction	104,544	BCY	$5	$522,720
	Habitat Area - excavation	14,836	BCY	$6	$89,014
	Habitat Area - nonhazardous transport and disposal	23,737	ton	$60	$1,424,224
	Hydroseeding	14,836	SY	$1	$8,901
	Stormwater collection and detention system	1,500	LF	$40	$60,000
Subtotal					*$5,937,565*
Tax		9.5%		$5,937,565	$564,069
Contingency[2]		25%		$6,501,634	$1,625,408
Total Upland Soil Cap Cost					$8,127,042
Solidification in areas with less than 4 cumulative ft of DNAPL					
	Mobilization/Demobilization[1]	1	LS	$1,447,509	$1,447,509
	Solidification - 8-ft diameter auger	**160,300**	**BCY**	$129	$20,678,700
	Solidification - 4-ft diameter auger	**-**	**BCY**	$149	$-
Subtotal					*$22,126,209*
Tax		9.5%		$22,126,209	$2,101,990
Contingency[2]		30%		$24,228,199	$7,268,460
Total Upland Soil Solidification Cost					$31,496,659
STAR					
	STAR Application (RR, MC, and QP-U DNAPL Areas and >4-foot Thickness)	**1**	**LS**	**$14,900,000**	**$14,900,000**
Subtotal					***14,900,000***
Tax		***9.5%***		**$14,900,000**	**$1,415,500**

Table 12-1. Cost Estimate Detail for OU1 Selected Remedy
Record of Decision for the Quendall Terminals Superfund Site

	Item	Quantity	Unit	Unit Cost	Total Cost
Total STAR Cost					**$16,315,500**
Subtotal Construction Costs					**$55,939,201**
Professional Services (as percent of construction and contingency costs)					
	Project management	5%		$55,939,201	$2,796,960
	Remedial design	6%		$55,939,201	$3,356,352
	Construction management	6%		$55,939,201	$3,356,352
Subtotal					*$9,509,664*
Total Estimated Capital Cost					**$65,448,865**
O&M Costs					
1st Year O&M					
	GW Monitoring	1	LS	$80,000	$80,000
Subtotal					*$80,000*
Tax		9.5%		$80,000	$7,600
Contingency(2)		25%		$87,600	$21,900
Total 1st Year O&M Cost					$109,500
Annual O&M					
	Groundwater Monitoring	1	LS	$25,000	$25,000
	Upland Cap inspection	6	hour	$80	$480
Subtotal					*$25,480*
Tax		9.5%		$25,480	$2,421
Contingency(2)		25%		$27,901	$6,975
Total Annual O&M Cost					$34,876
Professional Services (as percent of Annual O&M costs)					
	Project management/Reporting	10%		$34,876	$3,488
Total, Annual O&M:					**$38,363**
Total Estimated O&M, 100 Years, No Net Present Value Analysis:					**$3,945,833**

Table 12-1. Cost Estimate Detail for OU1 Selected Remedy

Record of Decision for the Quendall Terminals Superfund Site

	Item	Quantity	Unit	Unit Cost	Total Cost
Periodic Costs					
Total Estimated Cost, No NPV Analyses					**$69,394,697**
OMB Circular Net Present Value Analysis					
	Annual O&M	100	year	$38,363	$2,057,910
	1st year O&M	1	LS	$109,500	$109,500
	Discount rate for NPV[(3)]	1.4%			
Total Estimated O&M and OMB Periodic NPV					**$2,167,410**
Total Estimated Cost					**$67,616,275**
Alternate Net Present Value Analysis					
	Annual O&M	100	year	$38,363	$547,416
	1st year O&M	1	LS	$109,500	$109,500
	Alternate discount rate for NPV[(4)]	7.0%			
Total Estimated O&M and Alternative Periodic NPV					**$656,916**
Total Estimated Cost					**$66,105,781**

Notes:

1. Mobilization/demobilization costs are assumed to include equipment transport and setup, temporary erosion and sedimentation control (TESC) measures, bonds, and insurance.
2. Contingency costs include miscellaneous costs not currently itemized due to the current (preliminary) stage of design development, as well as costs to address unanticipated conditions encountered during construction.
3. A 1.4% discount rate was used in the net present value analysis based on the 2015 Appendix C OMB Circular A-94 real interest rate.
4. A 7.0% discount rate was used in the alternate net present value analysis as directed by EPA based on OMB Circular A-94 and guidance found in OSWER No. 9355.0-75.

Table 12-2. Cost Estimate Detail for OU2 Selected Remedy
Record of Decision for the Quendall Terminals Superfund Site

	Item	Quantity	Unit	Unit Cost	Total Cost
Capital Construction Costs					
Enhanced Natural Recovery					
	Mobilization/Demobilization(1)	1	LS	$57,456	$57,456
	Sand Material	22,880	ton	$20	$457,600
	Sand Placement	22,880	ton	$15	$343,200
	Confirmation of Placement	1	LS	$20,000	$20,000
Subtotal					*$878,256*
Tax		9.5%		$878,256	$83,434
Contingency(2)		25%		$961,690	$240,422.58
Total Enhanced Natural Recovery Cost					$1,202,113
Engineered Sand Cap					
	Mobilization/Demobilization(1)	1	LS	$63,553	$63,553
	Sand Material	21,760	ton	$20	$435,200
	Sand Placement	21,760	ton	$20	$435,200
	Geotextile Separation Layer	35,000	SF	$1	$17,500
	Confirmation of Placement	1	LS	$20,000	$20,000
Subtotal					*$971,453*
Tax		9.5%		$971,453	$92,288
Contingency(2)		25%		$1,063,741	$265,935
Total Engineered Sand Cap Cost					$1,329,676
Sediment Removal					
	Mobilization/Demobilization(1)	1	LS	$1,001,828	$1,001,828
	Mechanical Dredging	43,100	BCY	$35	$1,508,500
	Hydraulic Dredging	15,200	BCY	$60	$912,000
	Debris Removal and Disposal	1	LS	$75,000	$75,000
	Transloading/Material Handling	58,300	BCY	$15	$874,500
	Dewatering	58,300	BCY	$10	$553,850
	Water Treatment	1	LS	$500,000	$500,000
	Residuals Cover Bulk Organoclay Material - (PM-199)	665	ton	$3,250	$2,162,599

Table 12-2. Cost Estimate Detail for OU2 Selected Remedy
Record of Decision for the Quendall Terminals Superfund Site

	Item	Quantity	Unit	Unit Cost	Total Cost
	Residuals Cover Sand Material	6,880	ton	$20	$137,600
	Residuals Cover Material Placement	7,545	ton	$15	$113,181
	Backfill Material	81,920	ton	$20	$1,638,400
	Backfill Material Placement	81,920	ton	$15	$1,228,800
	Transportation and Disposal - Nonhazardous	75,790	ton	$60	$4,547,400
	Dredging Confirmation	1	LS	$60,000	$60,000
Subtotal					*$15,313,658*
Tax		9.5%		$15,313,658	$1,454,798
Contingency(2)		25%		$16,768,456	$4,192,114
Total Sediment Removal Cost					$20,960,569
Sheet Pile Enclosure					
	Mobilization/Demobilization(1)	1	LS	$396,900	$396,900
	Steel Unit Cost	63,000	SF	$35	$2,205,000
	Installation Unit Cost	63,000	SF	$45	$2,835,000
	Removal Unit Cost	63,000	SF	$15	$945,000
	Salvage Unit Value	3,150,000	lb	$(0.1)	$(315,000)
Subtotal					*$6,066,900*
Tax		9.5%		$6,066,900	$576,356
Contingency(2)		25%		$6,643,256	$1,660,814
Total Sheet Pile Enclosure Cost					$8,304,069
Capital Construction Costs					
Sediment Environmental Controls and Monitoring					
	Water Quality Monitoring	250	day	$2,500	$625,000
	Water Quality Controls and BMPs (Absorbent Booms, Silt Curtains, Oil Booms)	1	LS	$150,000	$150,000
	Odor Control	150	day	$2,500	$375,000
	Noise Monitoring	1	LS	$30,000	$30,000
	Erosion Protection for Shoreline Area	1	LS	$250,000	$250,000
Subtotal					*$1,430,000*
Tax		9.5%		$1,430,000	$135,850

Table 12-2. Cost Estimate Detail for OU2 Selected Remedy
Record of Decision for the Quendall Terminals Superfund Site

	Item	Quantity	Unit	Unit Cost	Total Cost
Contingency[2]		25%		$1,565,850	$391,463
Total Sediment Environmental Controls and Monitoring Cost					$1,957,313
Subtotal Construction Costs					**$33,753,741**
Professional Services (as percent of construction and contingency costs)					
	Project management	5%		$33,753,741	$1,687,687
	Remedial design	6%		$33,753,741	$2,025,224
	Construction management	6%		$33,753,741	$2,025,224
Subtotal					*$5,738,136*
Total Estimated Capital Cost					**$39,491,876**
O&M Costs					
1st Year O&M					
	Sediment Sand Cap and ENR Sampling	1	LS	$25,000	$25,000
	Sediment Cap Inspection	1	LS	$15,000	$15,000
	Backfilled Area Surface Sediment Monitoring	1	LS	$25,000	$25,000
	DNR Lease	0.3	acre	$20,000	$6,000
Subtotal					*$71,000*
Tax		9.5%		$71,000	$6,745
Contingency[2]		25%		$77,745	$19,436
Total 1st Year O&M Cost					$97,181
Annual O&M					
	DNR Lease	0.3	acre	$20,000	$6,000
Subtotal					*$6,000*
Tax		9.5%		$6,000	$570
Contingency[2]		25%		$6,570	$1,643
Total Annual O&M Cost					$8,213
Professional Services (as percent of Annual O&M costs)					
	Project management/Reporting	10%		$8,213	$821

Table 12-2. Cost Estimate Detail for OU2 Selected Remedy
Record of Decision for the Quendall Terminals Superfund Site

	Item	Quantity	Unit	Unit Cost	Total Cost
Total, Annual O&M:					**$9,034**
Total Estimated O&M, 100 Years, No NPV Analysis:					**$1,000,556**
Periodic Costs					
Sand Cap and ENR					
	Sediment Sand Cap and ENR Sampling at 2 years				$25,000
	Sediment Sand Cap and ENR Sampling at 5 years				$25,000
	Sediment Sand Cap and ENR Sampling at 10 years				$25,000
	Sediment Cap Inspection at 2 years				$15,000
	Sediment Cap Inspection at 5 years				$15,000
	Sediment Cap Inspection at 10 years				$15,000
	Sand Cap Shoreline Maintenance at 30 years				$25,000
	Sand Cap Shoreline Maintenance at 60 years				$25,000
	Sand Cap Shoreline Maintenance at 90 years				$25,000
Subtotal					*$195,000*
TOTAL ESTIMATED COST, NO NPV ANALSYS					**$40,687,433**
Capital Construction Costs					
OMB Circular Net Present Value Analysis					
	Annual O&M	100	year	$9,034	$484,594
	1st year O&M	1	LS	$97,181	$97,181
	Sediment Sand Cap and ENR Sampling at 2 years	1	LS	$25,000	$24,314
	Sediment Sand Cap and ENR Sampling at 5 years	1	LS	$25,000	$23,321
	Sediment Sand Cap and ENR Sampling at 10 years	1	LS	$25,000	$21,755
	Sediment Cap Inspection at 2 years	1	LS	$15,000	$14,589
	Sediment Cap Inspection at 5 years	1	LS	$15,000	$13,993
	Sediment Cap Inspection at 10 years	1	LS	$15,000	$13,053
	Sand Cap Shoreline Maintenance at 30 years	1	LS	$25,000	$16,474
	Sand Cap Shoreline Maintenance at 60 years	1	LS	$25,000	$10,856
	Sand Cap Shoreline Maintenance at 90 years	1	LS	$25,000	$7,154
	2015 discount rate for NPV(3)	1.4%			

Table 12-2. Cost Estimate Detail for OU2 Selected Remedy

Record of Decision for the Quendall Terminals Superfund Site

	Item	Quantity	Unit	Unit Cost	Total Cost
Total Estimated O&M and OMB Periodic NPV					**$727,284**
TOTAL ESTIMATED COST					**$40,219,161**
Alternate Net Present Value Analysis					
	Annual O&M	100	year	$9,034	$128,905
	1st year O&M	1	LS	$97,181	$97,181
	Sediment Sand Cap and ENR Sampling at 2 years	1	LS	$25,000	$24,314
	Sediment Sand Cap and ENR Sampling at 5 years	1	LS	$25,000	$23,321
	Sediment Sand Cap and ENR Sampling at 10 years	1	LS	$25,000	$21,755
	Sediment Cap Inspection at 2 years	1	LS	$15,000	$14,589
	Sediment Cap Inspection at 5 years	1	LS	$15,000	$13,993
	Sediment Cap Inspection at 10 years	1	LS	$15,000	$13,053
	Sand Cap Shoreline Maintenance at 30 years	1	LS	$25,000	$16,474
	Sand Cap Shoreline Maintenance at 60 years	1	LS	$25,000	$10,856
	Sand Cap Shoreline Maintenance at 90 years	1	LS	$25,000	$7,154
	Alternate discount rate for NPV(4)	7.0%			
Total Estimated O&M and Alternative Periodic NPV					**$371,595**
TOTAL ESTIMATED COST					**$39,863,471**

Notes:

1. Mobilization/demobilization costs are assumed to include equipment transport and setup, temporary erosion and sedimentation control measures, bonds, and insurance.
2. Contingency costs include miscellaneous costs not currently itemized due to the current (preliminary) stage of design development, as well as costs to address unanticipated conditions encountered during construction.
3. A 1.4% discount rate was used in the net present value analysis based on the 2015 Appendix C OMB Circular A-94 real interest rate.
4. A 7.0% discount rate was used in the alternate net present value analysis as directed by EPA based on OMB Circular A-94 and guidance found in OSWER No. 9355.0-75.

Table 12-3. Remedial Action Objective Achievement Measures for Operable Unit 1 Selected Remedy
Record of Decision for the Quendall Terminals Superfund Site

Remedial Action Objective	Measures Used to Determine When the RAO Has Been Met and Anticipated Timeframe
RAO 1—Reduce migration of COCs from DNAPL to groundwater to levels that allow restoration of groundwater to drinking water standards.	This RAO will be met when: (1) total petroleum hydrocarbon concentrations in thermally treated areas are below 3,000 ppm, and (2) solidification performance goals are met in solidified areas. This goal is expected to be met upon completion of the OU1 remedial action (5 years).
RAO 2— Restore groundwater in the shallow alluvium and deeper alluvium aquifers to drinking water standards to achieve its highest beneficial use (drinking water) within a reasonable timeframe.	This RAO will be met when the concentration of COCs in Site monitoring wells, are at or below MCLs or cleanup levels for the protection of human health (Table 8-3). Groundwater COC concentrations are expected to significantly decline following active remedial measures that treat DNAPL in soil. Institutional controls will prohibit use of groundwater for drinking water purposes and construction of wells for any purpose, including domestic uses (e.g., inhalation while showering) until the RAO is met. The goal is expected to be met in 25-30 years.
RAO 3—Reduce to acceptable levels the risk to future residents from direct contact or incidental ingestion of COCs in surface and subsurface soil.	This RAO will be met when the 95UCL concentration of COCs in the top 15 feet of soil, is at or below cleanup levels for the protection of human health (Table 8-3), or direct contact is prevented with a minimum 3-foot soil cap and institutional controls. This goal is expected to be met upon completion of the OU1 remedial action (5 years).
RAO 4—Reduce to acceptable levels the risk to terrestrial wildlife from direct contact or incidental ingestion of COCs in soils or soil invertebrates.	This RAO will be met when the 95UCL concentration of COCs in the top 5 feet of soil, is at or below cleanup levels for the protection of ecological receptors (Table 8-3), or direct contact is prevented with a minimum 3-foot soil cap and institutional controls. This goal is expected to be met upon completion of the OU1 remedial action (5 years).
RAO 5—Reduce to acceptable levels the human health risk from inhalation of vapors from groundwater and/or soils contaminated with COCs.	This RAO will be met when vapors are at acceptable levels, concentrations in groundwater and soils are at or below cleanup levels for the protection of human health (Table 8-3), and vapors are controlled to acceptable levels by a soil cap and institutional controls. Institutional controls will require that any future use that results in human occupation in enclosed spaces will require an assessment for potential vapor intrusion risks and, if necessary, require engineering controls to eliminate exposure to vapors. If engineering controls are implemented, indoor air monitoring and maintenance of vapor control devices will be required until the RAO is met.

ARAR = applicable or relevant and appropriate requirement

COC = contaminant of concern

DNAPL = dense nonaqueous phase liquid

HRSC = high-resolution site characterization

ISS = in situ solidification

MCL = maximum contaminant level

RAO = Remedial Action Objective

95UCL = 95 percent upper confidence limit on the mean

Table 12-4. Remedial Action Objective Achievement Measures for Operable Unit 2

Record of Decision for the Quendall Terminals Superfund Site

Remedial Action Objective	Measures Used to Determine When the RAO Has Been Met and Anticipated Timeframe
RAO 1—Reduce migration of COCs from DNAPL to sediment to levels that allow restoration of sediment to acceptable levels.	This RAO will be met when DNAPL-containing sediment has been removed and disposed of offsite. This goal is expected to be met upon completion of the OU2 remedial action (4 years).
RAO 2—Reduce to acceptable levels the risk to adults and children from ingestion of resident fish and shellfish taken from the Site.	This RAO will be met when the 95UCL concentrations of COCs in the top 10 centimeters of sitewide sediment are at or below cleanup levels for the protection of human health (Table 8-4). Actions to minimize the release of COCs from the upland area to Lake Washington, in combination with active remedial measures in the lake, will reduce COC concentrations in sediment and in porewater. These reductions are expected to result in declining contaminant concentrations in fish and shellfish tissue.
RAO 3—Reduce to acceptable levels the risk to future beach users from playing or wading in shallow water near shore resulting in incidental ingestion or/and dermal exposure to contaminated sediments.	This RAO will be met when the 95UCL concentrations of COCs in the top 10 centimeters of nearshore sediment (areas where water depths are at or below 10 feet) are at or below cleanup levels for the protection of human health (Table 8-4). This goal is expected to be met upon completion of the OU2 remedial action (4 years).
RAO 4—Reduce to acceptable levels the risk to aquatic organisms (benthos, aquatic plants, and fish) and aquatic-dependent wildlife (sediment-probing birds and piscivorous mammals) from direct contact and/or incidental ingestion of COCs in sediment, surface water/porewater, and prey.	This RAO will be met when: (1) the concentration of total PAHs in the top 10 centimeters of sediment, on a point-by-point basis, are at or below cleanup levels for the protection of benthic organisms (Table 8-4); and (2) the 95UCL concentrations of COCs other than total PAHs in the top 10 centimeters of sediment, are at or below cleanup levels for the protection of other aquatic life (Table 8-4). This goal is expected to be met upon completion of the OU2 remedial action (4 years).

ARAR = applicable or relevant and appropriate requirement

COC = contaminant of concern

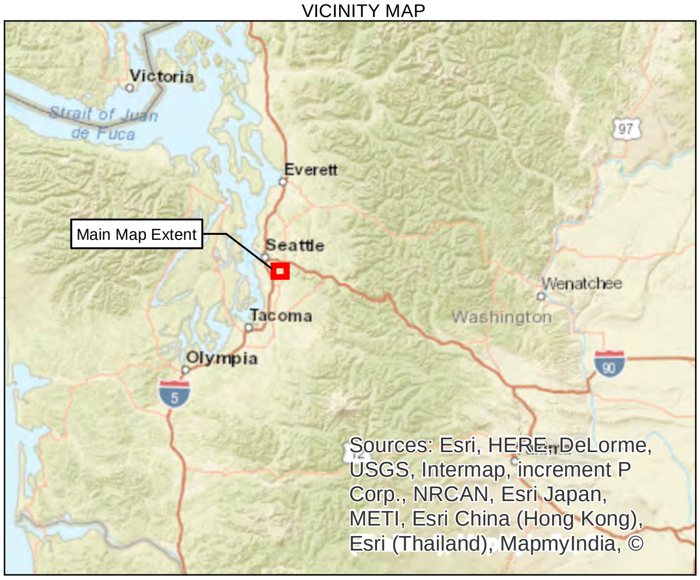
DNAPL = dense nonaqueous phase liquid

RAO = Remedial Action Objective

95UCL = 95 percent upper confidence limit on the mean

Figures

VICINITY MAP



LEGEND

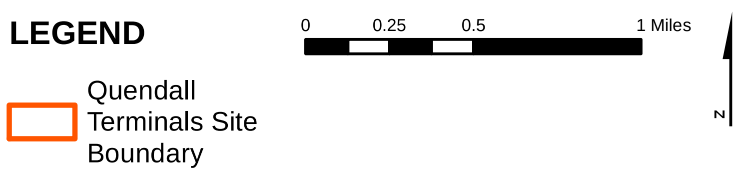


Figure 1-1
Quendall Terminals Site Location and Vicinity Map
Record of Decision for the
Quendall Terminals Superfund Site
Renton, Washington

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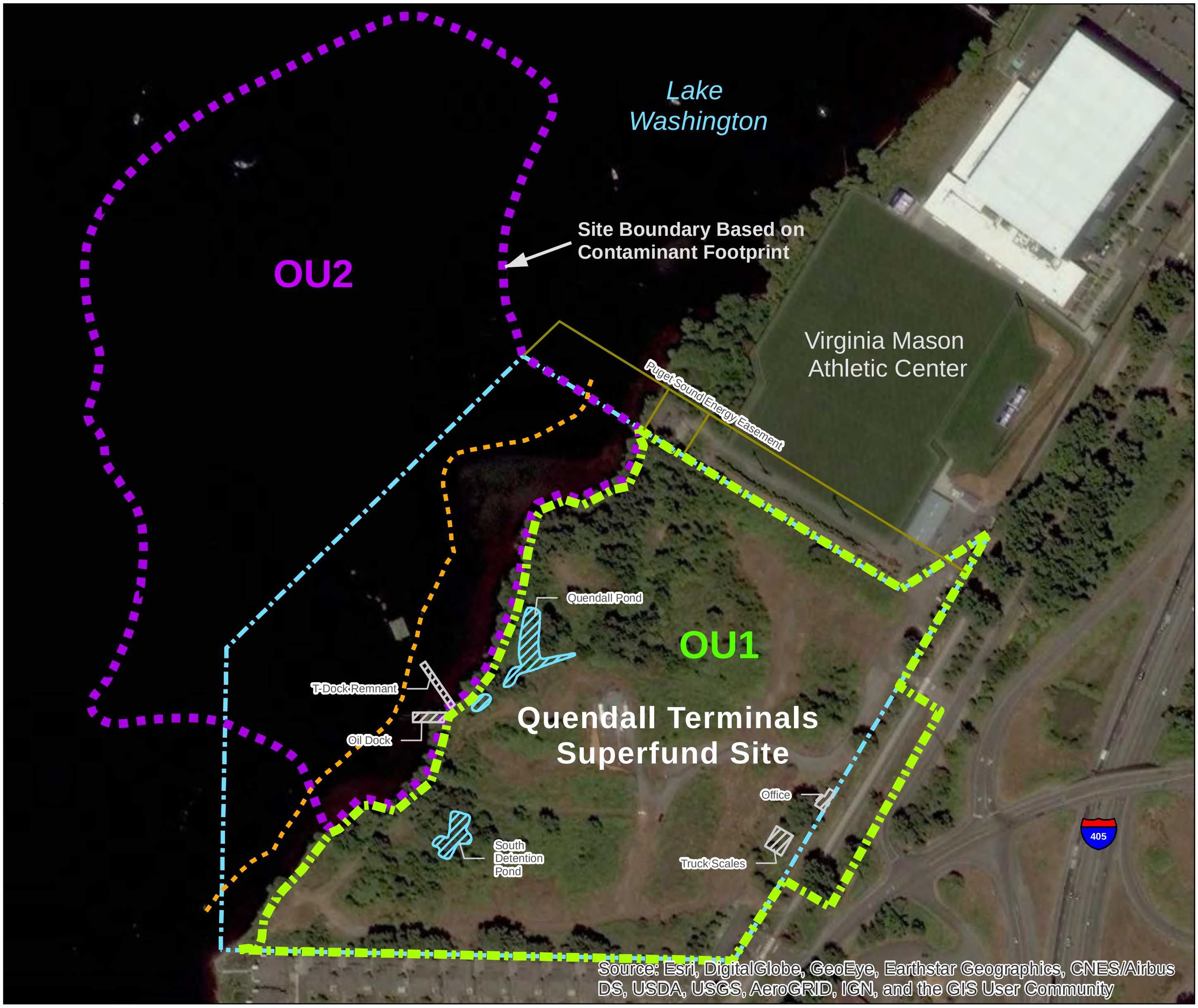
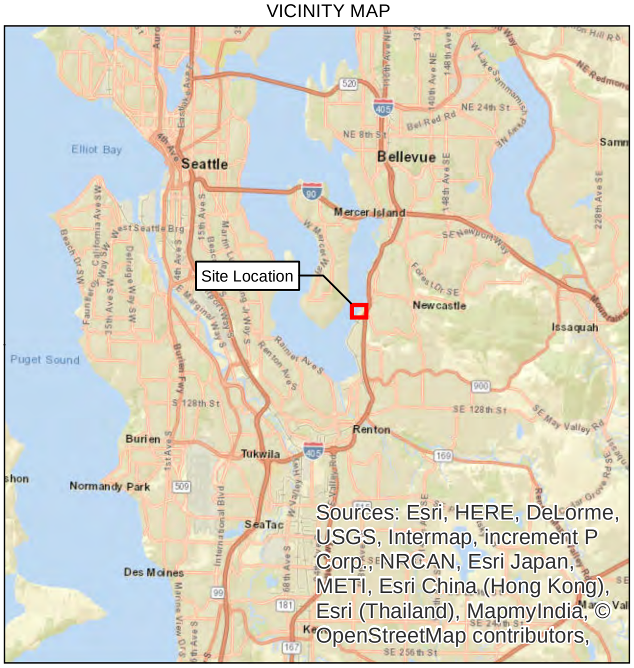


VICINITY MAP



LEGEND

- OU1 Boundary
- OU2 Boundary
- Quendall Property Line
- Existing Structure
- Extent of Nearshore Area (Nearshore extends from shoreline to approximately 10 ft water depth)

0 125 250 500 Feet

N

Figure 1-2
Current Site Features and Operable Units
Record of Decision for the
Quendall Terminals Superfund Site
Renton, Washington

EPA

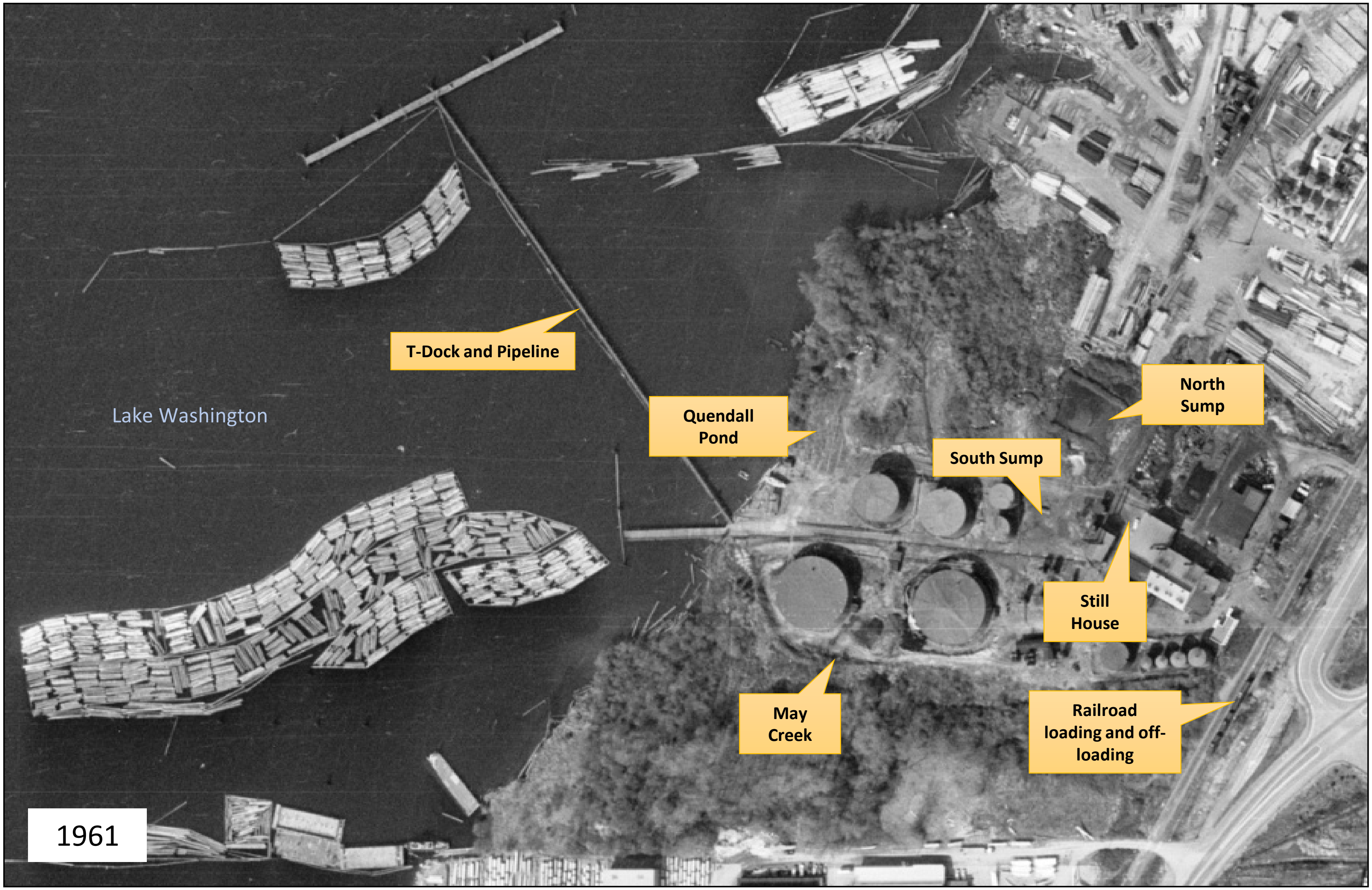


Figure 2-1
Summary of Historical Site Features
Record of Decision for the
Quendall Terminals Superfund Site
Renton, Washington

EPA

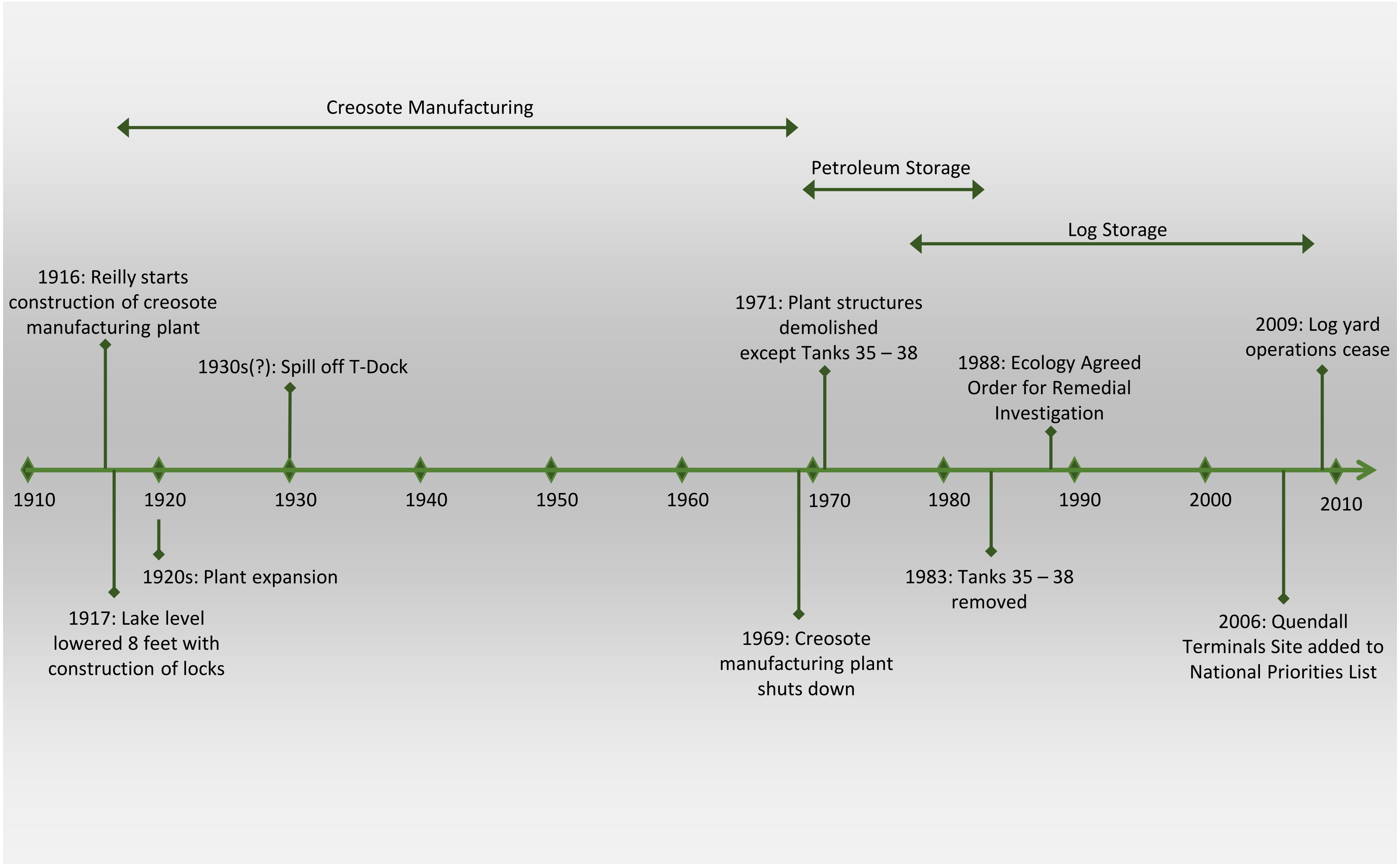


Figure 2-2
Timeline of Site Operations
Record of Decision for the
Quendall Terminals Superfund Site
Renton, Washington

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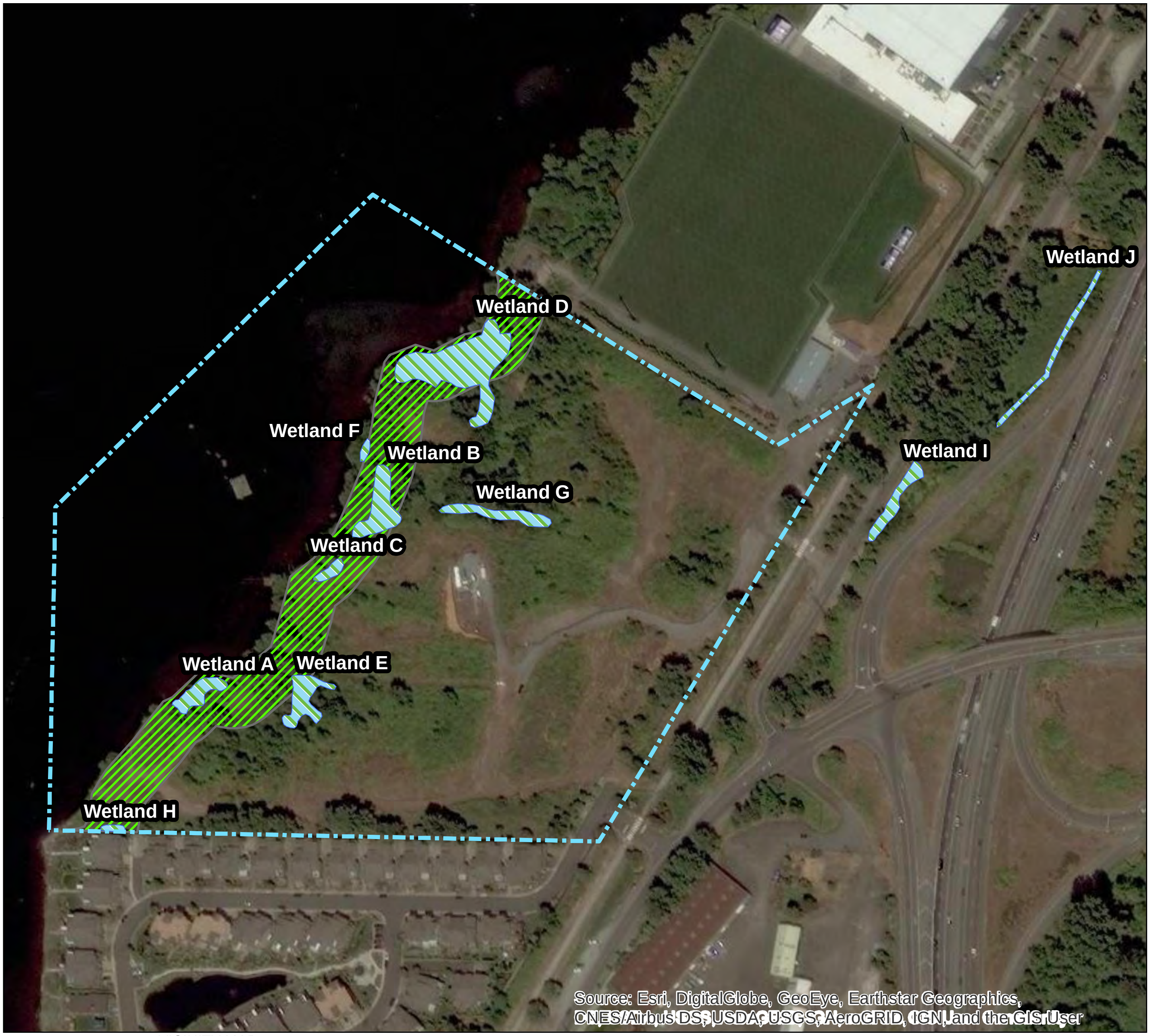

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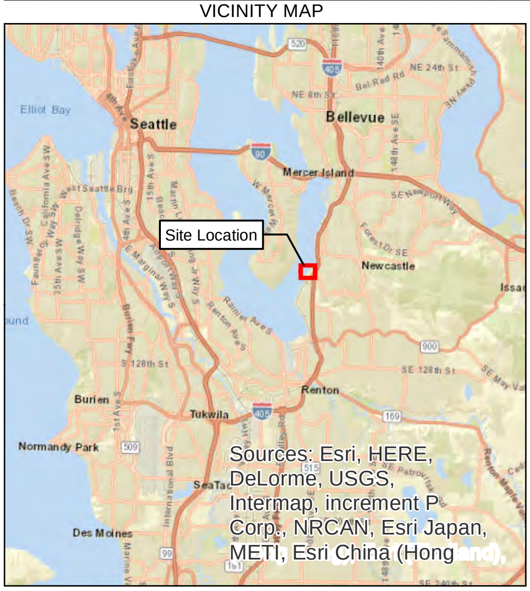

LEGEND

- Quendall Property Line
- Wetlands
- Habitat Area

Sources:
Wetlands digitized from *Quendall Terminals Baseline Habitat Technical Memorandum* (Grette Associates, 2016)

0 125 250 500 Feet

N

Figure 5-1
Habitat Area and Site Wetlands
Record of Decision for the Quendall Terminals Superfund Site Renton, Washington

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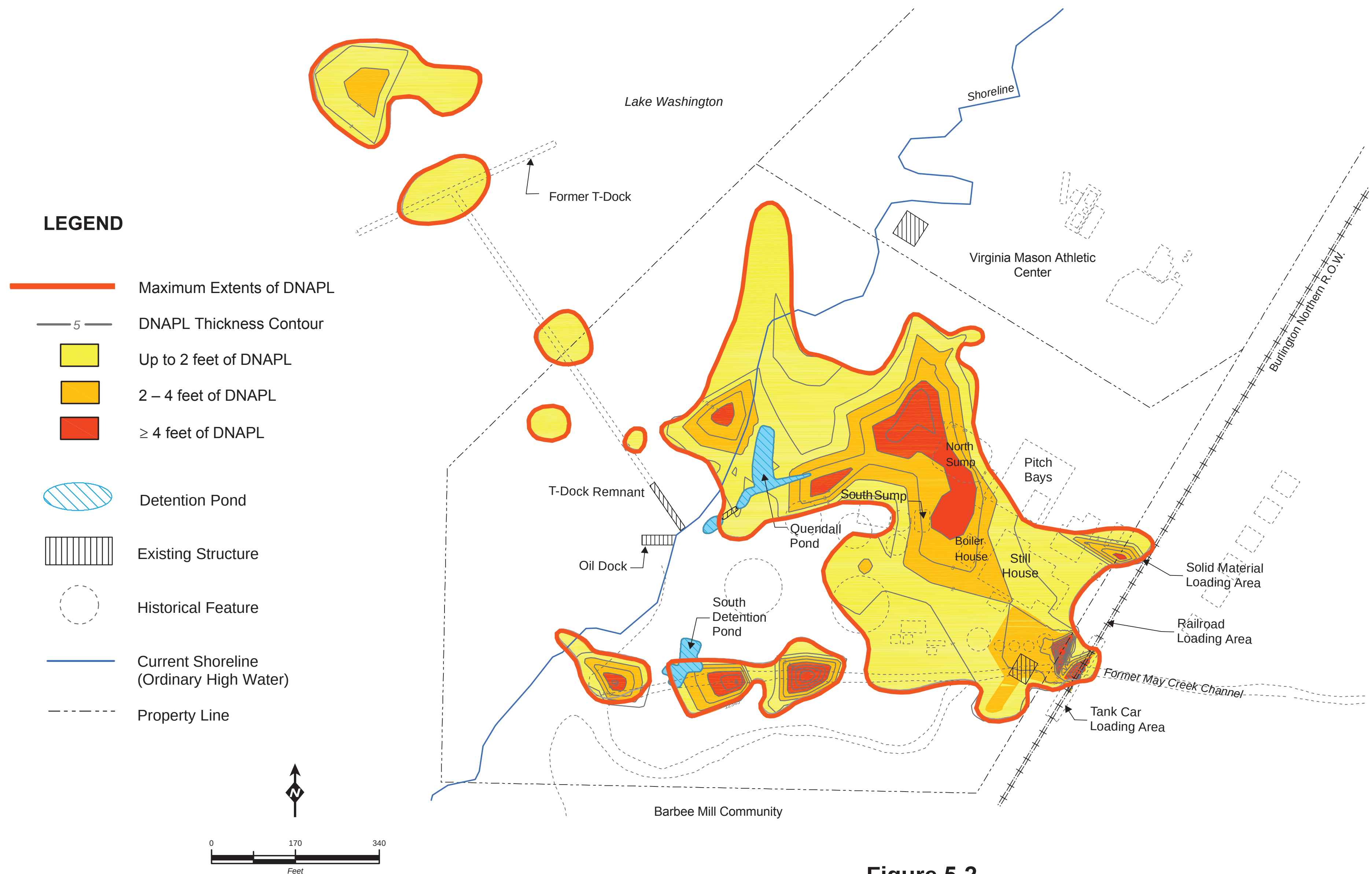


Figure 5-2
Approximate Extent and Thickness of DNAPL
Record of Decision for the
Quendall Terminals Superfund Site
Renton, Washington

EPA

LEGEND

- Subsurface Core Location
- Grab Sample Location
- Well Location

Benzene Detected

- Above MCL (5 µg/L)
- Inferred from Lines of Evidence other than Groundwater Chemistry

Naphthalene Detected

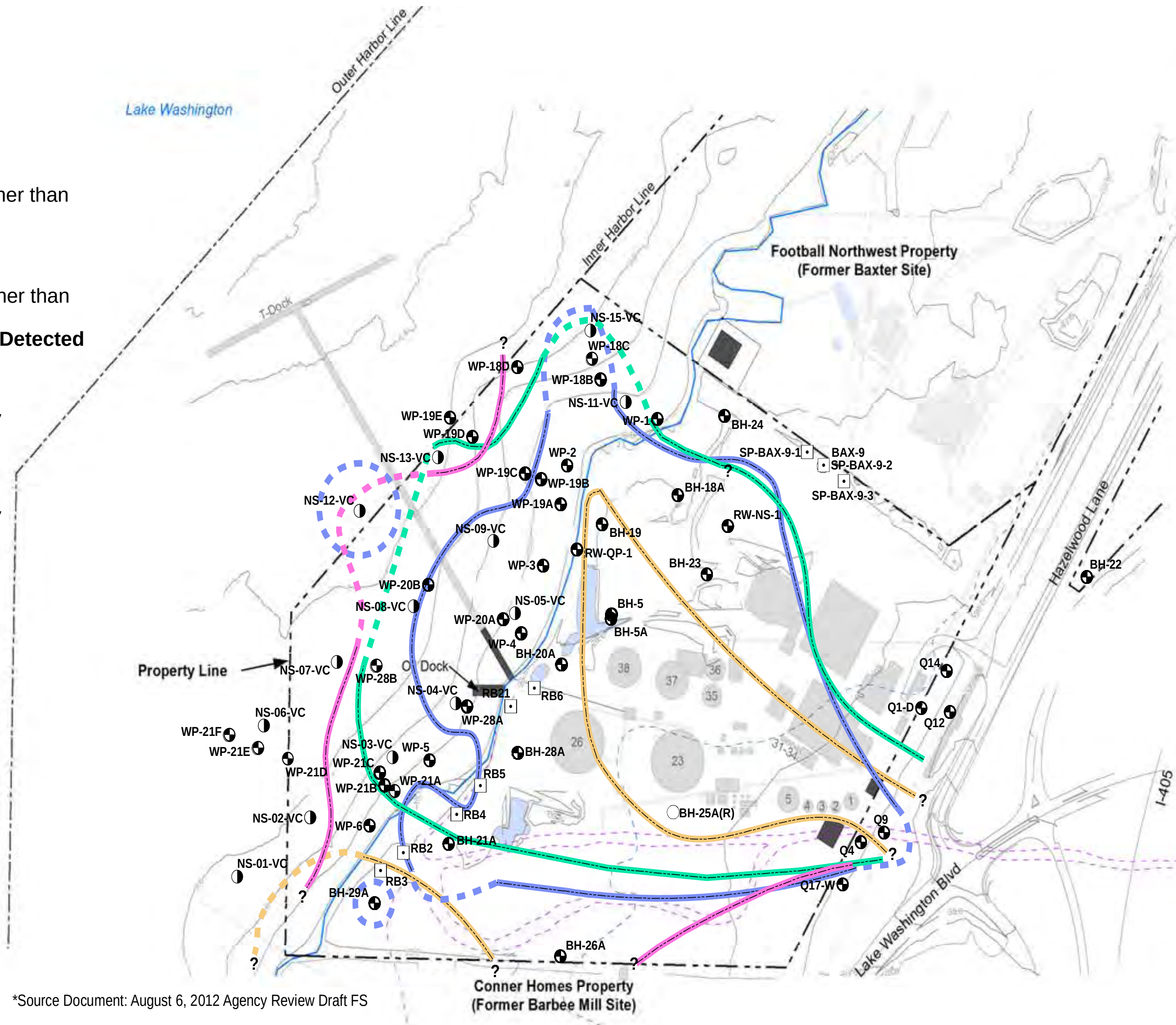
- Above PRG (1.7 µg/L)
- Inferred from Lines of Evidence other than Groundwater Chemistry

cPAHs (Benzo[a]Pyrene Equivalents) Detected

- Above MCL (0.2 µg/L)
- Inferred from Lines of Evidence other than Groundwater Chemistry

Arsenic Detected

- Above MCL (10 µg/L)
- Inferred from Lines of Evidence other than Groundwater Chemistry
- Current Shoreline
- Historical Shoreline (1916)
- Former May Creek Channel
- Property Boundary
- Existing Structure
- Historical Structure
- Detention Pond

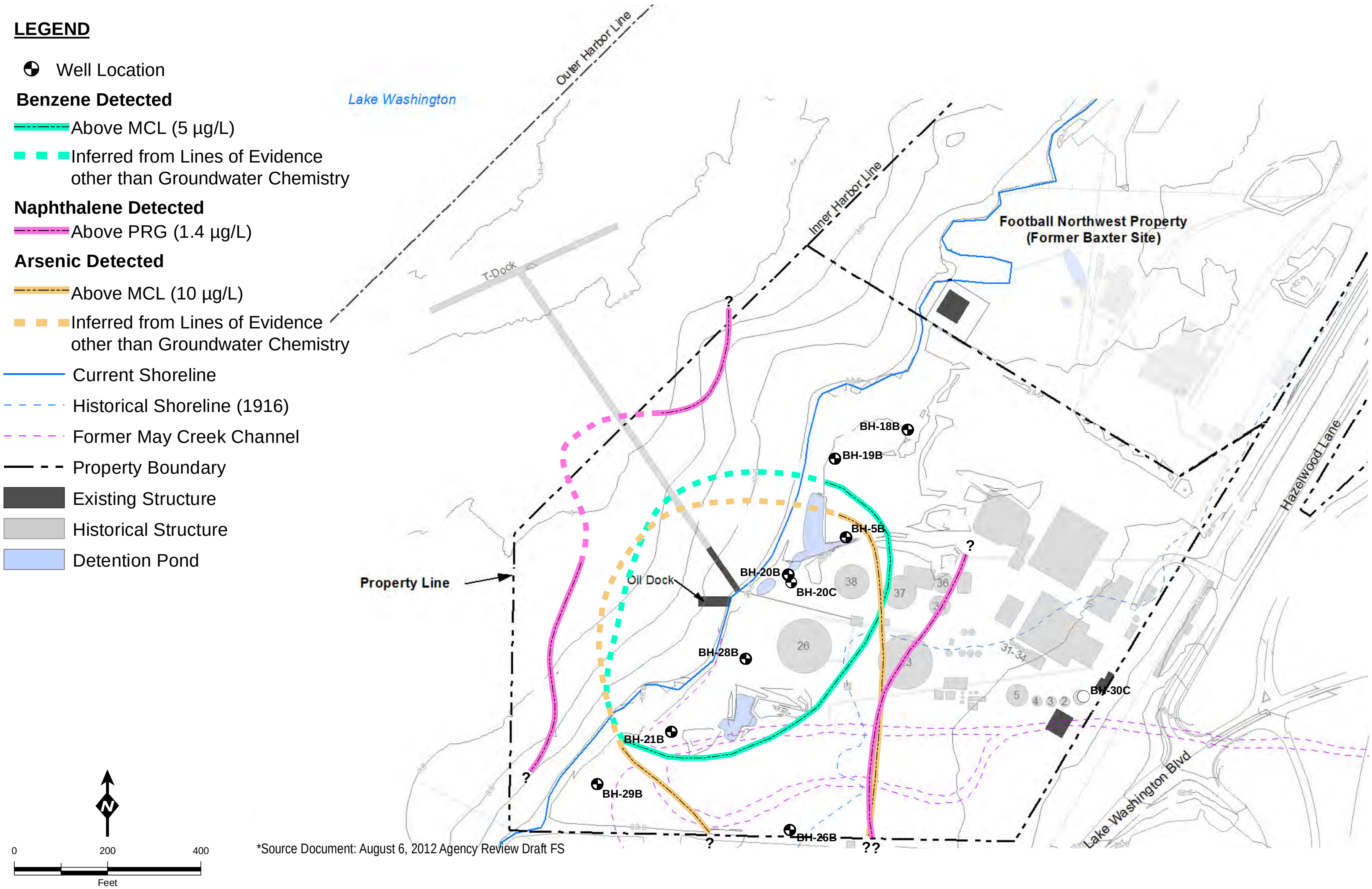


Notes:
1. Contour Intervals are 5 ft, NAVD 88.
2. See Figures 5.2-1, 5.2-8, 5.2-14, and 5.2-16 of the RI Report for basis of approximate extents (Anchor QEA and Aspect 2012). Naphthalene extent has been adjusted from the RI Report based on its lower PRG for the FS (lower PRG based on cancer risk of 10^{-5}). Estimated extents do not consider dispersion.

Figure 5-3
Approximate Extent of Groundwater Contamination in the Shallow Aquifer

Record of Decision for the
Quendall Terminals Superfund Site
Renton, Washington

EPA

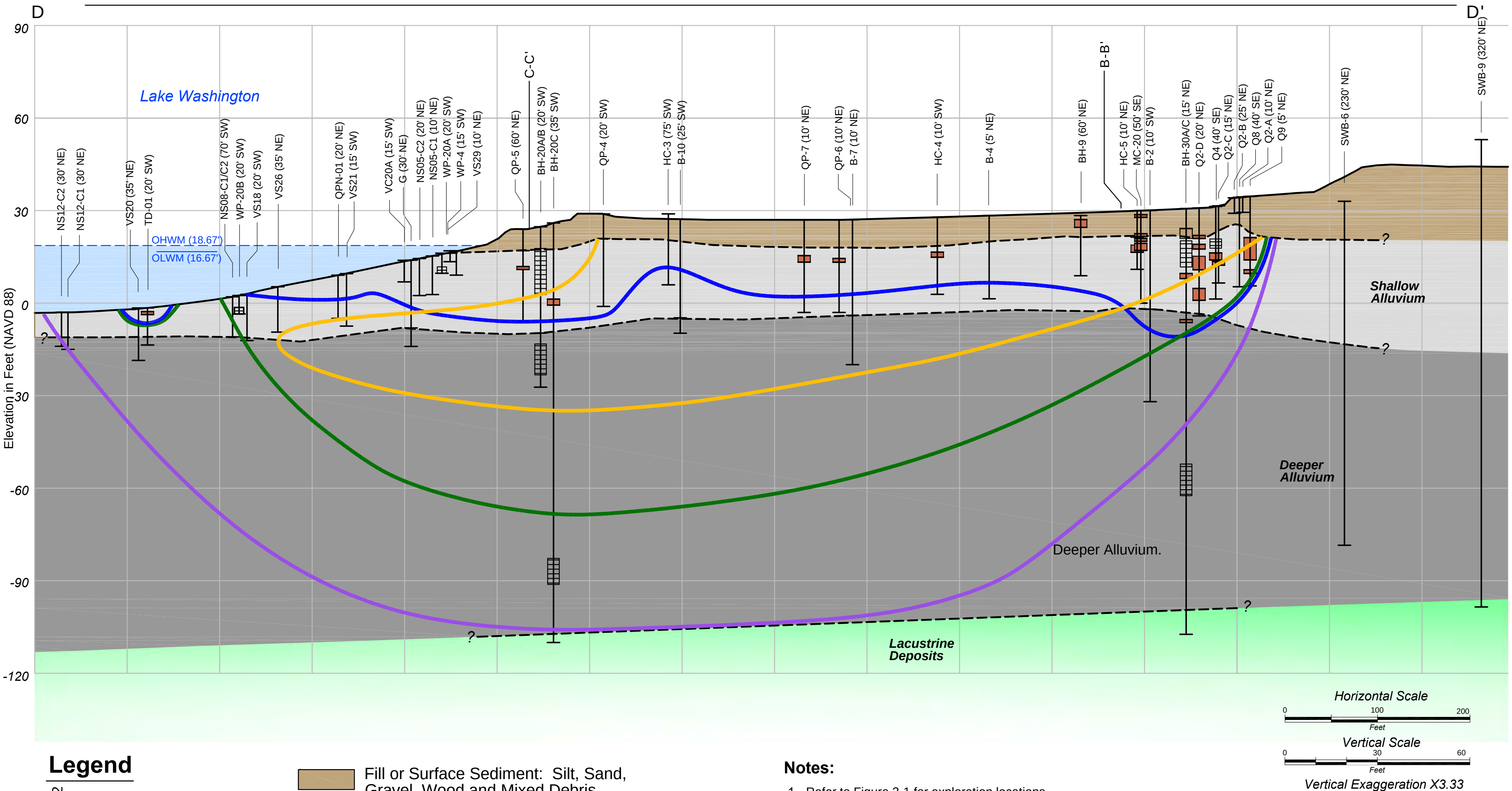


Notes:

1. Contour intervals are 5 ft, NAVD 88.
2. cPAHs (Benzo[a]pyrene Equivalent) have not been detected above the PRG in wells completed in the Deep Aquifer.
3. See Figures 5.2-2, 5.2-9, 5.2-15, and 5.2-17 of the RI Report for basis of approximate extents (Anchor QEA and Aspect 2012). Naphthalene extent has been adjusted from the RI Report based on its lower PRG for the FS. Estimated extents do not consider dispersion.

Figure 5-4
Approximate Extent of Groundwater Contamination in the Deep Aquifer
Record of Decision for the Quendall Terminals Superfund Site Renton, Washington

EPA



Legend

NS12-C2 (30' NE) — Exploration ID and Offset from Cross Section

Non-Aqueous Phase Liquid

Well Screen

Fill or Surface Sediment: Silt, Sand, Gravel, Wood and Mixed Debris

Shallow Alluvium: Stratified Organic Silt, Peat, Sand

Deep Alluvium: Sand and Gravels

Lacustrine Deposits: Silt and Clay

Estimated extent of Benzene exceeding PRG in groundwater and porewater (5 ug/L)

Estimated extent of Naphthalene exceeding PRG in groundwater and porewater (1.4 ug/L)

Estimated extent of cPAHs (Benzo[a]pyrene Equivalents) exceeding PRG in groundwater and porewater (0.2 ug/L)

Estimated extent of Arsenic exceeding PRG in groundwater and porewater (10 ug/L)

Notes:

1. Refer to Figure 3-1 for exploration locations.
2. Vertical extents generally based on groundwater data from wells BH-20A, BH-20B, and BH-20C (Figures 5.2-1, 5.2-2, 5.2-8, 5.2-9, 5.2-14, 5.2-15, 5.2-16, and 5.2-17 of the RI Report (Anchor QEA and Aspect 2012)) and groundwater grab samples at BH-20C and BH-30C (Appendix A of the RI Report). Vertical extent of Benzo(a)pyrene approximate based on model predictions (Appendix A of this FS), adjusted to account for empirical data and artifacts from model cell size. Vertical extent of Naphthalene based on base of Deeper Alluvium.
3. Vertical extents of PRG exceedances on this figure consider fate and transport predictions of the RI groundwater model (Anchor QEA and Aspect 2012). Therefore, the estimated boundaries shown do not exactly match the estimated extent of contamination in Deep and Shallow groundwater shown on Figures 3-6 and 3-7.

Figure 5-5
Cross-Section Showing Extent of Groundwater Exceeding PRGs

Record of Decision for the Quendall Terminals Superfund Site
Renton, Washington

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LEGEND

Detected Organic Carbon Normalized cPAH (B[a]P Equivalent) Concentration in mg/kg-OC

- <6.2
- ≥6.2 - 17.5
- ≥17.5

Historical Organic Carbon Normalized cPAH (B[a]P Equivalent) Concentration in mg/kg-OC

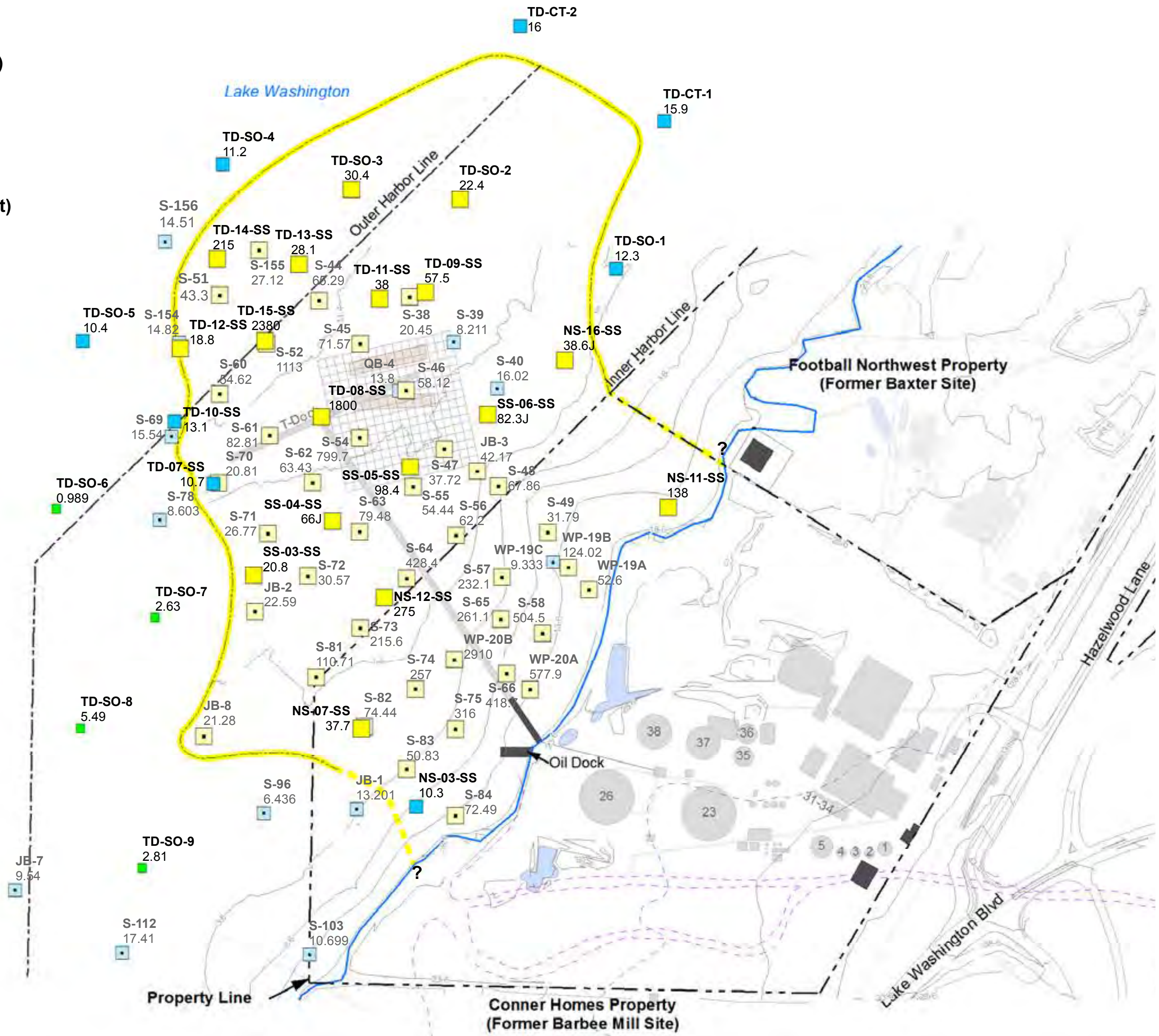
- <6.2
- ≥6.2 - 17.5
- ≥17.5

- Approximate Extent of Detected cPAH Concentrations Exceeding the Background Threshold Value (BTV)
- Inferred from Historical Data
- Current Shoreline
- Historical Shoreline (1916)
- Former May Creek Channel
- Property Boundary
- Existing Structure
- Historical Structure
- Detention Pond
- Sand Placement Grid
- Dry Dock Concrete

Basis of Screening Level Intervals

6.2 90% Upper Confidence Limit

17.5 Background Threshold Value (BTV)



Notes:

1. Contour intervals are 5 ft, NAVD 88.
2. U = Non-Detect
3. J = Estimated Value
4. The organic carbon normalized PRG screening level for cPAHs in surface bulk sediment of 6.2 milligrams per kilogram (mg/kg)-OC is the 90 percent upper confidence limit on the mean site-specific background samples collected during the 2009 RI field investigation and documented in the RI Report (Anchor QEA and Aspect 2012).
5. The historical stations shown on this figure were sampled by Retec (in 1996 and 1997) and Anchor (in 2002 and 2003).

Figure 5-6

Surface Bulk Sediment Organic Carbon Normalized cPAH (Benzo[a]pyrene Equivalent) Concentrations

Record of Decision for the

Quendall Terminals Superfund Site

Renton, Washington

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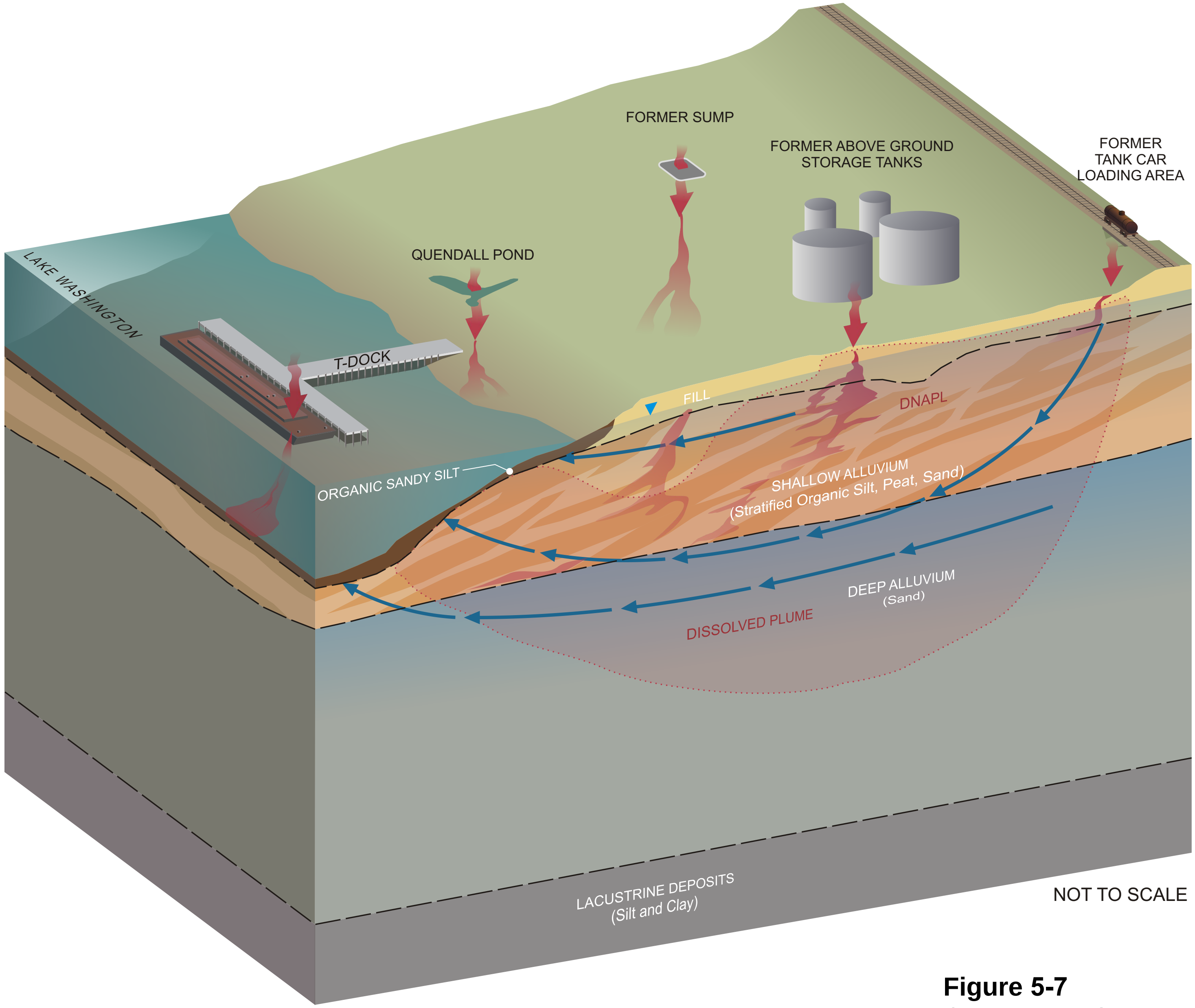

Figure 5-7
Conceptual Site Model
Record of Decision for the
Quendall Terminals Superfund Site
Renton, Washington

*Source Document: August 6, 2012 Agency Review Draft FS

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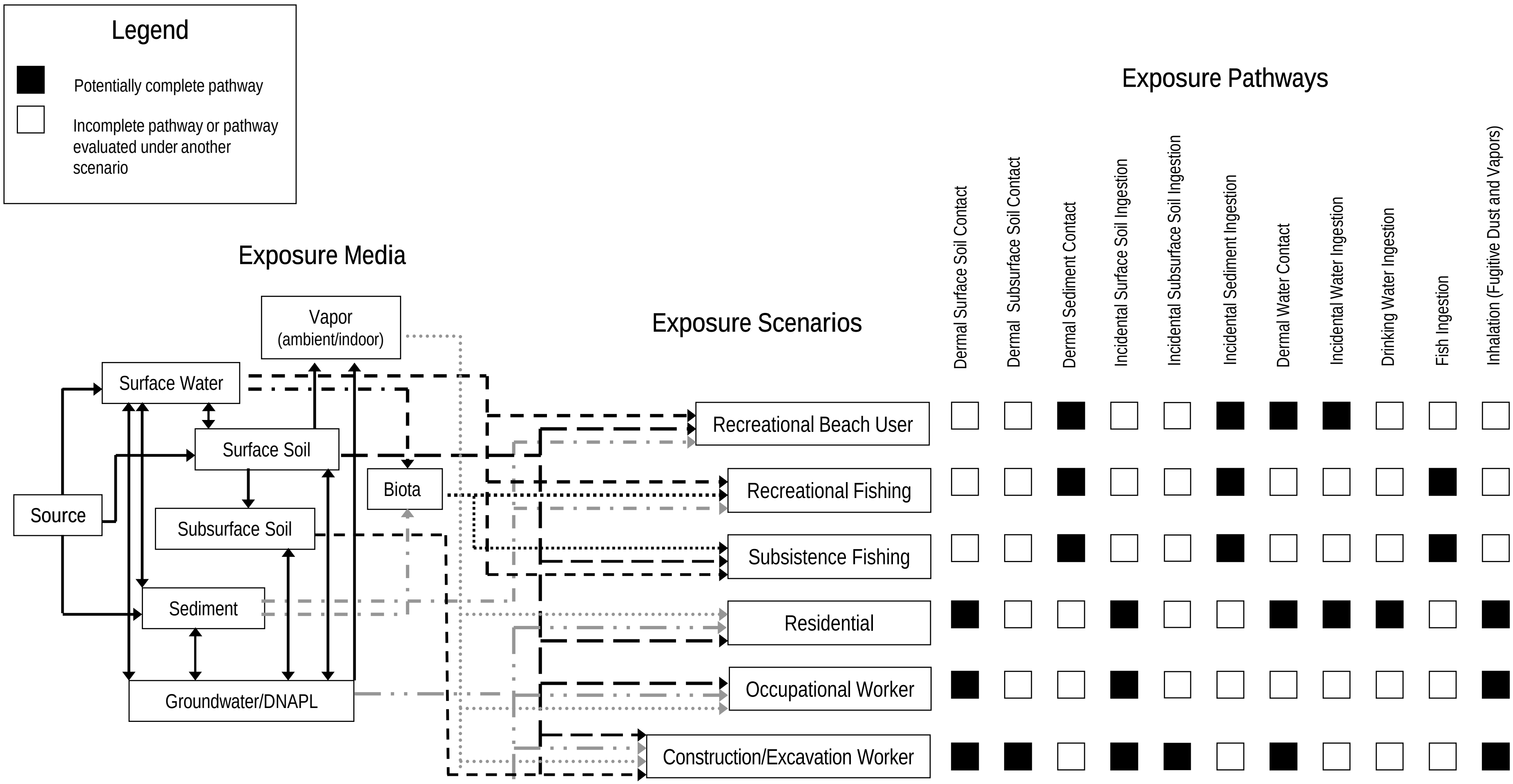
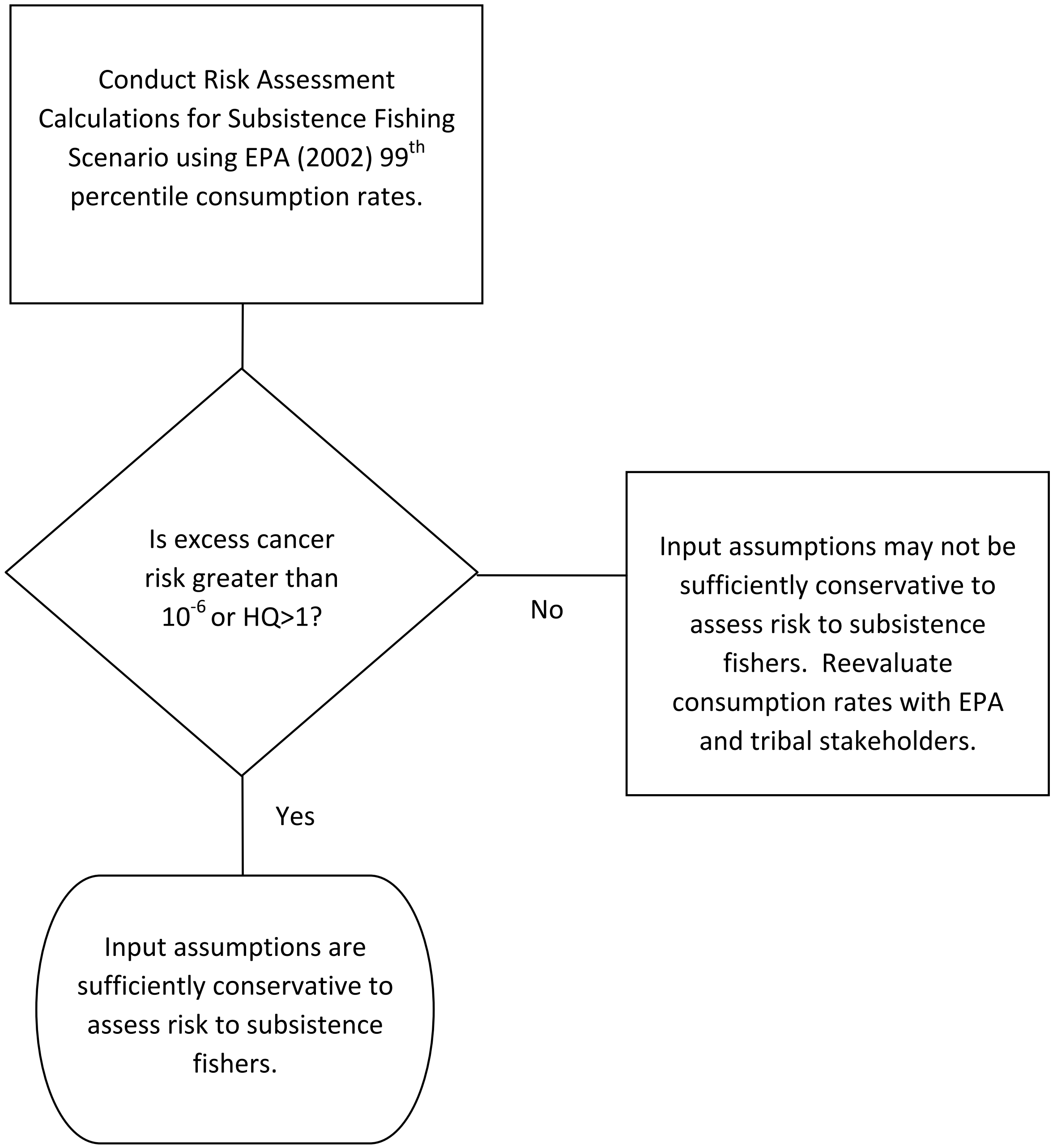


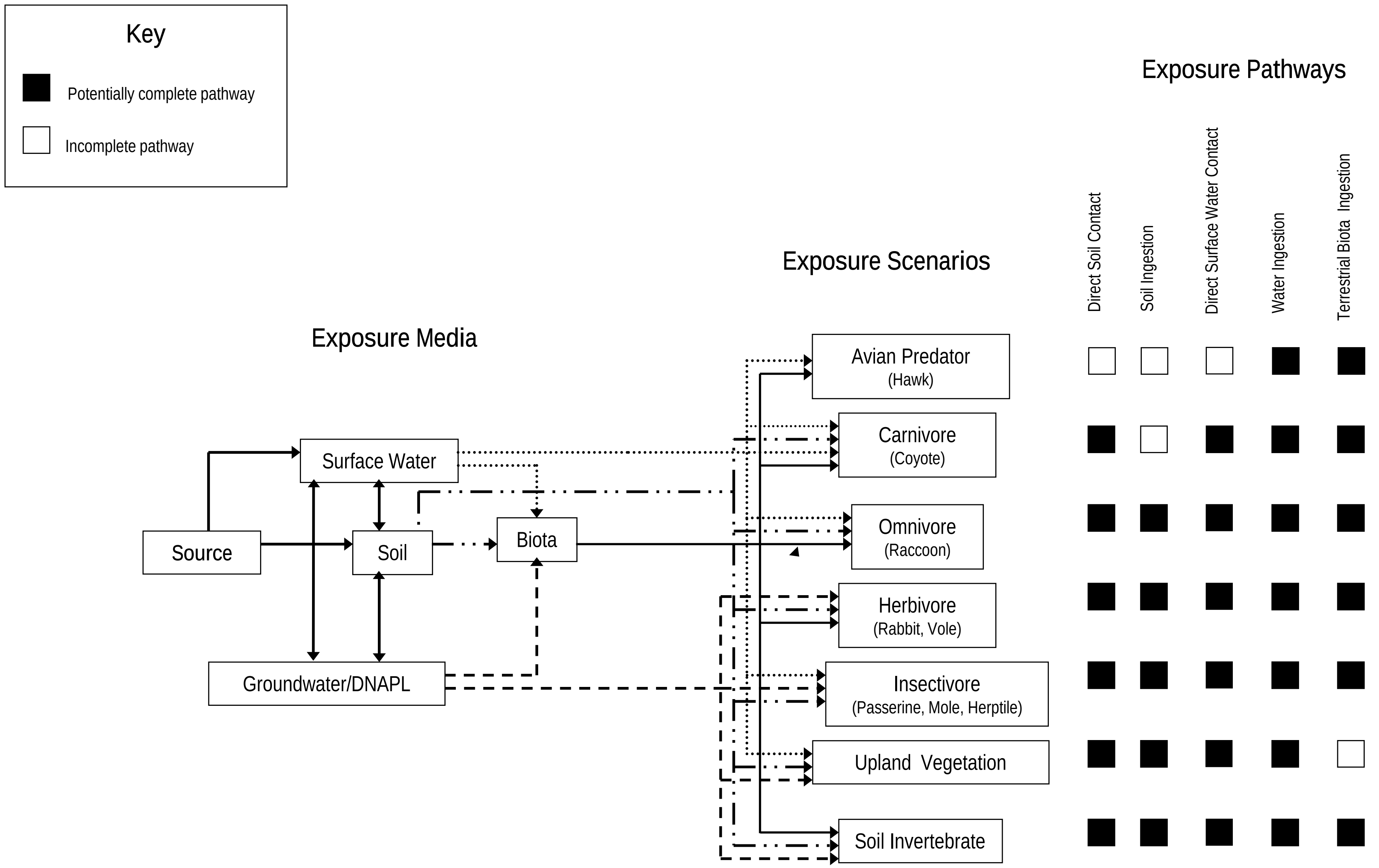
Source: RI Figure 7.1-6 (Anchor QEA and Aspect, 2012)

Figure 7-1
Human Health Conceptual Site Exposure Model
Record of Decision for the
Quendall Terminals Superfund Site
Renton, Washington



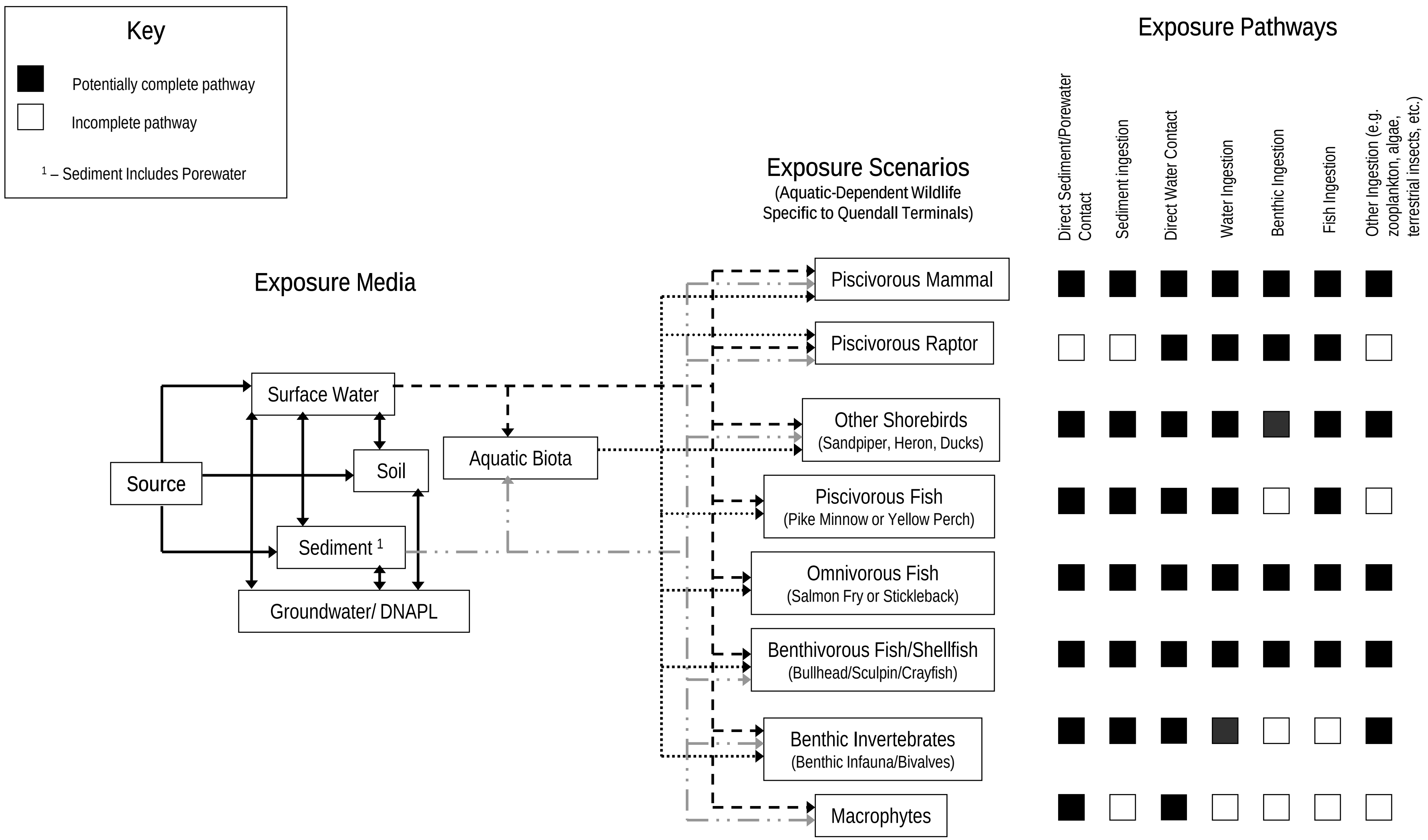
Source: Human and Ecological Risk Assessment Work Plan Figure 5-6 (Anchor QEA and Aspect, 2009)

Figure 7-2
Decision Matrix for Evaluation of Subsistence and Tribal Fishing Scenarios
Record of Decision for the
Quendall Terminals Superfund Site
Renton, Washington



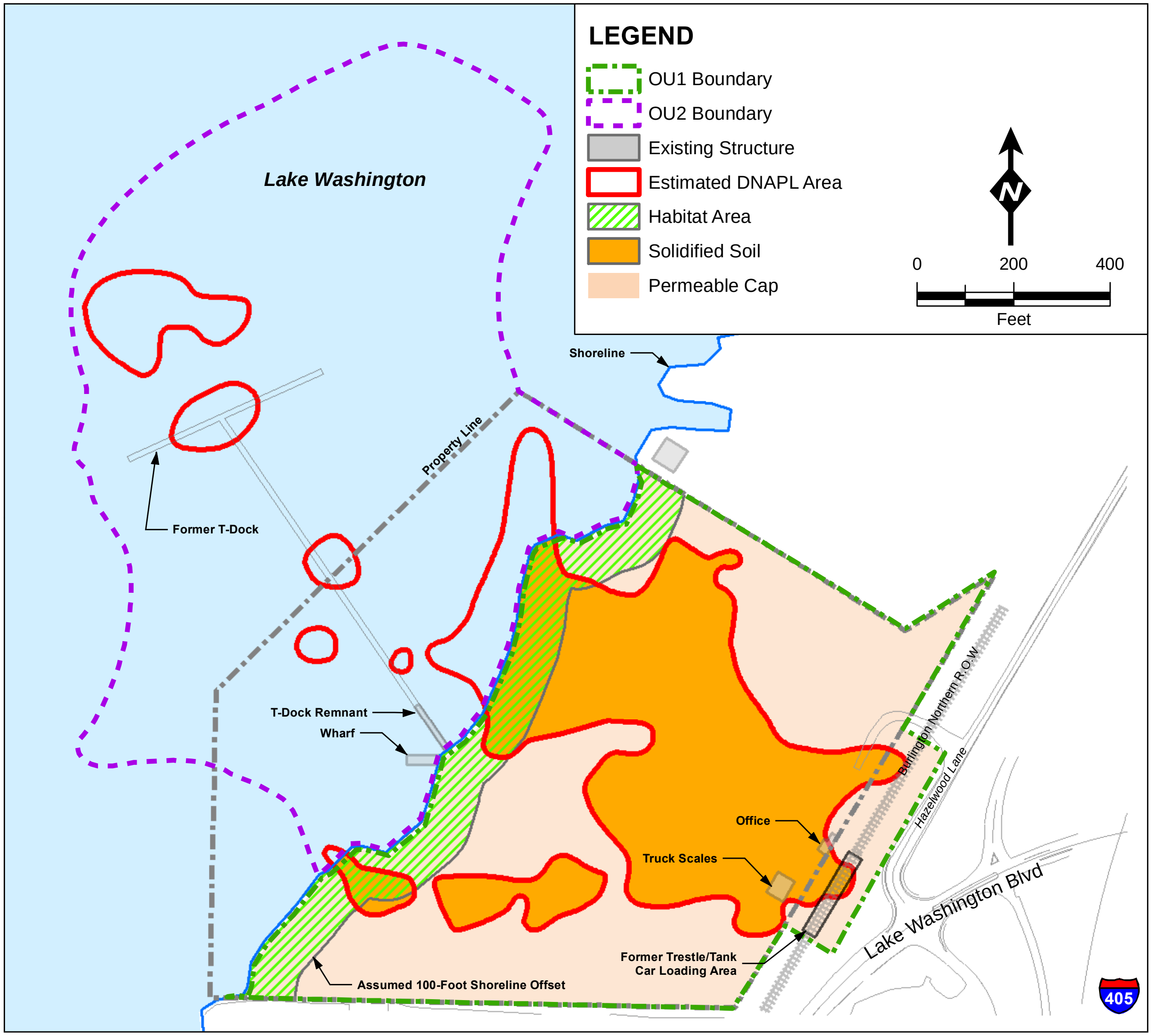
Source: RI Figure 7.2-1 (Anchor QEA and Aspect, 2012)

Figure 7-3
Terrestrial Receptors Conceptual Site Exposure Model
Record of Decision for the
Quendall Terminals Superfund Site
Renton, Washington



Source: RI Figure 7.2-2 (Anchor QEA and Aspect, 2012)

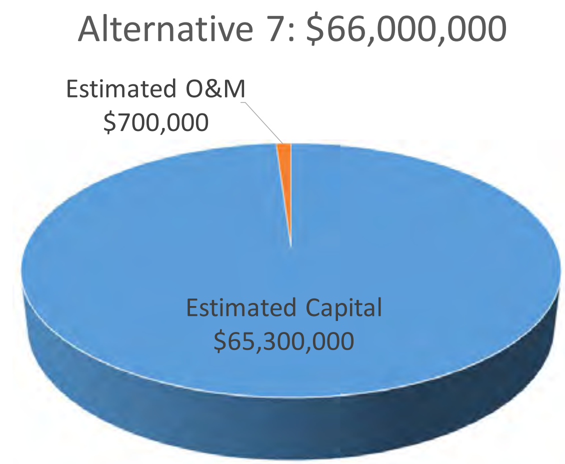
Figure 7-4
Aquatic Receptors Conceptual Site Exposure Model
Record of Decision for the
Quendall Terminals Superfund Site
Renton, Washington



DNAPL Remedial Technology	% DNAPL Addressed by Technology (by vol.)
Solidification	100%
Excavation	0%

Note: A three-foot soil cap will be placed over areas of the site where soil cleanup levles are exceeded.

Acronyms:
DNAPL = dense nonaqueous phase liquid
O&M = operations and maintenance
OU = operable unit



Implementation Sequence

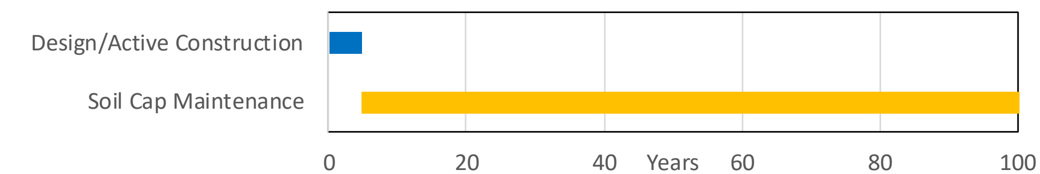


Figure 9-1
Alternative 7 – In Situ Solidification of DNAPL and Soil Capping
Record of Decision for the
Quendall Terminals Superfund Site
Renton, Washington

\\SEAFPP01\PROJ\USENVIRONMENTALPROTE\682283QUENDALL\DELIVERABLESBYTASK\TASK12_FS\2016-12_FINAL_FS\GISFILES\QUENDALL_FS_FIGURE_FILES\MAPFILES\2019\ROD\FIGURE_9-1_ALTERNATIVE7_OU1.MXD GGEE 3/19/2020 11:55:32 AM

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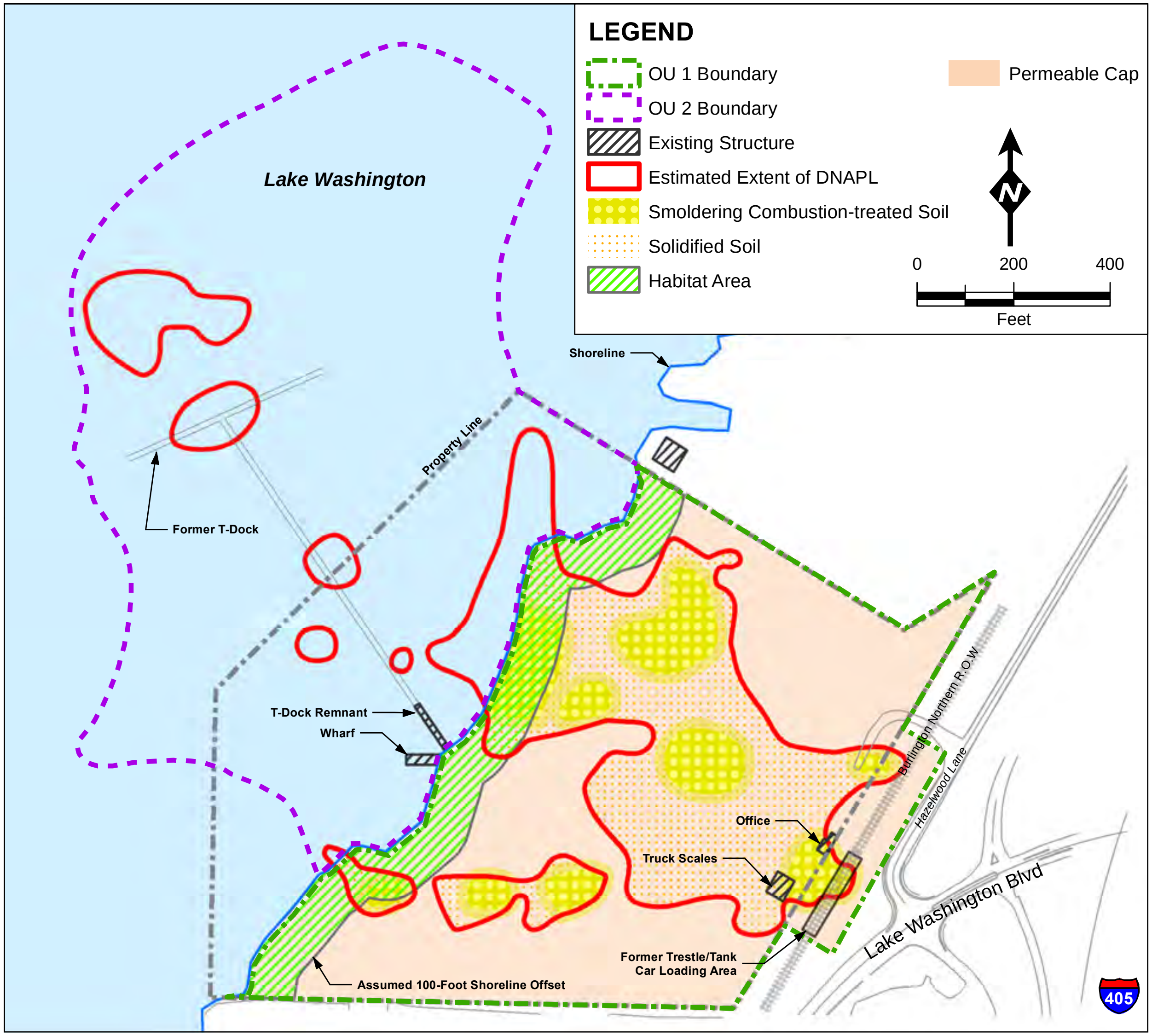


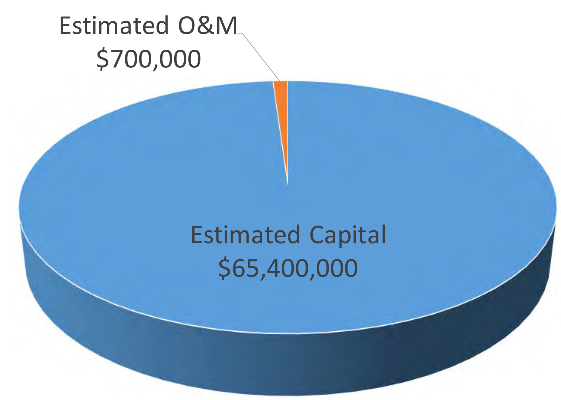
DNAPL Remedial Technology*	% DNAPL Addressed by Technology* (by vol.)
Smoldering Combustion	56%
Solidification	44%

*For FS-level cost-estimating, smoldering combustion is assumed to treat approx. 56% of DNAPL-impacted soil. Although the total area (acres) treated by smoldering combustion is shown as less than the area estimated for possible ISS, areas targeted for smoldering combustion contain greater thicknesses of DNAPL than the areas shown for ISS.

Note: A three-foot soil cap will be placed over areas of the site where soil cleanup levels are exceeded.

Acronyms:
DNAPL = dense nonaqueous phase liquid
O&M = operations and maintenance
OU = operable unit

Alternative 7a: $66,100,000



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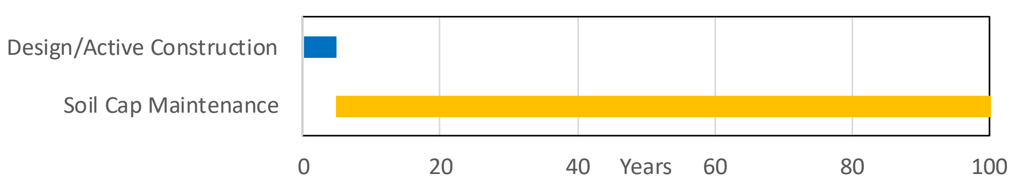
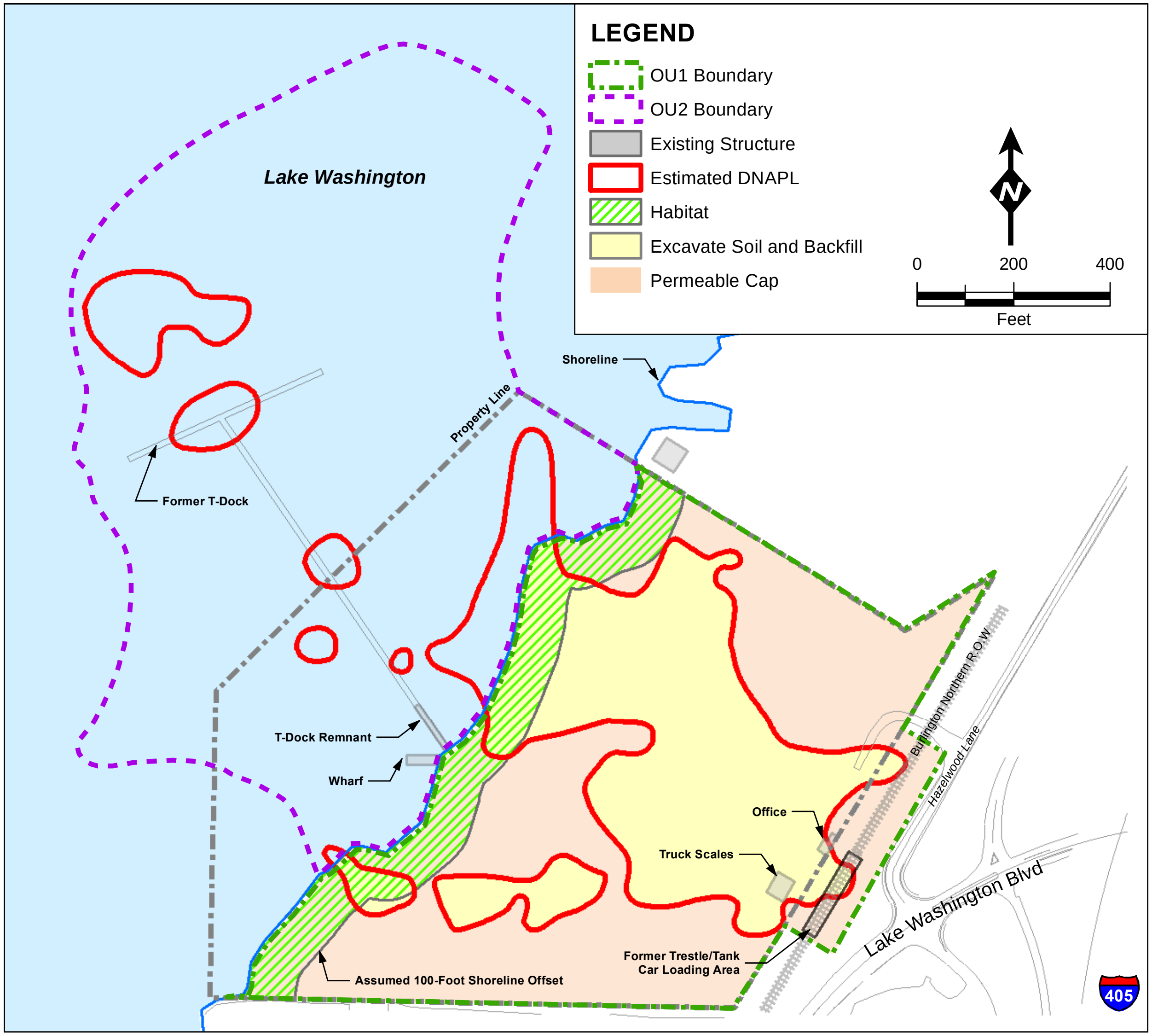


Figure 9-2
Alternative 7a – In Situ Smoldering Combustion or In Situ Solidification of DNAPL and Soil Capping
Record of Decision for the Quendall Terminals Superfund Site
Renton, Washington

EPA



DNAPL Remedial Technology	% DNAPL Addressed by Technology (by vol.)
Solidification	0%
Excavation	100%

Note: A three-foot soil cap will be placed over areas of the site where soil cleanup levels are exceeded.

Acronyms:
DNAPL = dense nonaqueous phase liquid
O&M = operations and maintenance
OU = operable unit

Implementation Sequence

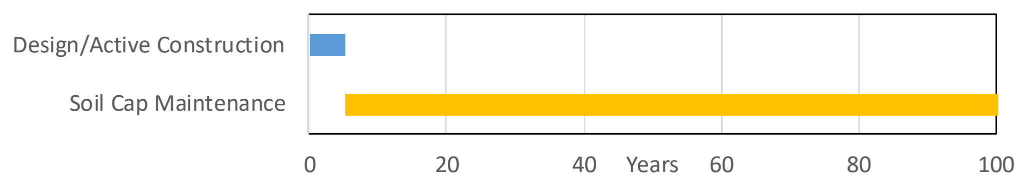


Figure 9-3
Alternative 8 – Removal/Onsite Thermal Treatment of DNAPL and Soil Capping
Record of Decision for the
Quendall Terminals Superfund Site
Renton, Washington

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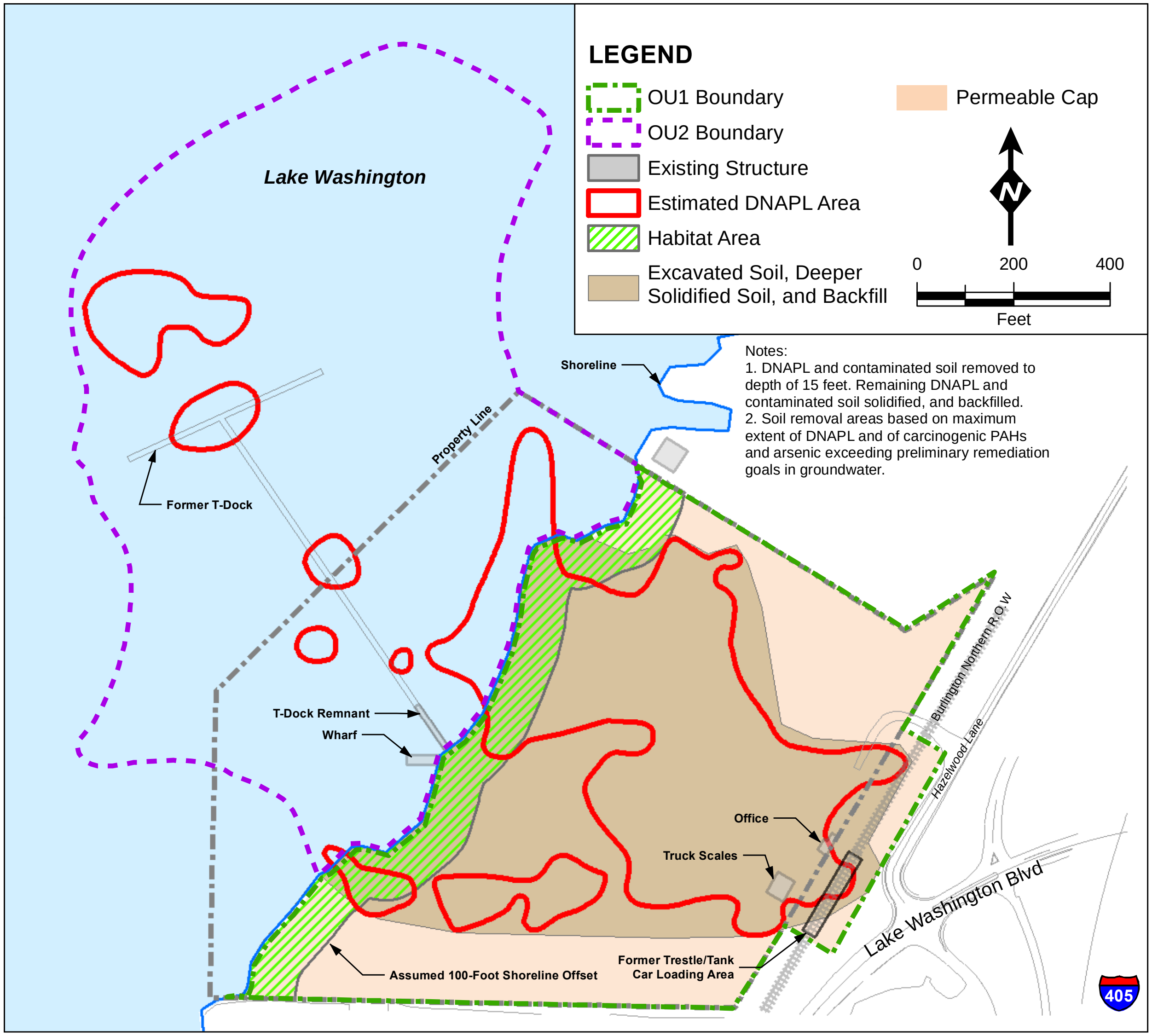
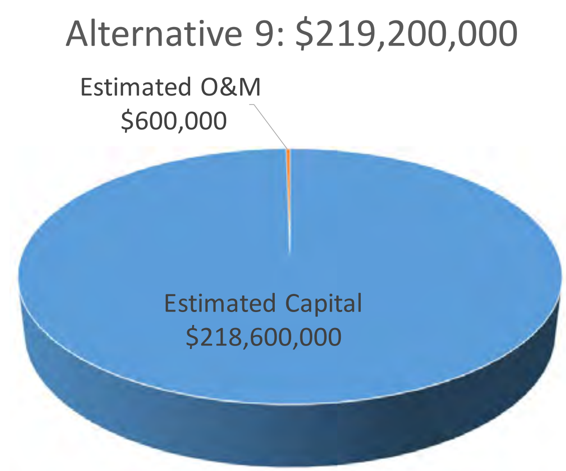
\\SEAFPP01\PROJ\USENVIRONMENTALPROTE\682283QUENDALL\DELIVERABLESBYTASK\TASK12_FS\2016-12_FINAL_FS\GISFILES\QUENDALL_FS_FIGURE_FILES\MAPFILES\2019\ROD\FIGURE_9-3_ALTERNATIVE8_OU1.MXD GGEE 3/19/2020 11:57:24 AM



DNAPL Remedial Technology	% DNAPL Addressed by Technology (by vol.)
Solidification	28%
Excavation	72%

Note: A three-foot soil cap will be placed over areas of the site where soil cleanup levels are exceeded.

Acronyms:
DNAPL = dense nonaqueous phase liquid
O&M = operations and maintenance
OU = operable unit



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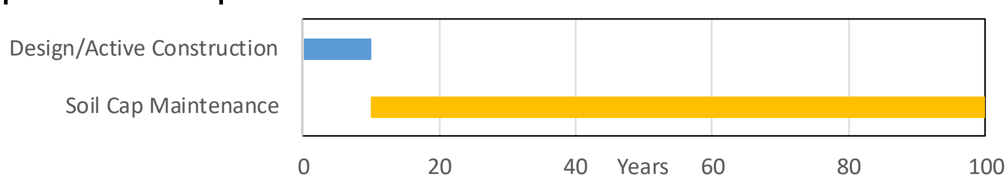
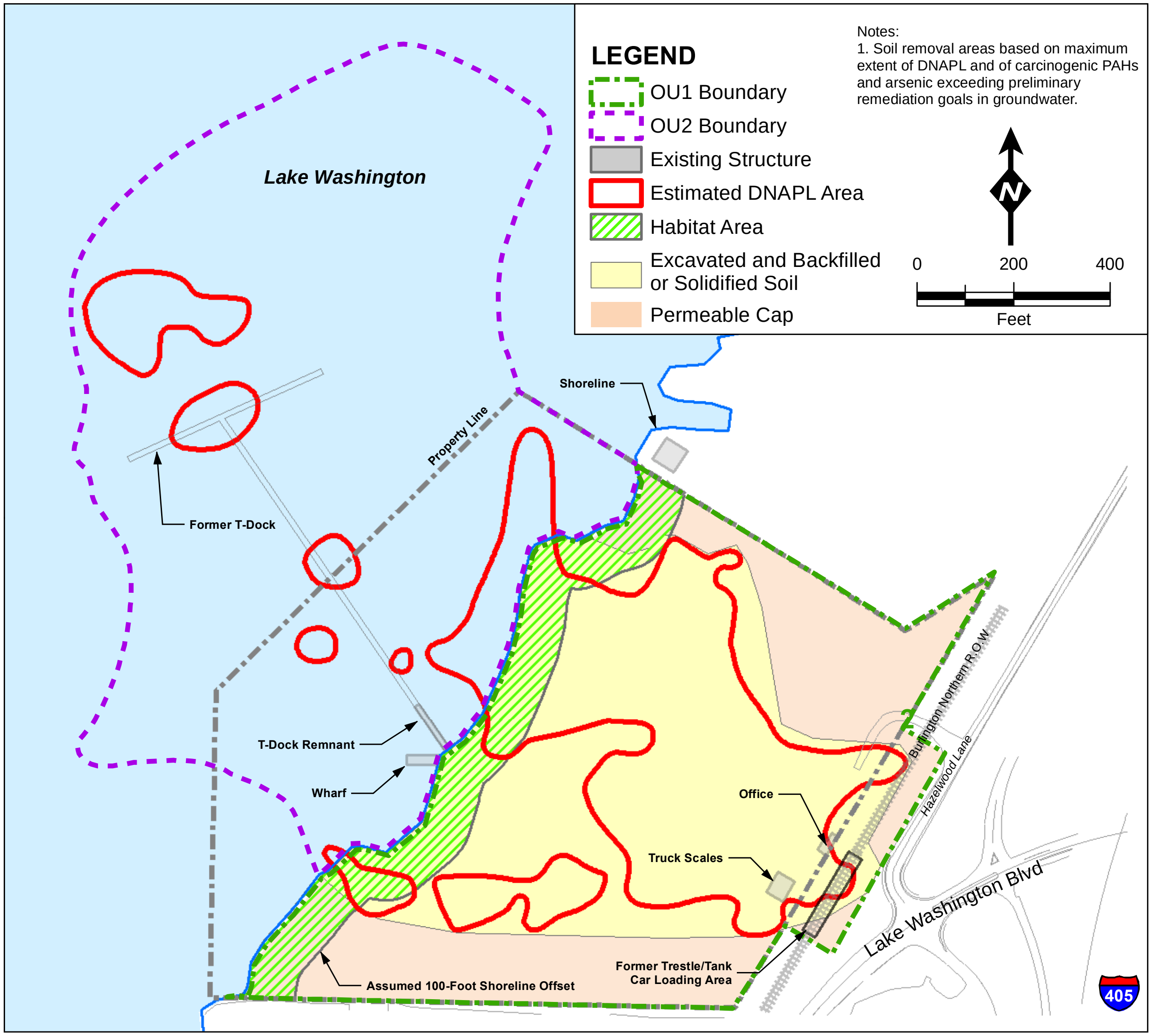


Figure 9-4
Alternative 9 – In Situ Solidification and Removal/Onsite Thermal Treatment of DNAPL and Contaminated Soil and Soil Capping
Record of Decision for the
Quendall Terminals Superfund Site
Renton, Washington

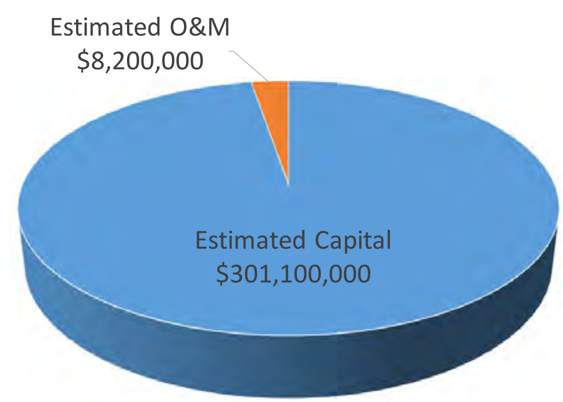


DNAPL Remedial Technology	% DNAPL Addressed by Technology (by vol.)
Solidification	0%
Excavation	100%

Note: A three-foot soil cap will be placed over areas of the site where soil cleanup levels are exceeded.

Acronyms:
DNAPL = dense nonaqueous phase liquid
O&M = operations and maintenance
OU = operable unit

Alternative 10: $309,300,000



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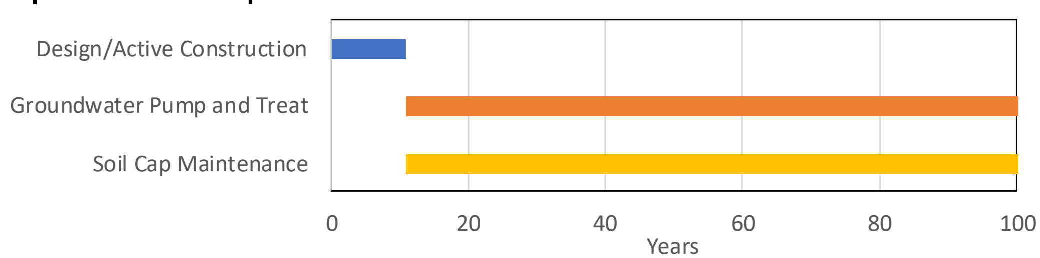

Figure 9-5
Alternative 10 – Removal/Onsite Thermal Treatment of DNAPL and Contaminated Soil, Soil Capping, and Active Groundwater Treatment
Record of Decision for the Quendall Terminals Superfund Site Renton, Washington

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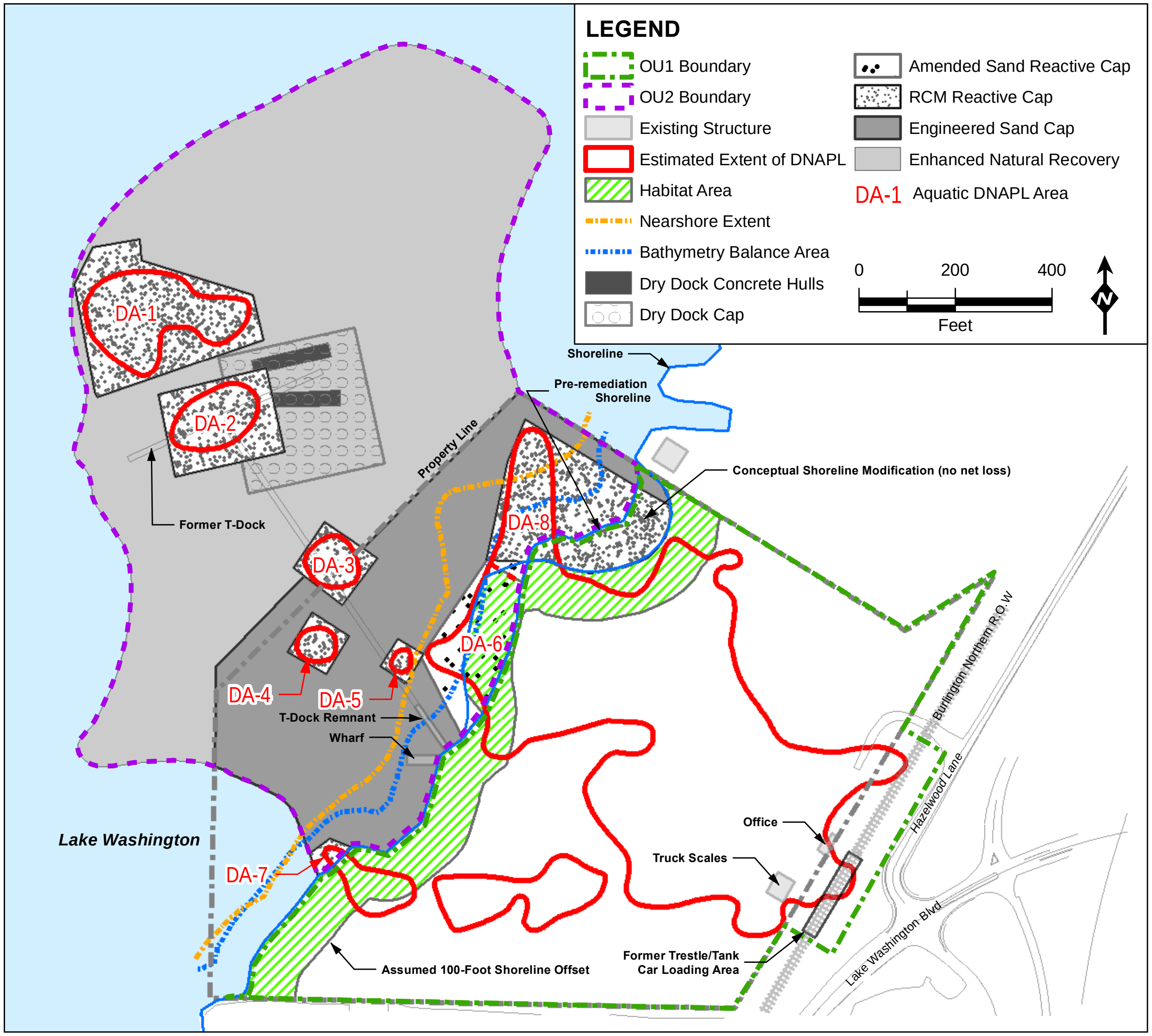
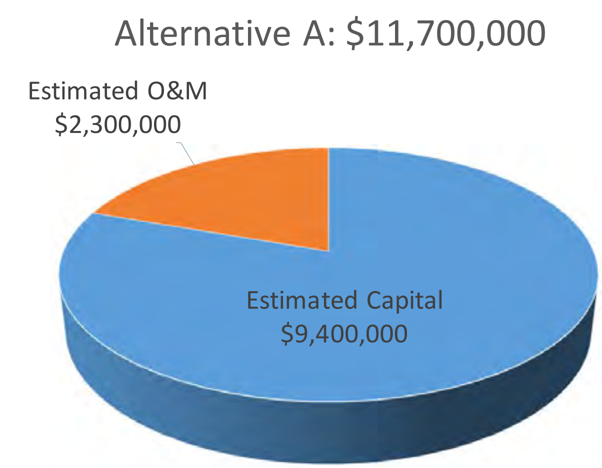


DNAPL Technology	% DNAPL Addressed by Technology (by vol.)
Capping	95%
Dredging	5%

Acronyms:
DA = dredge area
DNAPL = dense nonaqueous phase liquid
ENR = enhanced natural recovery
O&M = operations and maintenance
RCM = reactive core mat



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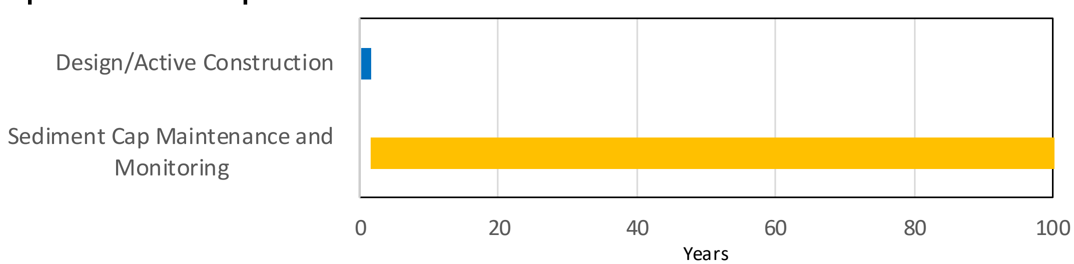
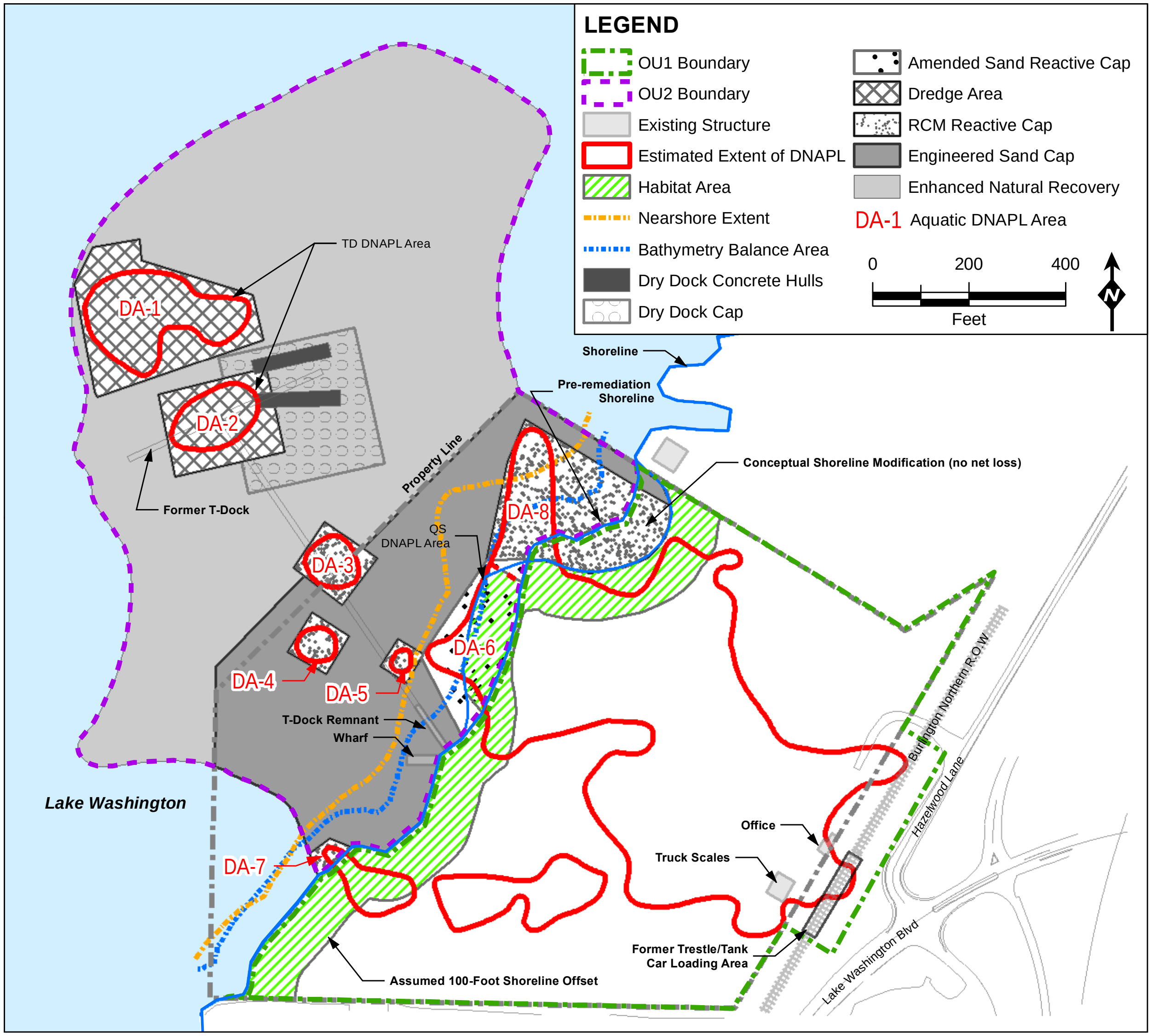


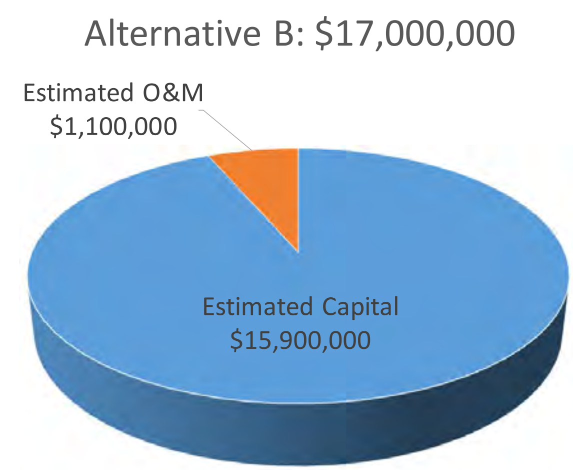
Figure 9-6
Alternative A – Amended Sand Cap, RCM Cap, Engineered Sand Cap, and ENR
Record of Decision for the
Quendall Terminals Superfund Site
Renton, Washington

EPA



DNAPL Technology	% DNAPL Addressed by Technology (by vol.)
Capping	74%
Dredging	26%

Acronyms:
DA = dredge area
DNAPL = dense nonaqueous phase liquid
ENR = enhanced natural recovery
O&M = operations and maintenance
RCM = reactive core mat
TD = T-Dock
QP-S = Quendall Pond Sediment



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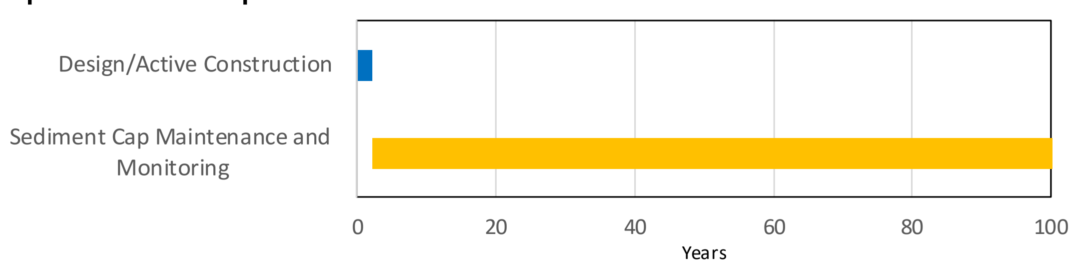
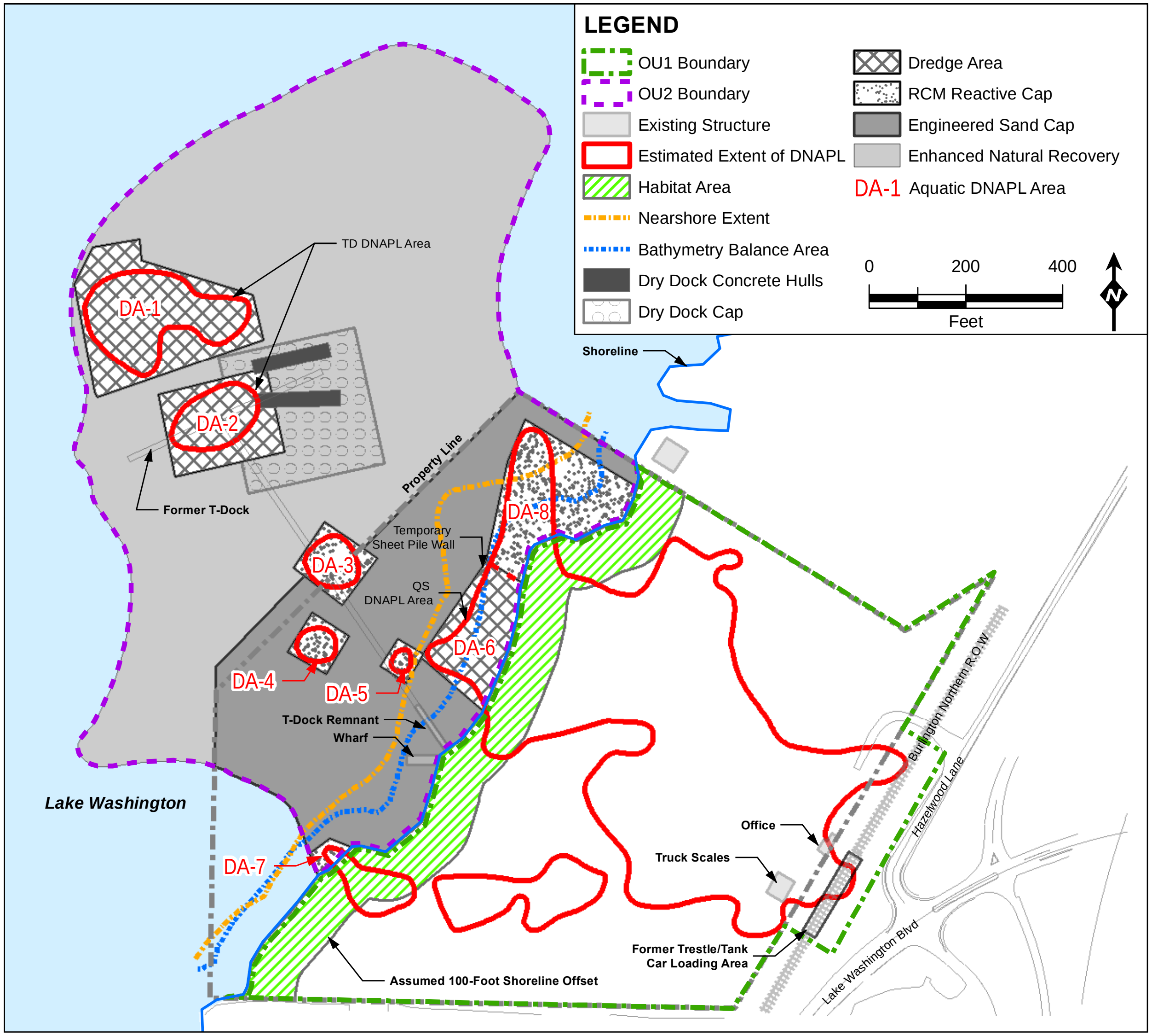


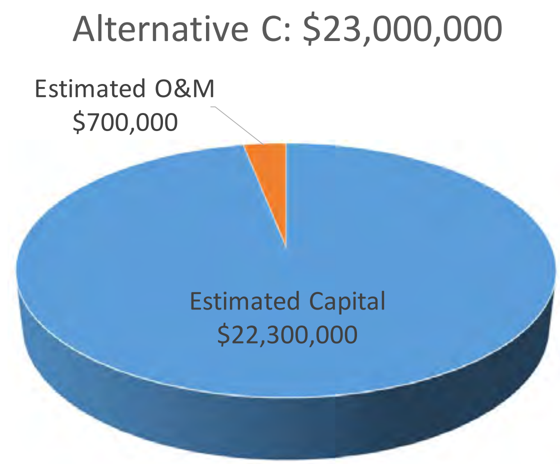
Figure 9-7
Alternative B – Targeted DNAPL Removal (TD DNAPL Area), Amended Sand Cap, RCM Cap, Engineered Sand Cap, and ENR
Record of Decision for the
Quendall Terminals Superfund Site
Renton, Washington

EPA



DNAPL Technology	% DNAPL Addressed by Technology (by vol.)
Capping	56%
Dredging	44%

Acronyms:
DA = dredge area
DNAPL = dense nonaqueous phase liquid
ENR = enhanced natural recovery
O&M = operations and maintenance
TD = T-Dock
QP-S = Quendall Pond Sediment



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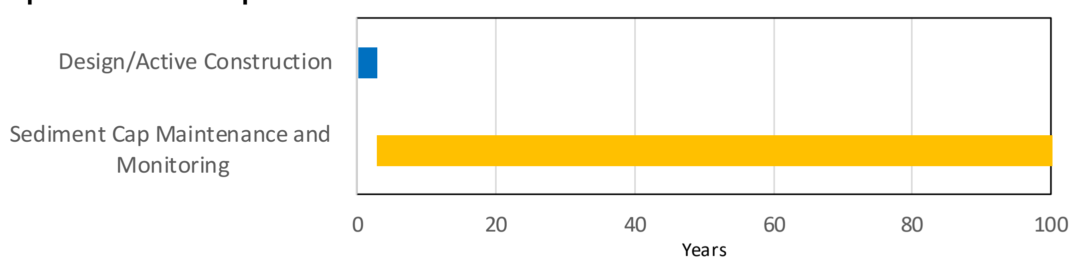

Figure 9-8
Alternative C – Targeted DNAPL Removal (TD and QP-S DNAPL Areas), RCM Cap, Engineered Sand Cap, and ENR
Record of Decision for the Quendall Terminals Superfund Site
Renton, Washington

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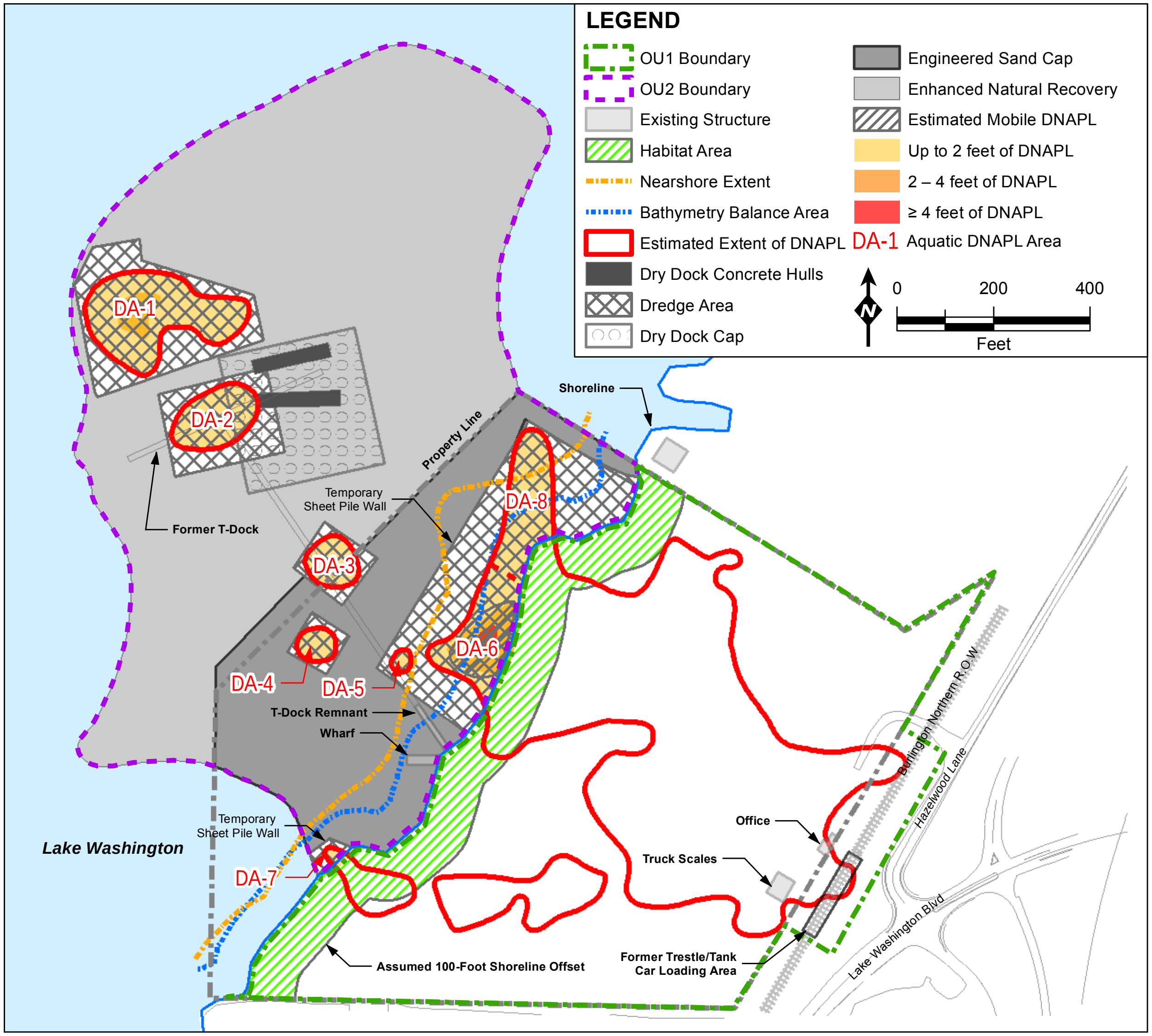
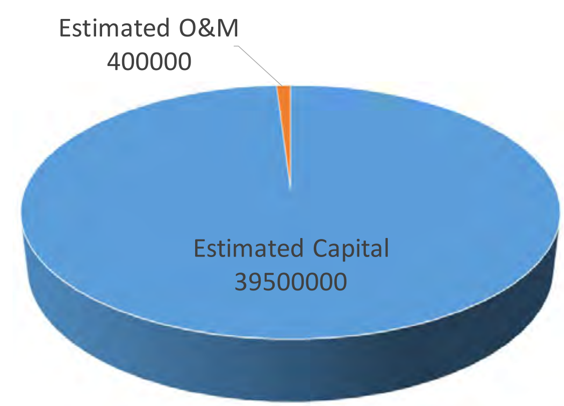


DNAPL Technology	% DNAPL Addressed by Technology (by vol.)
Capping	0%
Dredging	100%

Acronyms:
DA = dredge area
DNAPL = dense nonaqueous phase liquid
ENR = enhanced natural recovery
O&M = operations and maintenance

Alternative D: $39,900,000



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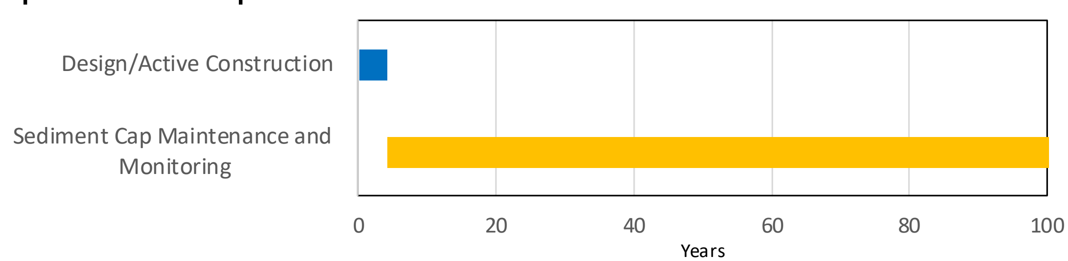

Figure 9-9
Alternative D – DNAPL Removal, Engineered Sand Cap, and ENR
Record of Decision for the
Quendall Terminals Superfund Site
Renton, Washington

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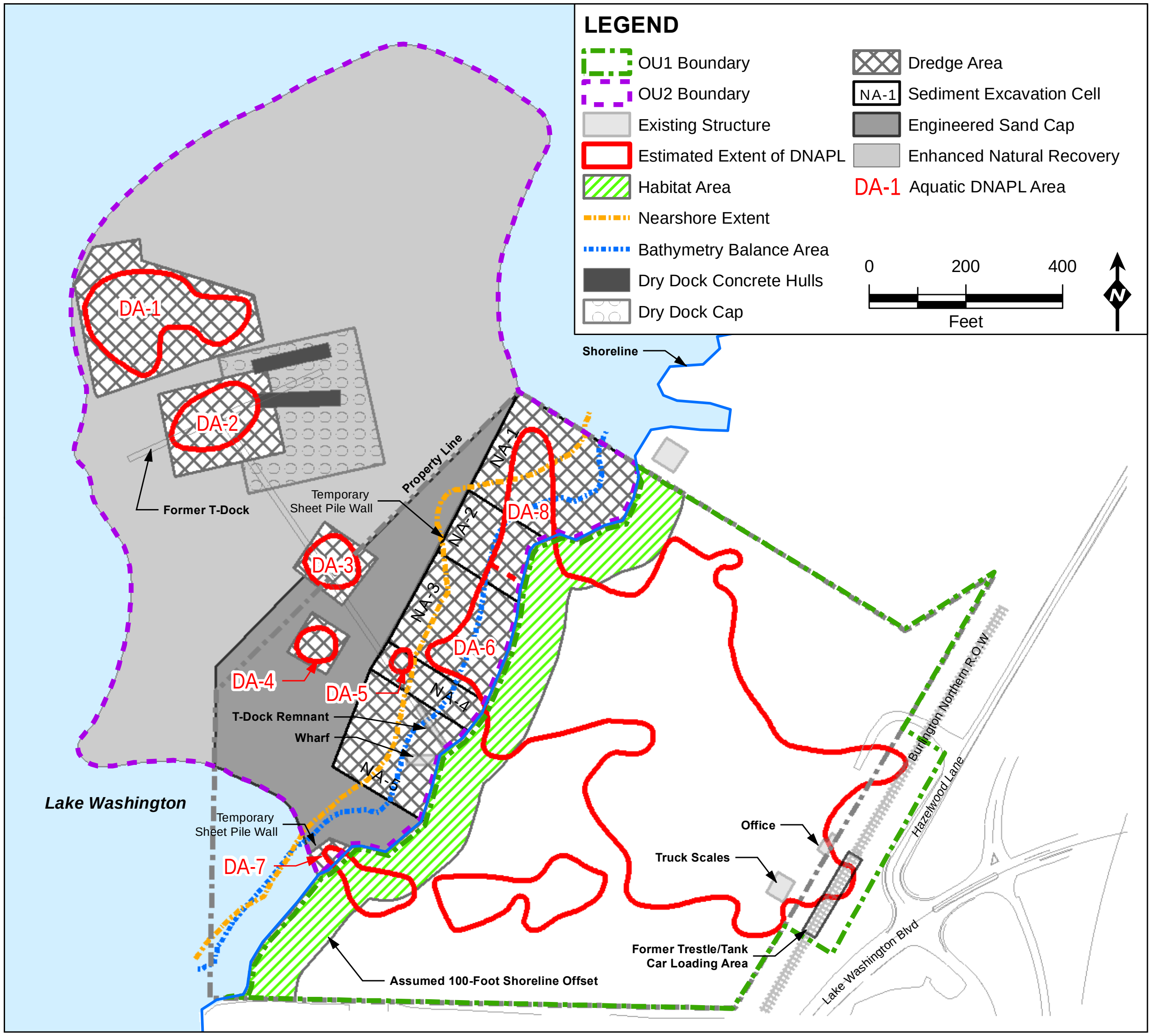
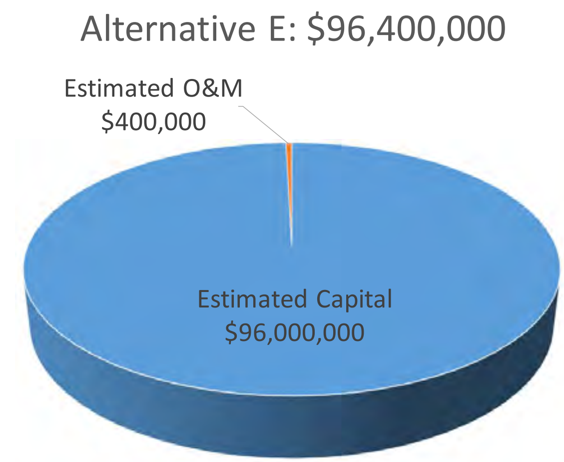


DNAPL Technology	% DNAPL Addressed by Technology (by vol.)
Capping	0%
Dredging	100%

Acronyms:
DA = dredge area
DNAPL = dense nonaqueous phase liquid
ENR = enhanced natural recovery
O&M = operations and maintenance



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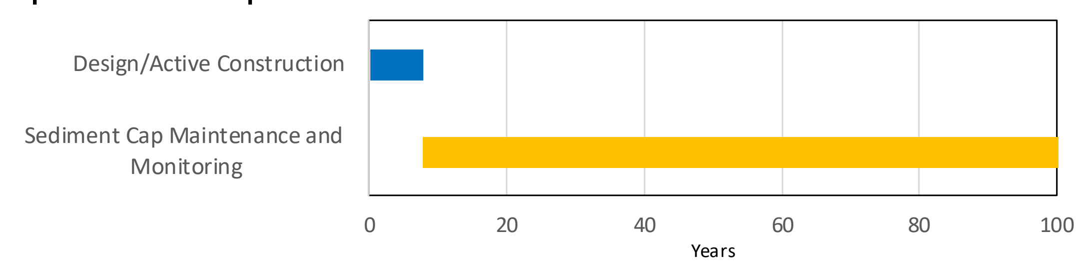
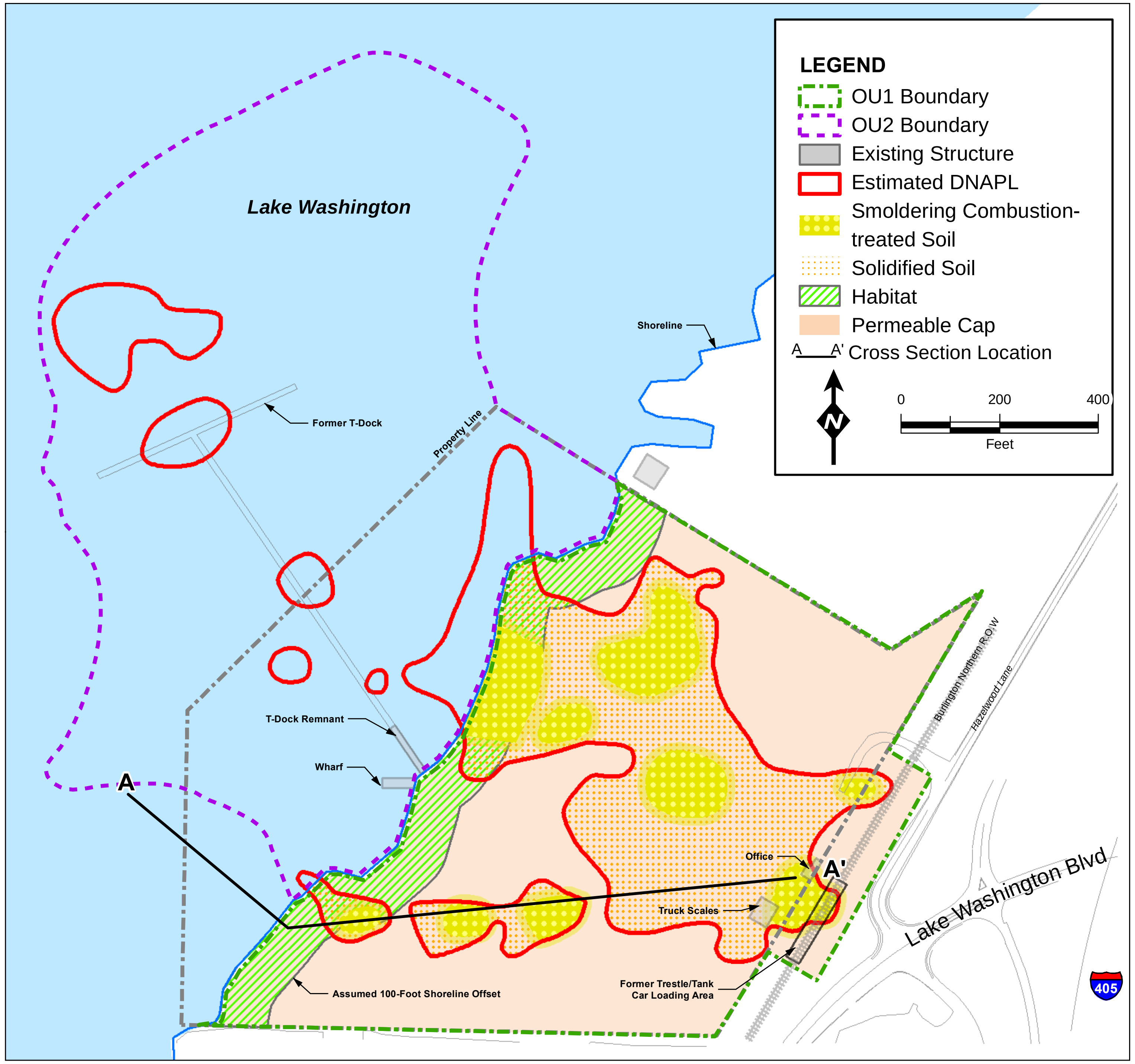
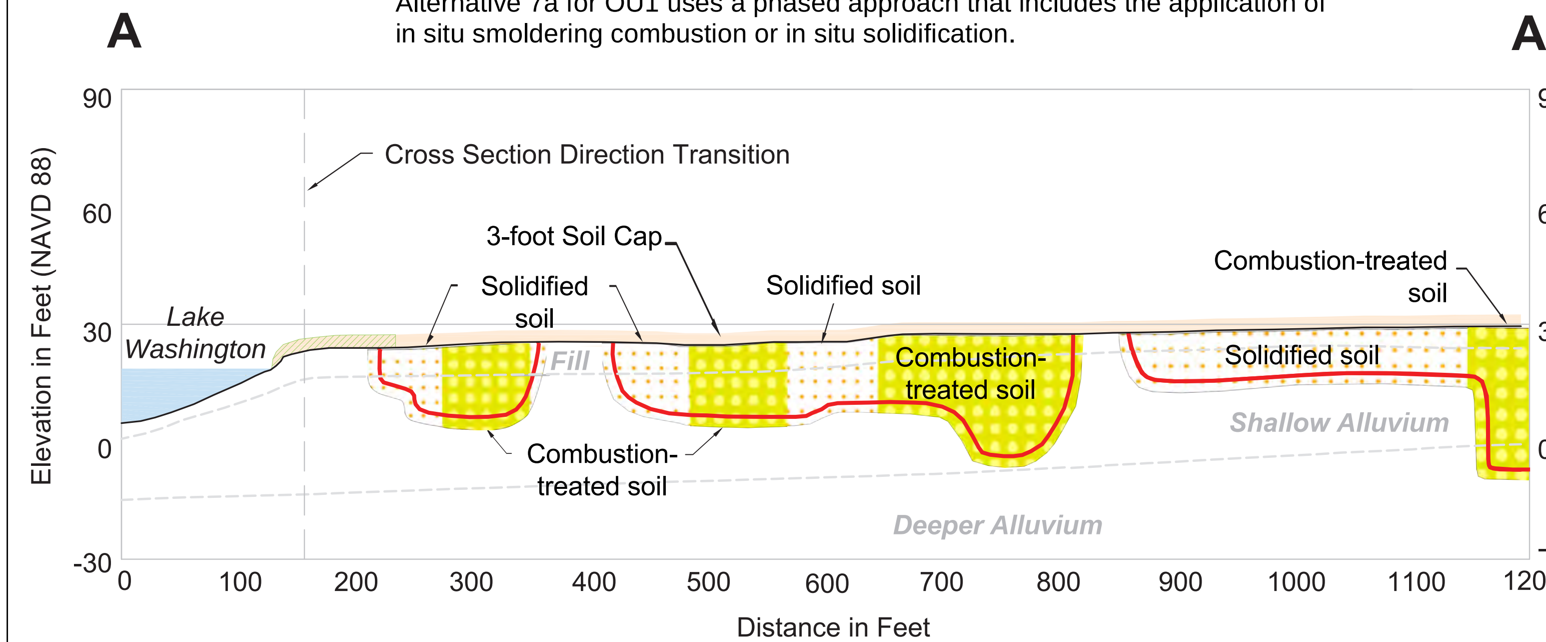


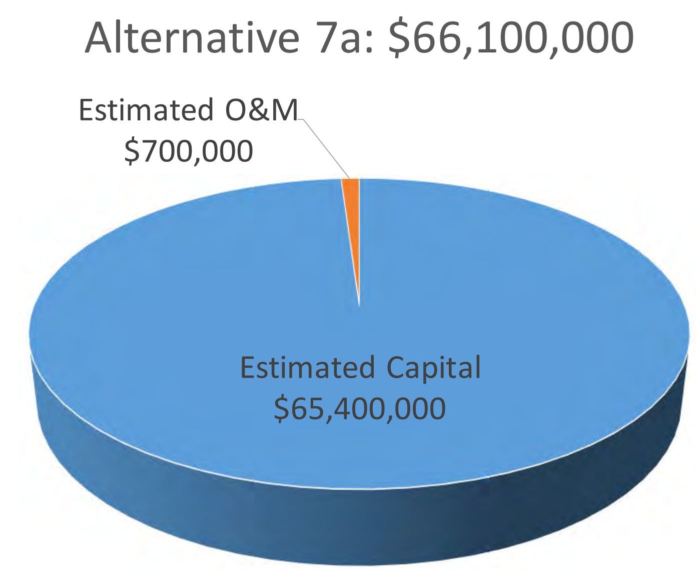
Figure 9-10
Alternative E – DNAPL and Contaminated Sediment Removal/Onsite Thermal Treatment, Engineered Sand Cap, and ENR
Record of Decision for the Quendall Terminals Superfund Site Renton, Washington



Alternative 7a for OU1 uses a phased approach that includes the application of in situ smoldering combustion or in situ solidification.



Note: A three-foot soil cap will be placed over areas of the site where soil cleanup levels are exceeded.



DNAPL Remedial Technology*	% DNAPL Addressed by Technology* (by vol.)
Smoldering Combustion	56%
Solidification	44%

Note:
*For FS-level cost-estimating, smoldering combustion is assumed to treat approx. 56% of DNAPL-impacted soil. Although the total area (acres) treated by smoldering combustion is shown as less than the area estimated for possible ISS, areas targeted for smoldering combustion contain greater thicknesses of DNAPL than the areas shown for ISS.

Acronyms:
DNAPL = dense nonaqueous phase liquid
NAVD 88 = North American Vertical Datum 1988
O&M = operations and maintenance
OU = operable unit

Implementation Sequence

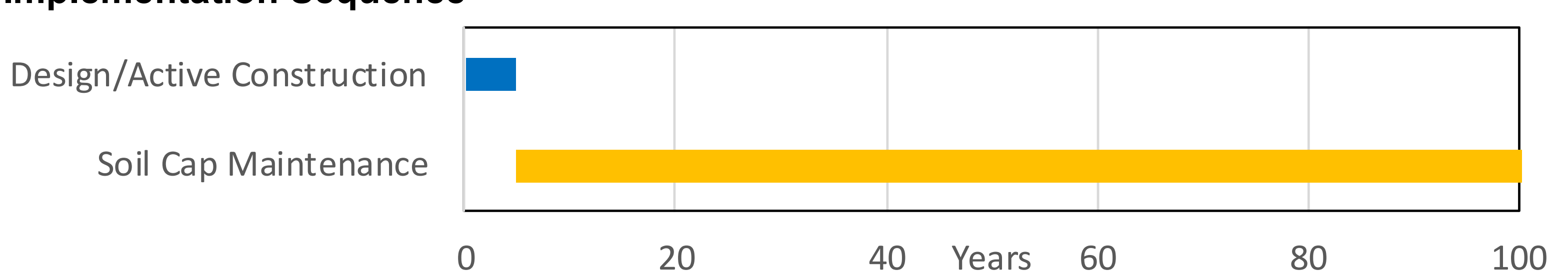
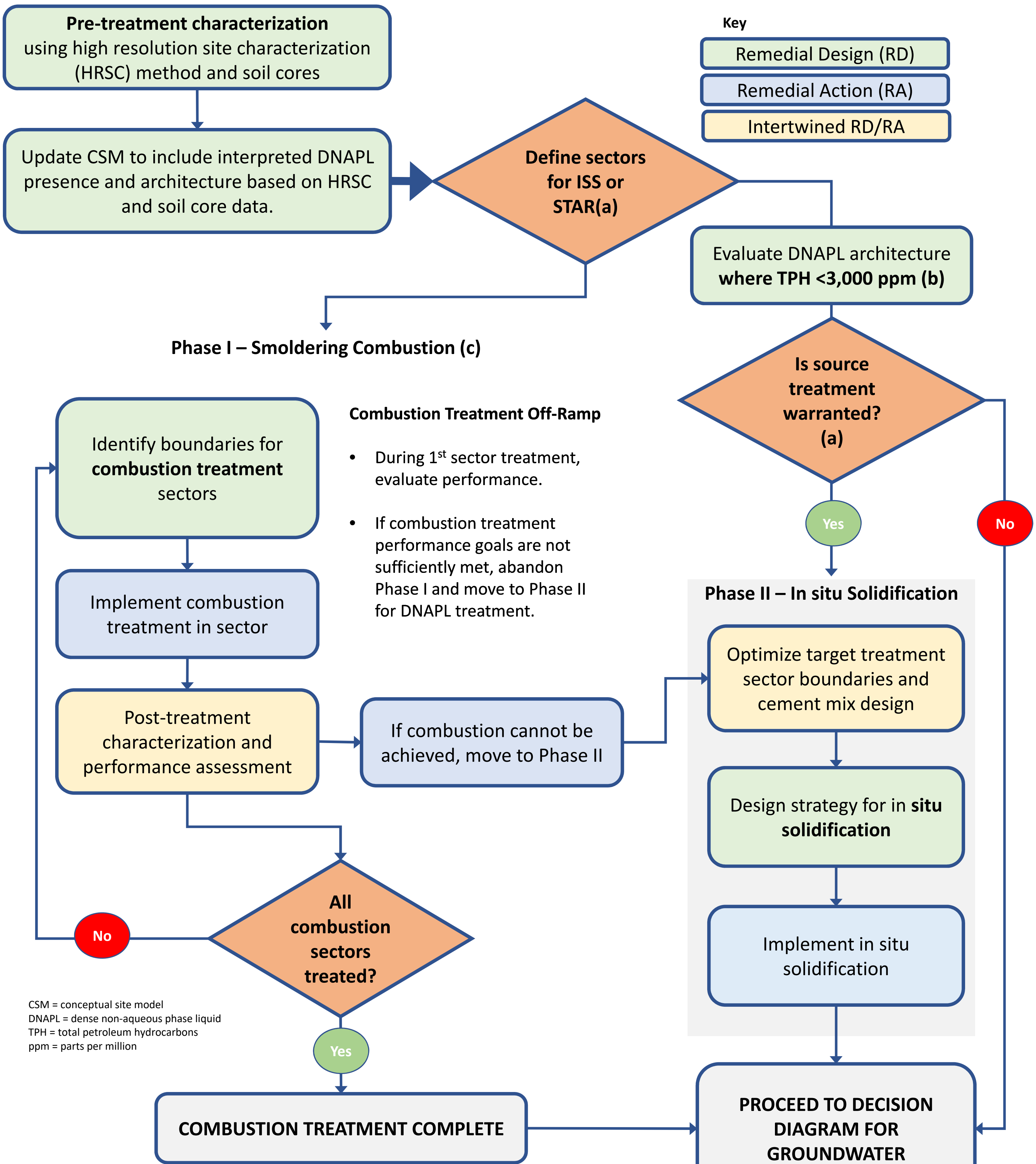


Figure 12-1
OU1 Selected Remedy – In Situ Smoldering Combustion or In Situ Solidification of DNAPL and Soil Capping
Record of Decision for the
Quendall Terminals Superfund Site
Renton, Washington



NOTES

(a) For determining areas for treatment, data evaluation will take into account the aggregate NAPL thickness at each location, the areal extent of NAPL occurrence, and the magnitude of the HRSC measured value, as they pertain to the associated remedial technology design considerations.

(b) Outside of sectors defined for combustion treatment.

(c) See next diagram.

Figure 12-2
Source Treatment Implementation through Intertwined RD/RA
Record of Decision for the Quendall Terminals Superfund Site
Renton, Washington

EPA

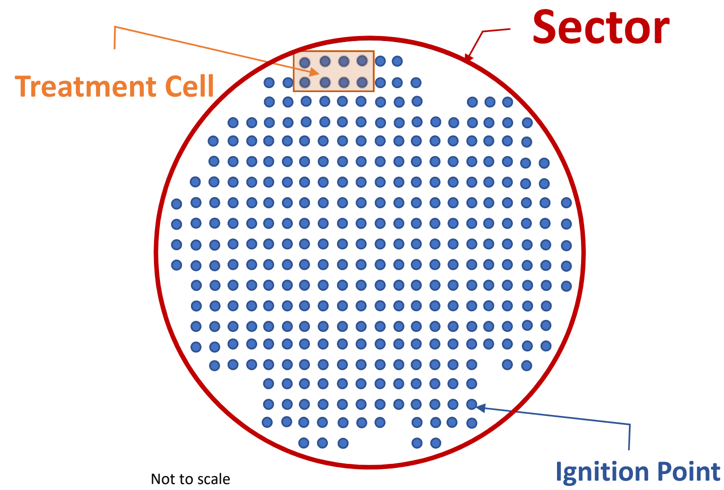
DEFINITIONS

Ignition Point: Location of down-hole heater placement and compressed air injection

Cell: Group of ~8 injection points treated at the same time

Sector: Area of treatment (~200 foot radius) that is operated on from a modular centralized location, able to treat ~100 cells.

Schematic of a Combustion Treatment Sector



**Implementation details to be refined during remedial design*

CELL BY CELL TREATMENT WITHIN EACH SECTOR

TREATMENT CELL PREPARATION

1. Set ~8 ignition points (see notes)
2. Depth intervals determined by characterization/soil cores, soil TPH concentrations > 3,000 ppm

COMBUSTION TREATMENT

1. Install heaters and initiate combustion
2. Monitor, capture, and treat soil vapors

POST-TREATMENT CHARACTERIZATION

Re-sample at least 3 representative intervals (e.g., 2 with highest pre-treatment TPH soil concentrations, 1 between IPs) – to be determined during RD.

COMBUSTION TARGET INTERVAL CRITERION

Evaluate whether TPH remains above 3,000 ppm

Have all target intervals been treated?

Yes → Move to next cell

No → **IGNITION POINT OPTIMIZATION**

1. Identify locations and intervals for potential re-treatment.
2. Optimize IPs for re-treatment. This may be more efficient after several cells or the entire sector have been treated.
3. Repeat for each cell until sector treatment is complete.

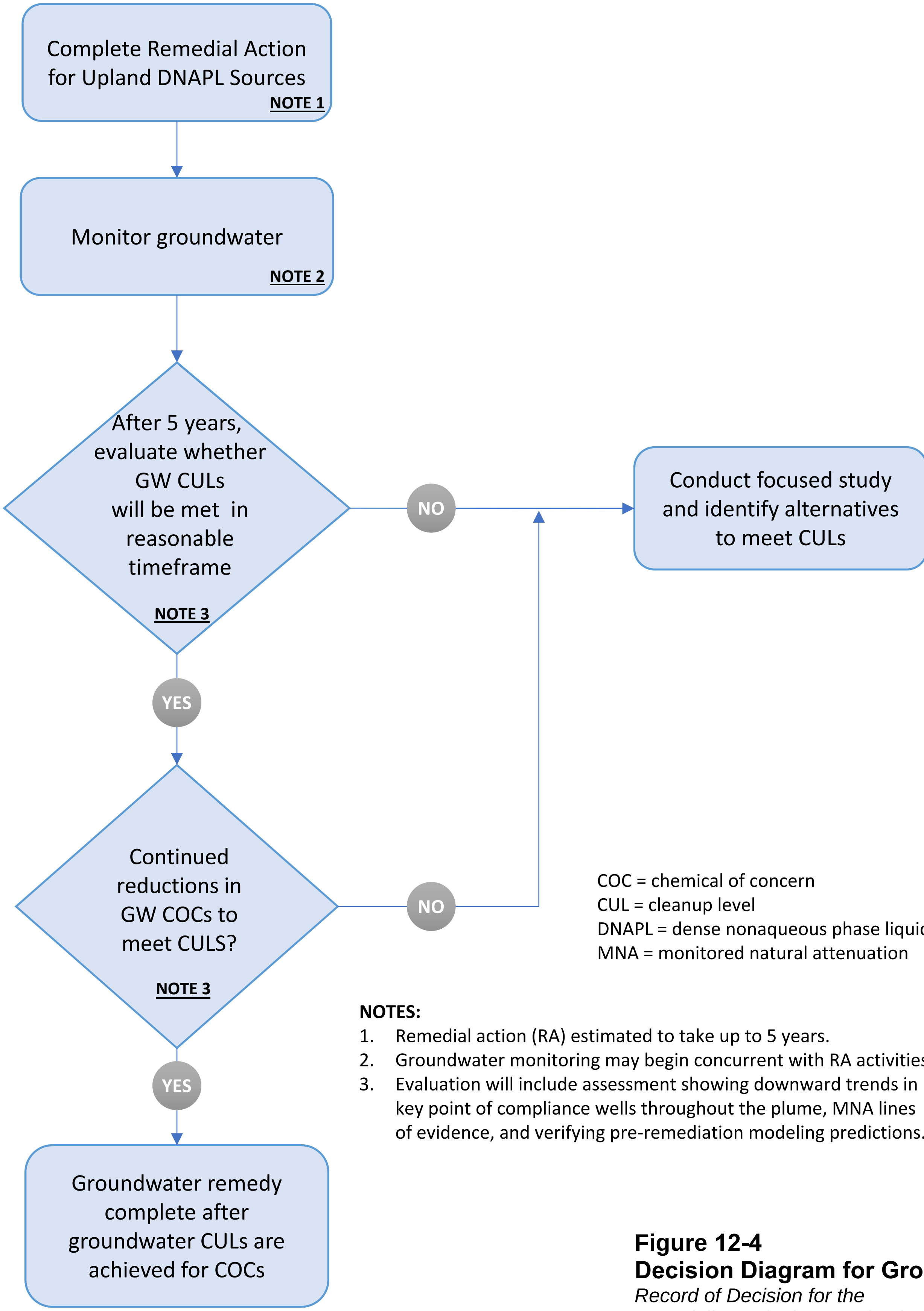
Key

- Remedial Design (RD)
- Remedial Action (RA)
- Intertwined RD/RA

Notes:

- Ignition point (IP) spacing at 14 feet is estimated based on the results of a field pilot study conducted in July 2018.
- IPs would be installed at the base of each target treatment interval using high resolution characterization and/or soil core TPH data.
- Multiple IPs may be required if the target treatment interval is more than 7 feet thick or if two or more treatment zones are stratigraphically separated by low permeability materials thicker than 2.5 feet (based on pilot study results).

Figure 12-3
Combustion Treatment by Sector and Cell
Record of Decision for the
Quendall Terminals Superfund Site
Renton, Washington

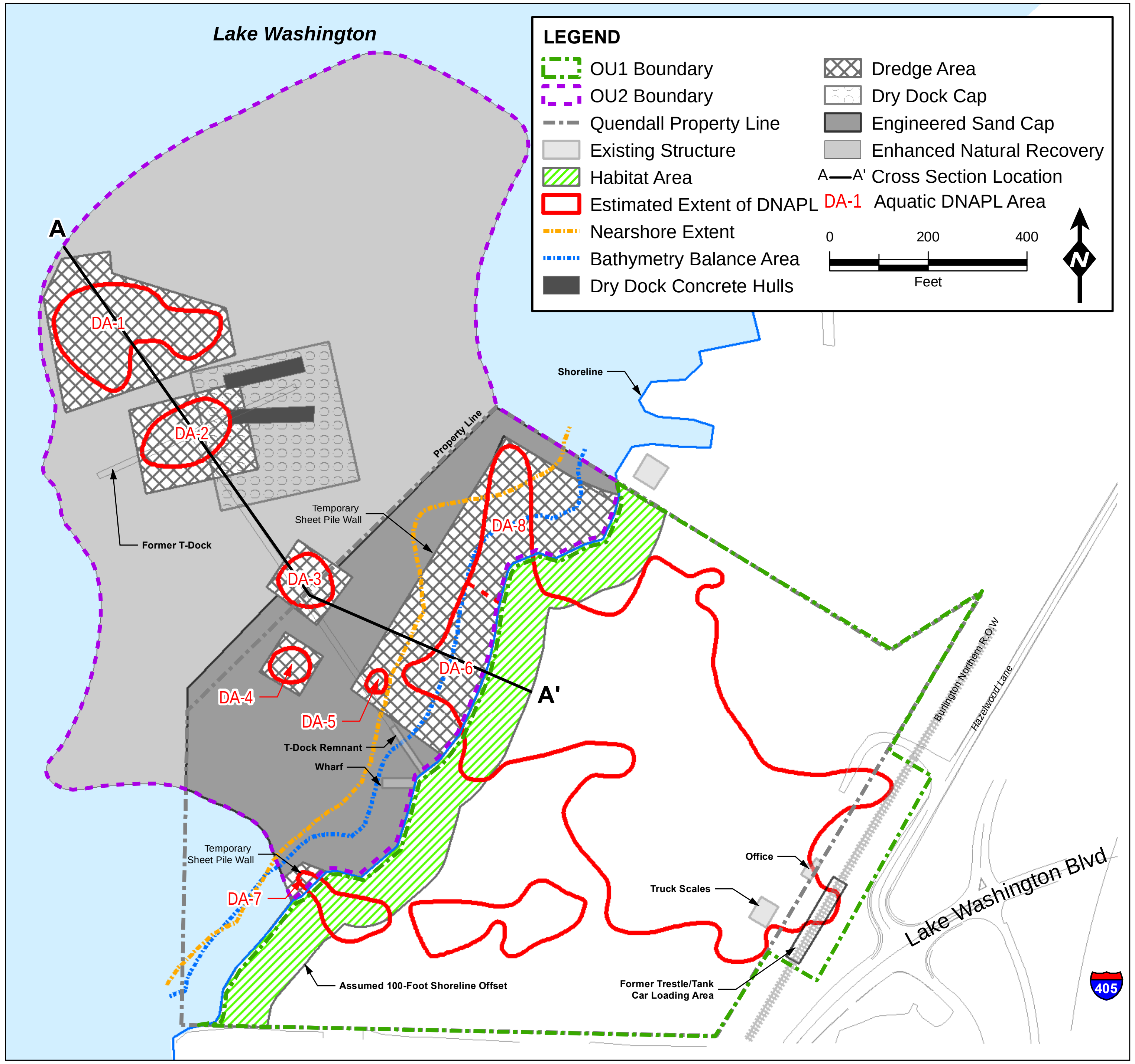


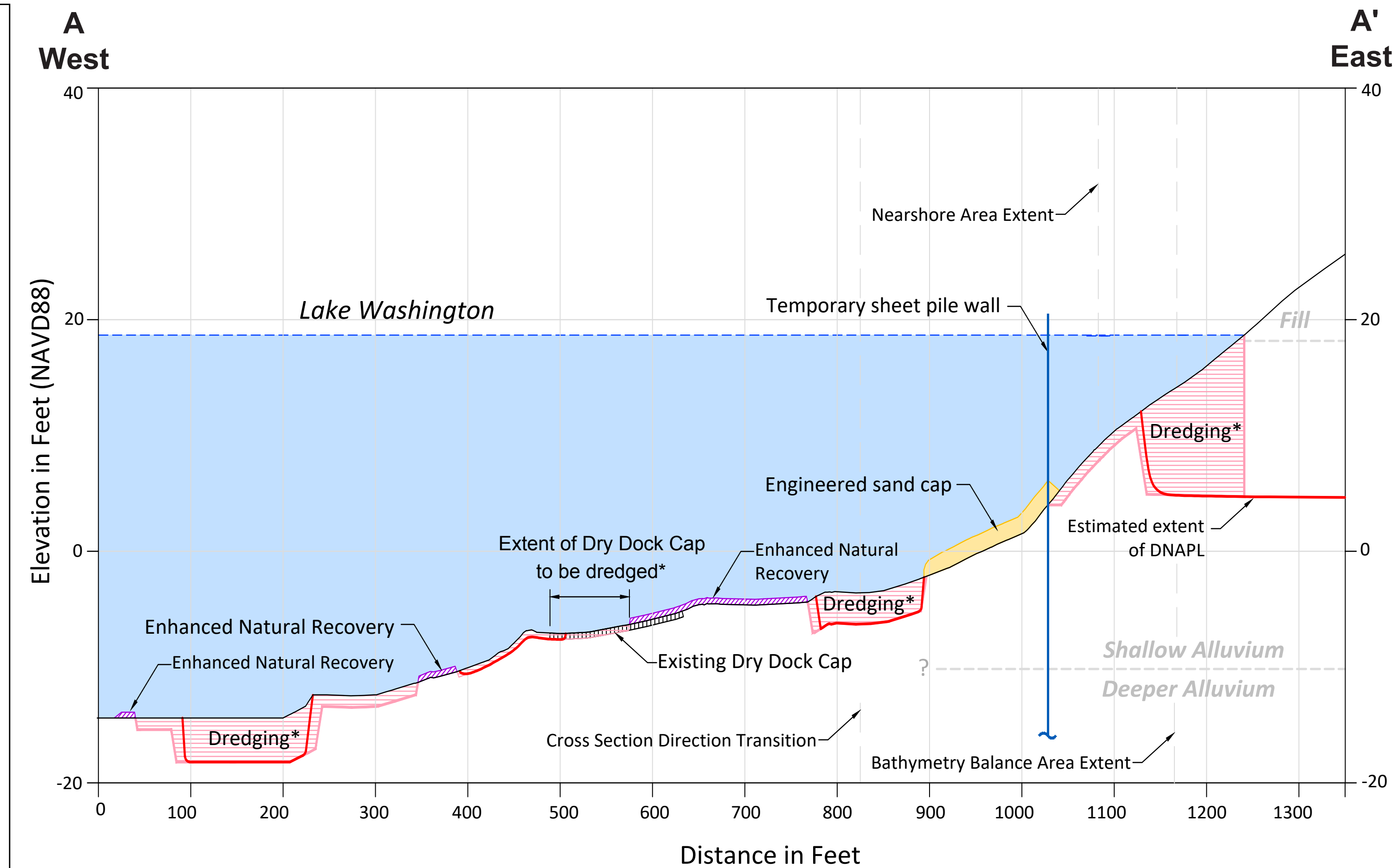
COC = chemical of concern
CUL = cleanup level
DNAPL = dense nonaqueous phase liquid
MNA = monitored natural attenuation

NOTES:

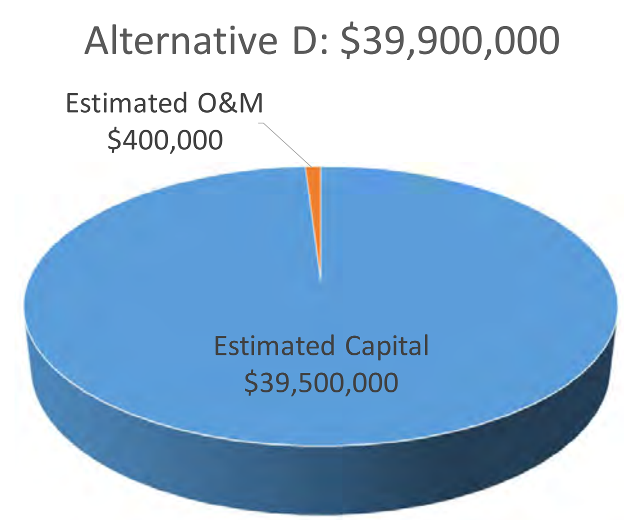
1. Remedial action (RA) estimated to take up to 5 years.
2. Groundwater monitoring may begin concurrent with RA activities.
3. Evaluation will include assessment showing downward trends in key point of compliance wells throughout the plume, MNA lines of evidence, and verifying pre-remediation modeling predictions.

Figure 12-4
Decision Diagram for Groundwater
Record of Decision for the
Quendall Terminals Superfund Site
Renton, Washington



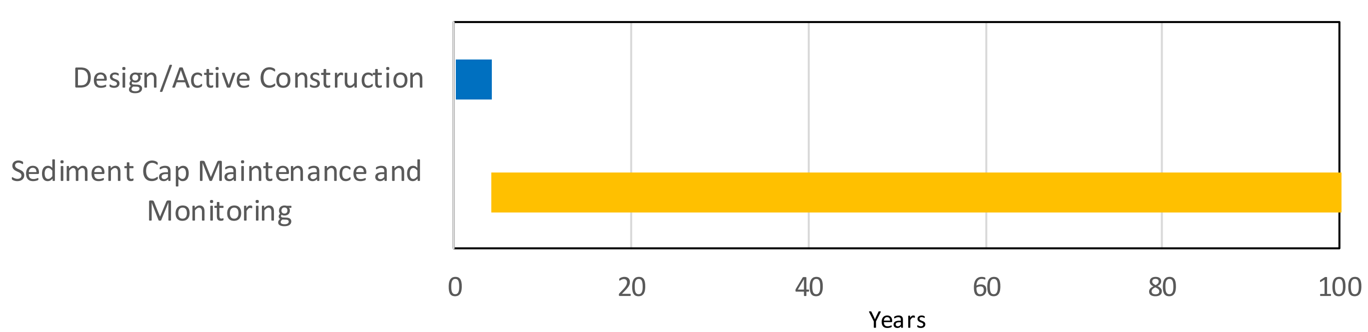


*Following dredging, a reactive residuals cover composed of a 6-inch layer of 10 percent organoclay and 90 percent coarse sand by weight will be placed in the dredged areas to address anticipated DNAPL and sediment residuals. Areas within 75 feet of the shoreline (defined as the bathymetry balance area) will then be backfilled with sand to the pre-dredge grade, while offshore areas will be backfilled to the grade determined by further evaluation during design.



DNAPL Technology	% DNAPL Addressed by Technology (by vol.)
Capping	0%
Dredging	100%

Implementation Sequence



Acronyms:
DA = dredge area
DNAPL = dense nonaqueous phase liquid
ENR = enhanced natural recovery
O&M = operations and maintenance

Figure 12-5
OU2 Selected Remedy – DNAPL Removal, Engineered Sand Cap, and ENR
Record of Decision for the
Quendall Terminals Superfund Site
Renton, Washington

Appendix 2A
Relevant Tables from Quendall Terminals Baseline Human Health and Ecological Risk Assessment

Relevant Tables from the Quendall Terminals Baseline Human Health and Ecological Risk Assessment

Table 7.1-3
Summary Statistics and Exposure Point Concentrations for COPCs Included in the Baseline Human Health Risk Assessment

Media	COPC	Units	Number of Samples	Number of Detects	Percent Detected	Minimum Value	Maximum Value	Mean	Median	95% UCL	EPC	EPC Basis
Soil	2-Methylnaphthalene	mg/kg	83	54	65%	0.025	5,200	175.5	3.3	533.1	533.1	97.5% KM (Chebyshev) UCL
Soil	Arsenic	mg/kg	61	33	54%	1.5	110	13.45	7.5	12.26	12.26	95% KM (t) UCL
Soil	Benzene	mg/kg	39	7	18%	0.038	4.4	0.916	0.35	0.4	0.4	95% KM (t) UCL
Soil	Benzo(a)anthracene	mg/kg	83	67	81%	0.012	1,500	81.08	4.9	220.3	220.3	97.5% KM (Chebyshev) UCL
Soil	Benzo(a)pyrene	mg/kg	83	65	78%	0.02	2,100	113.6	5.2	299.6	299.6	97.5% KM (Chebyshev) UCL
Soil	Benzo(b)fluoranthene	mg/kg	83	65	78%	0.018	1,700	87.53	4.9	229.7	229.7	97.5% KM (Chebyshev) UCL
Soil	Benzo(g,h,i)perylene	mg/kg	83	64	77%	0.015	1,500	66.97	2.3	196.8	196.8	97.5% KM (Chebyshev) UCL
Soil	Benzo(k)fluoranthene	mg/kg	83	65	78%	0.019	1,400	66.42	3.8	178.3	178.3	97.5% KM (Chebyshev) UCL
Soil	Chromium	mg/kg	8	8	100%	18.3	65.3	37.58	29.7	49.66	49.66	95% Student's-t UCL
Soil	Chrysene	mg/kg	83	68	82%	0.019	2,500	125.4	7	343	343	97.5% KM (Chebyshev) UCL
Soil	Dibenz(a,h)anthracene	mg/kg	83	44	53%	0.041	190	17.41	1.35	32.16	32.16	97.5% KM (Chebyshev) UCL
Soil	Dibenzofuran	mg/kg	82	46	56%	0.011	1,200	40.64	1.95	115.3	115.3	97.5% KM (Chebyshev) UCL
Soil	Ethylbenzene	mg/kg	39	12	31%	0.11	92	10.36	1.7	18.49	18.49	97.5% KM (Chebyshev) UCL
Soil	Fluoranthene	mg/kg	83	68	82%	0.027	4,400	201.5	7.75	588	588	97.5% KM (Chebyshev) UCL
Soil	Fluorene	mg/kg	83	59	71%	0.016	2,500	81.3	2.7	251.4	251.4	97.5% KM (Chebyshev) UCL
Soil	Indeno(1,2,3-c,d)pyrene	mg/kg	83	61	73%	0.014	1,500	59.83	2.5	173.5	173.5	97.5% KM (Chebyshev) UCL
Soil	Lead	mg/kg	52	38	73%	3	1,120	129.8	18.5	327.1	327.1	97.5% KM (Chebyshev) UCL
Soil	Naphthalene	mg/kg	98	73	74%	0.0029	11,000	285.2	2	984.5	984.5	97.5% KM (Chebyshev) UCL
Soil	Phenanthrene	mg/kg	83	73	88%	0.012	7,800	289	6.1	930.7	930.7	97.5% KM (Chebyshev) UCL
Soil	Pyrene	mg/kg	83	70	84%	0.042	5,200	284	12.5	818.4	818.4	97.5% KM (Chebyshev) UCL
Groundwater	2,4-Dimethylphenol	ug/L	30	5	17%	3.4	9,500	--	--	--	SS	--
Groundwater	2-Methylnaphthalene*	ug/L	30	27	90%	0.054	17,000	--	--	--	SS	--
Groundwater	2-Methylphenol (o-Cresol)	ug/L	30	3	10%	7.9	2,000	--	--	--	SS	--
Groundwater	4-Methylphenol (p-Cresol)	ug/L	30	5	17%	1.2	7,800	--	--	--	SS	--
Groundwater	Acenaphthene*	ug/L	30	23	77%	0.19	10,000	--	--	--	SS	--
Groundwater	Anthracene*	ug/L	30	11	37%	0.041	3,600	--	--	--	SS	--
Groundwater	Arsenic	ug/L	30	24	80%	0.7	389	--	--	--	SS	--
Groundwater	Benzene*	ug/L	30	16	53%	0.4	31,000	--	--	--	SS	--
Groundwater	Benzo(a)anthracene	ug/L	30	7	23%	0.018	3,100	--	--	--	SS	--
Groundwater	Benzo(a)pyrene	ug/L	30	5	17%	0.24	2,000	--	--	--	SS	--
Groundwater	Benzo(b)fluoranthene	ug/L	30	6	20%	0.01	1,900	--	--	--	SS	--
Groundwater	Benzo(k)fluoranthene	ug/L	30	6	20%	0.01	1,400	--	--	--	SS	--
Groundwater	Bis(2-ethylhexyl) phthalate	ug/L	30	7	23%	1	8	--	--	--	SS	--
Groundwater	Chloroform*	ug/L	30	1	3%	0.3	0.3	--	--	--	SS	--
Groundwater	Chrysene	ug/L	30	8	27%	0.025	2,200	--	--	--	SS	--
Groundwater	Dibenz(a,h)anthracene	ug/L	30	4	13%	0.13	200	--	--	--	SS	--
Groundwater	Dibenzofuran*	ug/L	30	17	57%	0.2	3,800	--	--	--	SS	--
Groundwater	Ethylbenzene*	ug/L	30	16	53%	14	2,900	--	--	--	SS	--
Groundwater	Fluoranthene	ug/L	30	13	43%	0.077	10,000	--	--	--	SS	--
Groundwater	Fluorene*	ug/L	30	20	67%	0.15	7,300	--	--	--	SS	--
Groundwater	Indeno(1,2,3-c,d)pyrene	ug/L	30	5	17%	0.45	760	--	--	--	SS	--
Groundwater	Naphthalene*	ug/L	30	29	97%	0.14	45,000	--	--	--	SS	--
Groundwater	Phenanthrene	ug/L	30	20	67%	0.15	23,000	--	--	--	SS	--
Groundwater	Pyrene*	ug/L	30	14	47%	0.065	11,000	--	--	--	SS	--
Groundwater	Styrene*	ug/L	30	3	10%	1.6	4,400	--	--	--	SS	--
Groundwater	Toluene*	ug/L	30	15	50%	0.6	19,000	--	--	--	SS	--
Groundwater	Total Xylenes*	ug/L	30	16	53%	8.5	10,600	--	--	--	SS	--
Sediment (Nearshore)	2-Methylnaphthalene	mg/kg	4	3	75%	0.0071	1.5	0.709	0.62	N/A	1.5	Max. Detect
Sediment (Nearshore)	Acenaphthene	mg/kg	6	4	67%	0.038	2.8	0.754	0.0895	1.447	1.447	95% KM (BCA) UCL
Sediment (Nearshore)	Acenaphthylene	mg/kg	6	5	83%	0.01	0.51	0.116	0.016	0.935	0.51	Max. Detect

Table 7.1-3
Summary Statistics and Exposure Point Concentrations for COPCs Included in the Baseline Human Health Risk Assessment

Media	COPC	Units	Number of Samples	Number of Detects	Percent Detected	Minimum Value	Maximum Value	Mean	Median	95% UCL	EPC	EPC Basis
Sediment (Nearshore)	Anthracene	mg/kg	6	5	83%	0.012	3.9	0.912	0.17	3.569	3.569	95% KM (Chebyshev) UCL
Sediment (Nearshore)	Benzo(a)anthracene	mg/kg	6	6	100%	0.022	8.2	1.524	0.245	14.82	8.2	Max. Detect
Sediment (Nearshore)	Benzo(a)pyrene	mg/kg	6	6	100%	0.021	16	3.19	0.8	38.1	16	Max. Detect
Sediment (Nearshore)	Benzo(g,h,i)perylene	mg/kg	6	6	100%	0.0093	6.7	1.527	0.62	7.69	6.7	Max. Detect
Sediment (Nearshore)	Chromium	mg/kg	5	5	100%	39	44	41.2	40	43.27	44	Max. Detect
Sediment (Nearshore)	Chrysene	mg/kg	6	6	100%	0.028	19	3.651	0.625	47.9	19	Max. Detect
Sediment (Nearshore)	Copper	mg/kg	5	5	100%	24.2	46.4	39.66	42	48.27	46.4	Max. Detect
Sediment (Nearshore)	Dibenz(a,h)anthracene	mg/kg	6	5	83%	0.12	2.5	0.672	0.25	3.034	2.5	Max. Detect
Sediment (Nearshore)	Fluoranthene	mg/kg	6	6	100%	0.024	38	6.583	0.29	129.6	38	Max. Detect
Sediment (Nearshore)	Fluorene	mg/kg	6	4	67%	0.038	3.4	0.902	0.084	6.459	3.4	Max. Detect
Sediment (Nearshore)	Indeno(1,2,3-c,d)pyrene	mg/kg	6	6	100%	0.0093	6.2	1.332	0.445	14.09	6.2	Max. Detect
Sediment (Nearshore)	Naphthalene	mg/kg	6	4	67%	0.066	12	3.709	1.385	6.068	6.068	95% KM (Percentile Bootstrap) UCL
Sediment (Nearshore)	Phenanthrene	mg/kg	6	6	100%	0.008	47	7.974	0.2	85.64	47	Max. Detect
Sediment (Nearshore)	Pyrene	mg/kg	6	6	100%	0.02	38	6.559	0.31	69.13	38	Max. Detect
Sediment (Nearshore)	Total 10 of 16 HPAH (U = 1/2)	mg/kg	6	6	100%	0.188	170.6	31.8	5.445	447.7	170.6	Max. Detect
Sediment (Nearshore)	Total 16 PAH (U = 1/2)	mg/kg	6	6	100%	0.212	231	44	6.526	628.3	230.8	Max. Detect
Sediment (Nearshore)	Total 6 of 16 LPAH (U = 1/2)	mg/kg	6	6	100%	0.0245	60	12	0.906	223	60	Max. Detect
Sediment (Site-Wide)	2-Methylnaphthalene	mg/kg	13	7	54%	0.0071	150	21.9	0.62	130.7	130.7	99% KM (Chebyshev) UCL
Sediment (Site-Wide)	4-Methylphenol (p-Cresol)	mg/kg	19	8	42%	0.017	0.068	0.0319	0.028	0.0298	0.0298	95% KM (t) UCL
Sediment (Site-Wide)	Acenaphthene	mg/kg	42	31	74%	0.0067	190	12.09	0.066	61.96	61.96	99% KM (Chebyshev) UCL
Sediment (Site-Wide)	Acenaphthylene	mg/kg	42	34	81%	0.0093	3	0.217	0.0345	0.55	0.55	95% KM (Chebyshev) UCL
Sediment (Site-Wide)	Anthracene	mg/kg	42	38	90%	0.012	240	9.198	0.22	66.93	66.93	99% KM (Chebyshev) UCL
Sediment (Site-Wide)	Benzo(a)anthracene	mg/kg	42	41	98%	0.022	260	13.06	0.58	57.7	57.7	97.5% KM (Chebyshev) UCL
Sediment (Site-Wide)	Benzo(a)pyrene	mg/kg	42	41	98%	0.021	140	9.911	1	37.14	37.14	97.5% KM (Chebyshev) UCL
Sediment (Site-Wide)	Benzo(g,h,i)perylene	mg/kg	42	42	100%	0.0093	33	2.875	0.64	7.14	7.14	95% Chebyshev (Mean, Sd) UCL
Sediment (Site-Wide)	Chromium	mg/kg	5	5	100%	39	44	41.2	40	43.27	44	Max. Detect
Sediment (Site-Wide)	Chrysene	mg/kg	42	42	100%	0.028	340	15.4	1.05	53.8	53.8	95% Chebyshev (Mean, Sd) UCL
Sediment (Site-Wide)	Copper	mg/kg	5	5	100%	24.2	46.4	39.66	42	48.27	46.4	Max. Detect
Sediment (Site-Wide)	Dibenz(a,h)anthracene	mg/kg	42	38	90%	0.024	17	1.299	0.24	3.315	3.315	95% KM (Chebyshev) UCL
Sediment (Site-Wide)	Dibenzofuran	mg/kg	8	3	38%	0.035	0.43	0.168	0.038	0.43	0.43	95% KM (BCA) UCL
Sediment (Site-Wide)	Fluoranthene	mg/kg	42	41	98%	0.024	670	36.07	0.61	245.5	245.5	99% KM (Chebyshev) UCL
Sediment (Site-Wide)	Fluorene	mg/kg	42	32	76%	0.0077	160	10.1	0.066	54.05	54.05	99% KM (Chebyshev) UCL
Sediment (Site-Wide)	Indeno(1,2,3-c,d)pyrene	mg/kg	42	42	100%	0.0093	34	2.747	0.59	7.107	7.107	95% Chebyshev (Mean, Sd) UCL
Sediment (Site-Wide)	Naphthalene	mg/kg	42	30	71%	0.0075	150	5.706	0.0545	39.79	39.79	99% KM (Chebyshev) UCL
Sediment (Site-Wide)	Phenanthrene	mg/kg	42	41	98%	0.008	720	34.55	0.26	237.3	237.3	99% KM (Chebyshev) UCL
Sediment (Site-Wide)	Pyrene	mg/kg	42	41	98%	0.02	440	25.06	0.64	162.8	162.8	99% KM (Chebyshev) UCL
Sediment (Site-Wide)	Total 10 of 16 HPAHs (U = 1/2)	mg/kg	42	42	100%	0.188	2,004	122.9	6.365	395.6	395.6	95% Chebyshev (Mean, Sd) UCL
Sediment (Site-Wide)	Total 16 PAHs (U = 1/2)	mg/kg	42	42	100%	0.212	2,948	185.9	7.916	611.8	611.8	95% Chebyshev (Mean, Sd) UCL
Sediment (Site-Wide)	Total 6 of 16 LPAHs (U = 1/2)	mg/kg	42	41	98%	0.0245	1,134	64.46	0.693	417.8	417.8	99% KM (Chebyshev) UCL
OC-Normalized Site Sediment	2-Methylnaphthalene	mg/kg	13	7	54%	0.179	2459	362.4	10.28	574.9	574.9	95% KM (BCA) UCL
OC-Normalized Site Sediment	Acenaphthene	mg/kg	42	31	74%	0.067	4,439	221.2	1.299	1,265	1,265	99% KM (Chebyshev) UCL
OC-Normalized Site Sediment	Acenaphthylene	mg/kg	42	34	81%	0.067	49.18	3.588	0.662	8.668	8.668	95% KM (Chebyshev) UCL
OC-Normalized Site Sediment	Anthracene	mg/kg	42	38	90%	0.306	2,553	128.7	3.264	810	810	99% KM (Chebyshev) UCL
OC-Normalized Site Sediment	Benzo(a)anthracene	mg/kg	42	41	98%	1.292	3,505	208.3	10.53	873.9	873.9	97.5% KM (Chebyshev) UCL
OC-Normalized Site Sediment	Benzo(a)pyrene	mg/kg	42	41	98%	1.866	2,295	168.2	16.88	601.5	601.5	97.5% KM (Chebyshev) UCL
OC-Normalized Site Sediment	Benzo(g,h,i)perylene	mg/kg	42	42	100%	0.917	420.6	51.79	10.96	116.7	116.7	95% Chebyshev (Mean, Sd) UCL
OC-Normalized Site Sediment	Chrysene	mg/kg	42	42	100%	2.057	3617	230.8	17.6	708.8	708.8	95% Chebyshev (Mean, Sd) UCL
OC-Normalized Site Sediment	Dibenz(a,h)anthracene	mg/kg	42	38	90%	0.246	200.9	22.62	4.833	65.49	65.49	97.5% KM (Chebyshev) UCL
OC-Normalized Site Sediment	Dibenzofuran	mg/kg	8	3	38%	0.339	4.019	1.624	0.515	2.015	2.015	95% KM (t) UCL
OC-Normalized Site Sediment	Fluoranthene	mg/kg	42	41	98%	1.531	15,654	639.9	11.11	4,593	4,593	99% KM (Chebyshev) UCL

Table 7.1-3
Summary Statistics and Exposure Point Concentrations for COPCs Included in the Baseline Human Health Risk Assessment

Media	COPC	Units	Number of Samples	Number of Detects	Percent Detected	Minimum Value	Maximum Value	Mean	Median	95% UCL	EPC	EPC Basis
OC-Normalized Site Sediment	Fluorene	mg/kg	42	32	76%	0.0622	3,738	181.9	1.293	1,072	1,072	99% KM (Chebyshev) UCL
OC-Normalized Site Sediment	Indeno(1,2,3-c,d)pyrene	mg/kg	42	42	100%	0.876	443.9	48.07	10.22	113.9	113.9	95% Chebyshev (Mean, Sd) UCL
OC-Normalized Site Sediment	Naphthalene	mg/kg	42	30	71%	0.067	2,459	104.3	0.848	667.3	667.3	99% KM (Chebyshev) UCL
OC-Normalized Site Sediment	Phenanthrene	mg/kg	42	41	98%	0.718	16,822	639	5.283	4,773	4,773	99% KM (Chebyshev) UCL
OC-Normalized Site Sediment	Pyrene	mg/kg	42	41	98%	1.483	10,280	447.8	11.2	3,054	3,054	99% KM (Chebyshev) UCL
OC-Normalized Site Sediment	OC Total 10 of 16 HPAHs (U = 1/	mg/kg	42	42	100%	15.18	37,397	2,096	126.2	6,674	6,674	95% Chebyshev (Mean, Sd) UCL
OC-Normalized Site Sediment	OC Total 16 PAHs (U = 1/2)	mg/kg	42	42	100%	16.46	63,881	3,217	137	10,736	10,736	95% Chebyshev (Mean, Sd) UCL
OC-Normalized Site Sediment	OC Total 6 of 16 LPAHs (U = 1/2)	mg/kg	42	41	98%	1.287	26,484	1,147	11.1	7,904	7,904	99% KM (Chebyshev) UCL
Sediment (Background)	Acenaphthene	mg/kg	10	5	50%	0.0054	0.0061	0.00582	0.0059	0.00579	0.00579	95% KM (t) UCL
Sediment (Background)	Acenaphthylene	mg/kg	10	1	10%	0.0067	0.0067	0.0067	0.0067	NA	0.0067	Max. Detect
Sediment (Background)	Anthracene	mg/kg	10	9	90%	0.0055	0.025	0.0142	0.013	0.0168	0.0168	95% KM (Percentile Bootstrap) UCL
Sediment (Background)	Arsenic	mg/kg	5	3	60%	9	20	13	10	16.44	20	Max. Detect
Sediment (Background)	Benzo(a)anthracene	mg/kg	10	10	100%	0.017	0.13	0.0672	0.056	0.0909	0.0909	95% Student's-t UCL
Sediment (Background)	Benzo(a)pyrene	mg/kg	10	10	100%	0.026	0.18	0.0891	0.075	0.118	0.118	95% Student's-t UCL
Sediment (Background)	Benzo(g,h,i)perylene	mg/kg	10	10	100%	0.025	0.12	0.0578	0.0585	0.0748	0.0748	95% Student's-t UCL
Sediment (Background)	Chromium	mg/kg	5	5	100%	21	48	39	44	49.77	48	Max. Detect
Sediment (Background)	Chrysene	mg/kg	10	10	100%	0.033	0.23	0.113	0.0985	0.152	0.152	95% Student's-t UCL
Sediment (Background)	Copper	mg/kg	5	5	100%	12	52.6	28.74	25.5	44.65	52.6	Max. Detect
Sediment (Background)	Dibenz(a,h)anthracene	mg/kg	10	10	100%	0.006	0.041	0.0182	0.0175	0.0244	0.0244	95% Student's-t UCL
Sediment (Background)	Fluoranthene	mg/kg	10	10	100%	0.051	0.34	0.121	0.095	0.178	0.178	95% Approximate Gamma UCL
Sediment (Background)	Fluorene	mg/kg	10	6	60%	0.0052	0.0084	0.00685	0.0066	0.00696	0.00696	95% KM (t) UCL
Sediment (Background)	Indeno(1,2,3-c,d)pyrene	mg/kg	10	10	100%	0.024	0.11	0.053	0.0495	0.0691	0.0691	95% Student's-t UCL
Sediment (Background)	Naphthalene	mg/kg	10	7	70%	0.0049	0.012	0.00723	0.0056	0.00796	0.00796	95% KM (Percentile Bootstrap) UCL
Sediment (Background)	Phenanthrene	mg/kg	10	10	100%	0.019	0.12	0.0509	0.0485	0.0706	0.0706	95% Approximate Gamma UCL
Sediment (Background)	Pyrene	mg/kg	10	10	100%	0.047	0.32	0.117	0.093	0.171	0.171	95% Approximate Gamma UCL
Sediment (Background)	Total 10 of 16 HPAHs (U = 1/2)	mg/kg	10	10	100%	0.301	1.718	0.84	0.694	1.103	1.103	95% Student's-t UCL
Sediment (Background)	Total 16 PAHs (U = 1/2)	mg/kg	10	10	100%	0.332	1.875	0.922	0.774	1.204	1.204	95% Student's-t UCL
Sediment (Background)	Total 6 of 16 LPAHs (U = 1/2)	mg/kg	10	10	100%	0.0308	0.157	0.0817	0.0793	0.103	0.103	95% Student's-t UCL
OC-Normalized Background Sediment	Acenaphthene	mg/kg	10	5	50%	0.149	0.324	0.22	0.219	0.221	0.221	95% KM (t) UCL
OC-Normalized Background Sediment	Acenaphthylene	mg/kg	10	1	10%	0.17	0.17	0.17	0.17	NA	0.17	Max. Detect
OC-Normalized Background Sediment	Anthracene	mg/kg	10	9	90%	0.206	1.02	0.519	0.456	0.645	0.645	95% KM (Percentile Bootstrap) UCL
OC-Normalized Background Sediment	Benzo(a)anthracene	mg/kg	10	10	100%	0.769	7.027	2.45	1.794	3.725	3.725	95% Approximate Gamma UCL
OC-Normalized Background Sediment	Benzo(a)pyrene	mg/kg	10	10	100%	1.176	9.73	3.328	2.755	4.955	4.955	95% Approximate Gamma UCL
OC-Normalized Background Sediment	Benzo(g,h,i)perylene	mg/kg	10	10	100%	0.906	4.324	2.11	2.037	2.759	2.759	95% Student's-t UCL
OC-Normalized Background Sediment	Chrysene	mg/kg	10	10	100%	1.493	11.35	4.114	3.275	6.123	6.123	95% Approximate Gamma UCL
OC-Normalized Background Sediment	Dibenz(a,h)anthracene	mg/kg	10	10	100%	0.217	1.405	0.658	0.643	0.887	0.887	95% Student's-t UCL
OC-Normalized Background Sediment	Fluoranthene	mg/kg	10	10	100%	1.91	18.38	4.737	3.374	11.48	11.48	95% Chebyshev (Mean, Sd) UCL
OC-Normalized Background Sediment	Fluorene	mg/kg	10	6	60%	0.135	0.449	0.245	0.228	0.267	0.267	95% KM (t) UCL
OC-Normalized Background Sediment	Indeno(1,2,3-c,d)pyrene	mg/kg	10	10	100%	0.906	4.432	1.945	1.815	2.597	2.597	95% Student's-t UCL
OC-Normalized Background Sediment	Naphthalene	mg/kg	10	7	70%	0.173	0.304	0.231	0.216	0.246	0.246	95% KM (t) UCL
OC-Normalized Background Sediment	Phenanthrene	mg/kg	10	10	100%	0.86	6.486	1.954	1.629	4.213	4.213	95% Chebyshev (Mean, Sd) UCL
OC-Normalized Background Sediment	Pyrene	mg/kg	10	10	100%	1.873	17.3	4.556	3.027	10.84	10.84	95% Chebyshev (Mean, Sd) UCL
OC-Normalized Background Sediment	OC Total 10 of 16 HPAHs (U = 1/	mg/kg	10	10	100%	13.63	92.86	31.35	26.31	45.56	45.56	95% Approximate Gamma UCL
OC-Normalized Background Sediment	OC Total 16 PAHs (U = 1/2)	mg/kg	10	10	100%	15.02	101.4	34.41	29.19	49.82	49.82	95% Approximate Gamma UCL
OC-Normalized Background Sediment	OC Total 6 of 16 LPAHs (U = 1/2)	mg/kg	10	10	100%	1.391	8.492	3.062	2.741	4.311	4.311	95% Approximate Gamma UCL
Surface Water	Arsenic	ug/L	6	2	33%	1	1	1	1	NA	1	Max. Detect
Surface Water	Benzene	ug/L	6	3	50%	16	68	33.33	16	44.19	68	Max. Detect
Surface Water	Benzo(a)anthracene	ug/L	6	1	17%	0.064	0.064	0.064	0.064	NA	0.064	Max. Detect
Surface Water	Benzo(a)pyrene	ug/L	6	4	67%	0.016	0.17	0.057	0.021	0.21	0.17	Max. Detect
Surface Water	Benzo(b)fluoranthene	ug/L	6	4	67%	0.02	0.25	0.0803	0.0255	0.31	0.25	Max. Detect

Table 7.1-3
Summary Statistics and Exposure Point Concentrations for COPCs Included in the Baseline Human Health Risk Assessment

Media	COPC	Units	Number of Samples	Number of Detects	Percent Detected	Minimum Value	Maximum Value	Mean	Median	95% UCL	EPC	EPC Basis
Surface Water	Benzo(k)fluoranthene	ug/L	6	3	50%	0.011	0.089	0.0373	0.012	0.089	0.089	Max. Detect
Surface Water	Chrysene	ug/L	6	1	17%	0.12	0.12	0.12	0.12	NA	0.12	Max. Detect
Surface Water	Dibenz(a,h)anthracene	ug/L	6	1	17%	0.092	0.092	0.092	0.092	NA	0.092	Max. Detect
Surface Water	Indeno(1,2,3-c,d)pyrene	ug/L	6	3	50%	0.026	0.15	0.0703	0.035	0.108	0.15	Max. Detect
Surface Water	Total Xylenes	ug/L	6	3	50%	3	12.9	9.233	11.8	10.57	12.9	Max. Detect
Surface Water	Naphthalene	ug/L	6	1	17%	2.2	2.2	2.2	2.2	NA	2.2	Max. Detect

Notes:

* - indicates the analyte is a volatile organic compound.

BSAF - biota-sediment accumulation factor
COPC - chemical of potential concern
EPC - exposure point concentration
HPAHs - high-molecular-weight polynuclear aromatic hydrocarbons
KM (BCA) - UCL based on Kaplan-Meier estimates using bias-corrected accelerated bootstrap method
KM (Chebyshev) - UCL based on Kaplan-Meier estimates using the Chebychev inequality
KM (percentile bootstrap) - UCL based on Kaplan-Meier estimates using the percentile bootstrap method
KM (t) - UCL based on Kaplan-Meier estimates using the Student's t-distribution cutoff value
LPAHs - low-molecular-weight polynuclear aromatic hydrocarbons
Max. Detect - UCL based on the maximum detected value
mg/kg - milligram(s) per kilogram
NA - not available
OC - organic carbon
PAHs - polynuclear aromatic hydrocarbons
sd - standard deviation
SS - sample-specific; groundwater statistics are based on maximum detected values from 30 wells sampled during the RI field investigation (2008 and 2009) and the Port of Seattle sampling at the Railroad Property.
UCL - upper confidence limit
ug/L - microgram(s) per liter

Table 7.1-4
Estimated Exposure Point Concentrations for Fish and Shellfish Tissue

	Literature-Based BSAFs			Sitewide Sediment Exposure Area					Background Sediment Exposure Area				
Chemical	Mollusk BSAF[a]	Freshwater Crustacean BSAF[a]	Bottom-feeding Fish BSAF[a]	Sediment EPC (mg/kg)	Mollusk Tissue EPC (mg/kg)	Freshwater Crustacean Tissue EPC (mg/kg)	Bottom-feeding Fish Tissue EPC (mg/kg)	Final Fish/Shellfish Tissue EPC (mg/kg)	Sediment EPC (mg/kg)	Mollusk Tissue EPC (mg/kg)	Freshwater Crustacean Tissue EPC (mg/kg)	Bottom-feeding Fish Tissue EPC (mg/kg)	Final Fish/Shellfish Tissue EPC (mg/kg)
2-Methylnaphthalene	5.52E-01	NV	9.58E-02	5.75E+02	4.31E+00	NV	2.11E+00	3.21E+00			NV	NV	NV
Acenaphthene	1.52E-01	4.42E-02	3.82E-02	1.27E+03	2.61E+00	2.77E+00	1.86E+00	2.41E+00	2.21E-01	4.56E-04	4.84E-04	3.24E-04	4.22E-04
Acenaphthylene	2.33E-01	3.75E-02	1.92E-02	8.67E+00	2.74E-02	1.61E-02	6.39E-03	1.66E-02	1.70E-01	5.38E-04	3.16E-04	1.25E-04	3.26E-04
Anthracene	2.09E-01	3.87E-02	1.05E-02	8.10E+02	2.30E+00	1.55E+00	3.27E-01	1.39E+00	6.45E-01	1.83E-03	1.24E-03	2.60E-04	1.11E-03
Arsenic	NV	NV	NV		NV	NV	NV	NV		NV	NV	NV	NV
Benzo(a)anthracene	1.92E-01	1.15E-02	2.24E-03	8.74E+02	2.28E+00	4.97E-01	7.52E-02	9.50E-01	3.73E+00	9.71E-03	2.12E-03	3.20E-04	4.05E-03
Benzo(a)pyrene	4.12E-02	8.44E-03	2.56E-03	6.02E+02	3.37E-01	2.52E-01	5.91E-02	2.16E-01	4.96E+00	2.77E-03	2.07E-03	4.87E-04	1.78E-03
Benzo(g,h,i)perylene	5.80E-02	1.55E-02	4.04E-03	1.17E+02	9.19E-02	8.99E-02	1.81E-02	6.66E-02	2.76E+00	2.17E-03	2.12E-03	4.28E-04	1.58E-03
Chrysene	2.09E-01	7.13E-03	2.57E-03	7.09E+02	2.01E+00	2.50E-01	7.00E-02	7.77E-01	6.12E+00	1.74E-02	2.16E-03	6.04E-04	6.72E-03
Copper	NV	NV	NV		NV	NV	NV	NV		NV	NV	NV	NV
Dibenz(a,h)anthracene	1.68E-01	NV	3.84E-03	6.55E+01	1.49E-01	NV	9.66E-03	7.95E-02	8.87E-01	2.02E-03	NV	1.31E-04	1.08E-03
Dibenzofuran	NV	NV	3.59E-02	2.02E+00	NV	NV	2.78E-03	2.78E-03		NV	NV	NV	NV
Fluoranthene	4.53E-01	8.88E-02	3.48E-03	4.59E+03	2.83E+01	2.02E+01	6.14E-01	1.64E+01	1.15E+01	7.06E-02	5.05E-02	1.53E-03	4.09E-02
Fluorene	3.57E-01	5.47E-02	2.61E-02	1.07E+03	5.20E+00	2.91E+00	1.07E+00	3.06E+00	2.67E-01	1.29E-03	7.24E-04	2.68E-04	7.62E-04
Indeno(1,2,3-c,d)pyrene	7.43E-02	NV	2.71E-03	1.14E+02	1.15E-01	NV	1.19E-02	6.34E-02	2.60E+00	2.62E-03	NV	2.70E-04	1.45E-03
Naphthalene	4.67E-01	5.19E-02	1.11E-01	6.67E+02	4.23E+00	1.72E+00	2.84E+00	2.93E+00	2.46E-01	1.56E-03	6.33E-04	1.05E-03	1.08E-03
Phenanthrene	2.29E-01	2.39E-02	8.50E-03	4.77E+03	1.48E+01	5.66E+00	1.56E+00	7.35E+00	4.21E+00	1.31E-02	4.99E-03	1.38E-03	6.49E-03
Pyrene	2.03E-01	8.88E-03	2.29E-03	3.05E+03	8.42E+00	1.34E+00	2.69E-01	3.34E+00	1.08E+01	2.99E-02	4.77E-03	9.53E-04	1.19E-02

Notes:

[a] Details on the identification of appropriate BSAFs are provided in Appendix J-5.

Lipid values used for tissue EPC calculations are listed below and summarized in Appendix J-5.

Species Guild	Lipid	Lipid Fraction
Freshwater Mollusk	1.358	0.01358
Freshwater Crustacean	4.956	0.04956
Bottom-Feeding Fish	3.84	0.0384

Lipid data are taken from:
http://el.erdc.usace.army.mil/bsafnew/LipidOrgMean.dbw

BSAF - biota-sediment accumulation factor
EPC - exposure point concentration
mg/kg - milligrams per kilogram
NV - No BSAF or sediment chemistry value

Table 7.1-7
Summary of Risk and Hazard Estimates for the Residential Exposure Scenario

Exposure Route	Noncancer Hazard Index	Excess Lifetime Cancer Risk	Primary Contributors to HI[a]	Primary Contributors to ELCR[a]
Exposure to Soil - 0 to 15 feet bgs				
Ingestion	1	2E-02	Naphthalene (HQ=7, 80%)	Benzo(a)pyrene (ELCR=2E-02, 77%)
Dermal	0.5	7E-03	2-Methylnaphthalene (HQ=0.6, 8%)	Benzo(b)fluoranthene (ELCR=2E-03, 6%)
Inhalation	6	3E-04		Benzo(a)anthracene (ELCR=1E-03, 6%)
Total Soil Routes	**8**	**3E-02**		Benzo(k)fluoranthene (ELCR=1E-03, 5%)
				Indeno(1,2,3-c,d)pyrene (ELCR=1E-03, 4%)
				Naphthalene (ELCR=3E-04, 1%)
				Chrysene (ELCR=2E-04, 0.9%)
				Dibenz(a,h)anthracene (ELCR=2E-04, 0.8%)
				Arsenic (ELCR=3E-05, 0.1%)
				Ethylbenzene (ELCR=3E-06, 0.01%)
Groundwater Use - Based on Maximum Well Risk (Q9)				
Ingestion	602	8E-01	Naphthalene (HQ=7,291, 91%)	Benzo(a)pyrene (ELCR=5E-01, 47%)
Dermal	175	5E-04	2-Methylnaphthalene (HQ=225, 3%)	Naphthalene (ELCR=3E-01, 26%)
Inhalation	7,218	3E-01	Dibenzofuran (HQ=206, 3%)	Benzo(a)anthracene (ELCR=1E-01, 9%)
Total Groundwater Routes	**7,995**	**>8E-01[b]**	Arsenic (HQ=197, 2%)	Benzo(b)fluoranthene (ELCR=6E-02, 6%)
			Benzene (HQ=41, 0.5%)	Benzo(k)fluoranthene (ELCR=5E-02, 4%)
			Pyrene (HQ=13, 0.2%)	Arsenic (ELCR=4E-02, 4%)
			Fluoranthene (HQ=9, 0.1%)	Indeno(1,2,3-c,d)pyrene (ELCR=3E-02, 2%)
			Total Xylenes (HQ=7, 0.09%)	Chrysene (ELCR=7E-03, 1%)
			Fluorene (HQ=6, 0.08%)	Dibenz(a,h)anthracene (ELCR=7E-03, 0.6%)
			Acenaphthene (HQ=6, 0.07%)	Benzene (ELCR=4E-03, 0.4%)
				Ethylbenzene (ELCR=6E-04, 0.1%)
Indoor Air - Based on Maximum Well Risk (BH-5A)				
Inhalation Route	**280**	**2E-02**	Benzene (HQ=180, 64%)	Benzene (ELCR=2E-02, 81%)
			Naphthalene (HQ=81, 29%)	Naphthalene (ELCR=4E-03, 16%)
			Total Xylenes (HQ=17, 6%)	Ethylbenzene (ELCR=7E-04, 3%)

Notes:

[a]Primary contributors to the total risk are listed when ELCR > 10^{-6} or HI > 1.
[b]Due to the very high concentrations found in this well and the inherent limitations quantifying risk at these levels, the ELCR is reported as a greater than estimate.

bgs - below ground surface
ELCR - excess lifetime cancer risk
HI - hazard index
HQ - hazard quotient

Table 7.1-8
Summary of Location-Specific Risk and Hazard Estimates for Residential Indoor Air Exposure
(Sorted from Higher to Lower Risk)

Well Location	Noncancer Hazard Index	Excess Lifetime Cancer Risk	Primary Contributors to HI[a]	Primary Contributors to ELCR[a]
Q9	7,995	>8E-01[b]	Naphthalene (HQ=7,291, 91%) 2-Methylnaphthalene (HQ=225, 3%) Dibenzofuran (HQ=206, 3%) Arsenic (HQ=197, 2%) Benzene (HQ=41, 0.5%) Pyrene (HQ=13, 0.2%) Fluoranthene (HQ=9, 0.1%) Total Xylenes (HQ=7, 0.09%) Fluorene (HQ=6, 0.08%) Acenaphthene (HQ=6, 0.07%)	Benzo(a)pyrene (ELCR=5E-01, 47%) Naphthalene (ELCR=3E-01, 26%) Benzo(a)anthracene (ELCR=1E-01, 9%) Benzo(b)fluoranthene (ELCR=6E-02, 6%) Benzo(k)fluoranthene (ELCR=5E-02, 4%) Arsenic (ELCR=4E-02, 4%) Indeno(1,2,3-cd)pyrene (ELCR=3E-02, 2%) Chrysene (ELCR=7E-03, 1%) dibenz(a,h)anthracene (ELCR=7E-03, 0.6%) Benzene (ELCR=4E-03, 0.4%) Ethylbenzene (ELCR=6E-04, 0.1%)
BH-5/5A	3,516	3E-01	Naphthalene (HQ=2,592, 74%) Benzene (HQ=787, 22%) 4-Methylphenol (HQ=56, 2%) Total Xylenes (HQ=36, 1%) 2-Methylnaphthalene (HQ=29, 0.8%) 2,4-Dimethylphenol (HQ=18, 0.5%) Toluene (HQ=11, 0.3%) Dibenzofuran (HQ=10, 0.3%) Arsenic (HQ=6, 0.2%) Ethylbenzene (HQ=2, 0.1%) Styrene (HQ=2, 0.1%)	Naphthalene (ELCR=1E-01, 35%) Benzo(a)pyrene (ELCR=9E-02, 31%) Benzene (ELCR=8E-02, 25%) Benzo(b)fluoranthene (ELCR=7E-03, 2%) Benzo(k)fluoranthene (ELCR=7E-03, 2%) Benzo(a)anthracene (ELCR=6E-03, 2%) Ethylbenzene (ELCR=2E-03, 0.6%) Arsenic (ELCR=1E-03, 0.4%) Chrysene (ELCR=9E-04, 0.3%) Indeno(1,2,3-cd)pyrene (ELCR=2E-05, 0.005%) dibenz(a,h)anthracene (ELCR=4E-06, 0.001%)
RW-QP-1	2,007	1E-01	Naphthalene (HQ=1,782, 89%) Benzene (HQ=196, 10%) Total Xylenes (HQ=53, 3%) Toluene (HQ=12, 0.6%) 2-Methylnaphthalene (HQ=10, 0.5%) Styrene (HQ=3, 0.2%) Ethylbenzene (HQ=3, 0.1%) Dibenzofuran (HQ=2, 0.09%)	Naphthalene (ELCR=7E-02, 78%) Benzene (ELCR=2E-02, 20%) Ethylbenzene (ELCR=2E-03, 2%) Arsenic (ELCR=2E-05, 0.02%)
BH-20A	1,832	9E-02	Naphthalene (HQ=1,620, 88%) Benzene (HQ=201, 11%) Total xylenes (HQ=12, 0.6%) 2-Methylnaphthalene (HQ=7, 0.4%) Ethylbenzene (HQ=2, 0.1%)	Naphthalene (ELCR=7E-02, 73%) Benzene (ELCR=2E-02, 21%) Benzo(a)pyrene (ELCR=3E-03, 3%) Ethylbenzene (ELCR=2E-03, 2%) Benzo(b)fluoranthene (ELCR=3E-04, 0.3%) Benzo(k)fluoranthene (ELCR=2E-04, 0.2%) Arsenic (ELCR=2E-04, 0.2%) Indeno(1,2,3-cd)pyrene (ELCR=1E-04, 0.2%) Benzo(a)anthracene (ELCR=1E-04, 0.1%) dibenz(a,h)anthracene (ELCR=6E-05, 0.1%) Chrysene (ELCR=1E-05, 0.01%)
BH-5B	2,120	9E-02	Naphthalene (HQ=2,106, 99%) 2-Methylnaphthalene (HQ=9, 0.4%) Total Xylenes (HQ=4, 0.2%) Benzene (HQ=2, 0.1%)	Naphthalene (ELCR=9E-02, 99%) Ethylbenzene (ELCR=5E-04, 0.5%) Arsenic (ELCR=2E-04, 0.3%) Benzene (ELCR=2E-04, 0.2%)
BH-25A(R)	1,823	8E-02	Naphthalene (HQ=1,782, 98%) 2-Methylnaphthalene (HQ=13, 0.7%) Benzene (HQ=13, 0.7%) 4-Methylphenol (HQ=6, 0.3%) Dibenzofuran (HQ=6, 0.3%) Total Xylenes (HQ=4, 0.2%) Arsenic (HQ=2, 0.1%)	Naphthalene (ELCR=7E-02, 98%) Benzene (ELCR=1E-03, 2%) Arsenic (ELCR=3E-04, 0.4%) Ethylbenzene (ELCR=3E-04, 0.4%)

Table 7.1-8
Summary of Location-Specific Risk and Hazard Estimates for Residential Indoor Air Exposure
(Sorted from Higher to Lower Risk)

Well Location	Noncancer Hazard Index	Excess Lifetime Cancer Risk	Primary Contributors to HI[a]	Primary Contributors to ELCR[a]
Q4	892	7E-02	Naphthalene (HQ=859, 96%) 2-Methylnaphthalene (HQ=15, 2%) Dibenzofuran (HQ=14, 2%) Total Xylenes (HQ=3, 0.3%) Benzene (HQ=2, 0.3%)	Naphthalene (ELCR=4E-02, 55%) Benzo(a)pyrene (ELCR=2E-02, 33%) Benzo(a)anthracene (ELCR=3E-03, 5%) Benzo(b)fluoranthene (ELCR=2E-03, 3%) Benzo(k)fluoranthene (ELCR=1E-03, 2%) Ethylbenzene (ELCR=3E-04, 0.4%) Indeno(1,2,3-c,d)pyrene (ELCR=2E-04, 0.04%) Benzene (ELCR=2E-04, 0.3%) Chrysene (ELCR=2E-04, 0.3%) Arsenic (ELCR=7E-05, 0.1%)
BH-20B	757	4E-02	Naphthalene (HQ=697, 92%) Benzene (HQ=48, 6%) Arsenic (HQ=6, 0.8%) 2-Methylnaphthalene (HQ=4, 0.5%) Total Xylenes (HQ=4, 0.5%)	Naphthalene (ELCR=3E-02, 82%) Benzene (ELCR=5E-03, 13%) Arsenic (ELCR=1E-03, 3%) Ethylbenzene (ELCR=6E-04, 2%)
BH-21A	357	2E-02	Naphthalene (HQ=340, 95%) 2-Methylnaphthalene (HQ=9, 3%) Dibenzofuran (HQ=6, 2%)	Naphthalene (ELCR=1E-02, 92%) Benzo(a)anthracene (ELCR=1E-03, 7%) Arsenic (ELCR=1E-04, 0.8%) Ethylbenzene (ELCR=3E-05, 0.2%) Benzene (ELCR=9E-06, 0.1%)
BH-29A	48	9E-03	Arsenic (HQ=45, 94%) Naphthalene (HQ=3, 6%)	Arsenic (ELCR=9E-03, 97%) Naphthalene (ELCR=1E-04, 1%) Benzo(a)pyrene (ELCR=8E-05, 0.9%) Benzo(a)anthracene (ELCR=5E-06, 05%) Benzo(k)anthracene (ELCR=5E-06, 05%) bis(2-Ethylhexyl)phthalate (ELCR=2E-06, 0.02%)
BH-28B	122	6E-03	Naphthalene (HQ=113, 93%) Arsenic (HQ=4, 3%) 2-Methylnaphthalene (HQ=2, 2%) Benzene (HQ=2, 2%)	Naphthalene (ELCR=5E-03, 83%) Arsenic (ELCR=8E-04, 13%) Benzene (ELCR=2E-04, 3%) Ethylbenzene (ELCR=3E-05, 0.4%) bis(2-Ethylhexyl)phthalate (ELCR=2E-06, 0.03%)
BH-21B	91	6E-03	Naphthalene (HQ=76, 84%) Arsenic (HQ=13, 14%) Dibenzofuran (HQ=2, 2%)	Naphthalene (ELCR=3E-03, 57%) Arsenic (ELCR=2E-03, 42%) Benzene (ELCR=4E-05, 0.7%) Ethylbenzene (ELCR=1E-05, 0.2%)
RW-NS-1	132	6E-03	Naphthalene (HQ=123, 93%) Dibenzofuran (HQ=4, 3%) 2-Methylnaphthalene (HQ=3, 2%)	Naphthalene (ELCR=5E-03, 95%) Benzene (ELCR=1E-04, 3%) Ethylbenzene (ELCR=8E-05, 1%) Arsenic (ELCR=6E-05, 1%)
BH-18A	88	4E-03	Naphthalene (HQ=75, 85%) Benzene (HQ=9, 10%) 2-Methylnaphthalene (HQ=2, 2%) Dibenzofuran (HQ=2, 2%)	Naphthalene (ELCR=3E-03, 72%) Benzene (ELCR=9E-04, 20%) Arsenic (ELCR=2E-04, 4%) Indeno(1,2,3-c,d)pyrene (ELCR=9E-05, 2%) Ethylbenzene (ELCR=7E-05, 2%) Dibenz(a,h)anthracene (ELCR=3E-05, 0.7%) Chrysene (ECLR=2E-06, 0.04%) bis(2-Ethylhexyl)phthalate (ELCR=2E-06, 0.04%)
BH-19B	84	4E-03	Naphthalene (HQ=83, 99%)	Naphthalene (ELCR=4E-03, 97%) Arsenic (ELCR=1E-04, 3%) Ethylbenzene (ELCR=2E-05, 0.5%) bis(2-Ethylhexyl)phthalate (ELCR=2E-06, 0.04%)

Table 7.1-8
Summary of Location-Specific Risk and Hazard Estimates for Residential Indoor Air Exposure
(Sorted from Higher to Lower Risk)

Well Location	Noncancer Hazard Index	Excess Lifetime Cancer Risk	Primary Contributors to HI[a]	Primary Contributors to ELCR[a]
BH-23	62	3E-03	Naphthalene (HQ=49, 79%) Benzene (HQ=9, 14%) 2-Methylnaphthalene (HQ=2, 4%)	Naphthalene (ELCR=2E-03, 65%) Benzene (ELCR=9E-04, 27%) Ethylbenzene (ELCR=1E-04, 4%) Arsenic (ELCR=1E-04, 4%) bis(2-Ethylhexyl)phthalate (ELCR=3E-06, 0.1%)
BH-19	10	9E-04	Naphthalene (HQ=4, 40%) Arsenic (HQ=3, 29%)	Arsenic (ELCR=6E-04, 61%) Naphthalene (ELCR=2E-04, 19%) Benzene (ELCR=1E-04, 16%) Ethylbenzene (ELCR=5E-05, 5%)
BH-26B	6	8E-04	Arsenic (HQ=4, 59%) Naphthalene (HQ=3, 41%)	Arsenic (ELCR=7E-04, 86%) Naphthalene (ELCR=1E-04, 14%)
BH-20C	10	5E-04	Naphthalene (HQ=9, 93%)	Naphthalene (ELCR=4E-04, 77%) Arsenic (ELCR=1E-04, 22%) bis(2-Ethylhexyl)phthalate (ELCR=7E-06, 1%) Chloroform (ELCR=2E-06, 0.3%)
Q1-D	1	2E-04	none identified	Arsenic (ELCR=2E-04, 100%)
Q12	2	1E-04	Naphthalene (HQ=2, 86%)	Naphthalene (ELCR=8E-05, 59%) Arsenic (ELCR=5E-05, 38%) Chrysene (ECLR=4E-06, 3%)
BH-18B	2	1E-04	Naphthalene (HQ=2, 88%)	Naphthalene (ELCR=8E-05, 64%) Arsenic (ELCR=5E-05, 36%)
BH-29B	1	1E-04	none identified	Arsenic (ELCR=7E-05, 60%) Naphthalene (ELCR=4E-05, 40%)
BH-26A	0.8	1E-04	none identified	Arsenic (ELCR=9E-05, 84%) Naphthalene (ELCR=2E-05, 16%)
BH-28A	1	7E-05	none identified	Arsenic (ELCR=4E-05, 51%) Naphthalene (ELCR=4E-05, 49%)
Q17-W	0.5	7E-05	none identified	Arsenic (ELCR=6E-05, 89%) Naphthalene (ELCR=8E-06, 11%)
Q14	0.7	7E-05	none identified	Arsenic (ELCR=5E-05, 72%) Naphthalene (ELCR=2E-05, 28%)
BH-22	0.5	7E-05	none identified	Arsenic (ELCR=6E-05, 84%) Naphthalene (ELCR=1E-05, 16%)
BH-24	0.7	7E-05	none identified	Arsenic (ELCR=5E-05, 76%) Naphthalene (ELCR=1E-05, 23%)
BH-30C	0.2	5E-05	none identified	Benzo(a)anthracene (ELCR=4E-05, 95%)

Notes:

[a]Primary contributors to the total risk are listed when ELCR > 10^{-6} or HI > 1.

[b]Due to the very high concentrations found in this well and the inherent limitations quantifying risk at these levels, the ELCR is reported as a greater than estimate.

ELCR - excess lifetime cancer risk
HI - hazard index
HQ - hazard quotient
ND - no chemicals were detected

Table 7.1-9
Summary of Location-Specific Risk and Hazard Estimates for Residential Indoor Air Exposure
(Sorted from Higher to Lower Risk)

Well	Noncancer Hazard Index	Excess Lifetime Cancer Risk	Primary Contributors to HI[a]	Primary Contributors to ELCR[a]
BH-5/5A	280	2E-02	Benzene (HQ=180, 64%) Naphthalene (HQ=81, 29%) Total Xylenes (HQ=17, 6%)	Benzene (ELCR=2E-02, 81%) Naphthalene (ELCR=4E-03, 16%) Ethylbenzene (ELCR=7E-04, 3%)
Q9	240	1E-02	Naphthalene (HQ=227, 95%) Benzene (HQ=9, 4%) Total Xylenes (HQ=4, 1%)	Naphthalene (ELCR=1E-02, 90%) Benzene (ELCR=9E-04, 8%) Ethylbenzene (ELCR=2E-04, 2%)
RW-QP-1	128	8E-03	Naphthalene (HQ=56, 44%) Benzene (HQ=45, 35%) Total Xylenes (HQ=25, 20%)	Benzene (ELCR=5E-03, 58%) Naphthalene (ELCR=2E-03, 32%) Ethylbenzene (ELCR=8E-04, 10%)
BH-20A	103	7E-03	Naphthalene (HQ=51, 49%) Benzene (HQ=46, 45%) Total Xylenes (HQ=6, 5%)	Benzene (ELCR=5E-03, 62%) Naphthalene (ELCR=2E-03, 30%) Ethylbenzene (ELCR=7E-04, 9%)
BH-5B	68	3E-03	Naphthalene (HQ=66, 97%) Total Xylenes (HQ=2, 3%)	Naphthalene (ELCR=3E-03, 93%) Ethylbenzene (ELCR=2E-04, 6%) Benzene (ELCR=4E-05, 1%)
BH-25A(R)	61	3E-03	Naphthalene (HQ=56, 92%) Benzene (HQ=3, 5%) Total Xylenes (HQ=2, 3%)	Naphthalene (ELCR=2E-03, 86%) Benzene (ELCR=3E-04, 10%) Ethylbenzene (ELCR=1E-04, 4%)
BH-20B	35	2E-03	Naphthalene (HQ=22, 62%) Benzene (HQ=11, 32%) Total Xylenes (HQ=2, 5%)	Benzene (ELCR=1E-03, 48%) Naphthalene (ELCR=9E-04, 42%) Ethylbenzene (ELCR=2E-04, 10%)
Q4	29	1E-03	Naphthalene (HQ=27, 93%)	Naphthalene (ELCR=1E-03, 88%) Ethylbenzene (ELCR=1E-04, 8%) Benzene (ELCR=5E-05, 4%)
BH-21A	11	5E-04	Naphthalene (HQ=11, 98%)	Naphthalene (ELCR=5E-04, 97%) Ethylbenzene (ELCR=1E-05, 2%) Benzene (ELCR=2E-06, 0.4%)
BH-18A	4	3E-04	Naphthalene (HQ=2, 53%) Benzene (HQ=2, 46%)	Benzene (ELCR=2E-04, 62%) Naphthalene (ELCR=1E-04, 31%) Ethylbenzene (ELCR=3E-05, 8%)
BH-23	4	3E-04	Benzene (HQ=2, 52%) Naphthalene (HQ=2, 39%)	Benzene (ELCR=2E-04, 64%) Naphthalene (ELCR=7E-05, 21%) Ethylbenzene (ELCR=5E-05, 16%)
RW-NS-1	5	2E-04	Naphthalene (HQ=4, 82%)	Naphthalene (ELCR=2E-04, 73%) Benzene (ELCR=3E-05, 15%) Ethylbenzene (ELCR=3E-05, 13%)
BH-28B	4	2E-04	Naphthalene (HQ=4, 87%)	Naphthalene (ELCR=2E-04, 73%) Benzene (ELCR=5E-05, 22%) Ethylbenzene (ELCR=1E-05, 5%)
BH-19B	3	1E-04	Naphthalene (HQ=3, 95%)	Naphthalene (ELCR=1E-04, 94%) Ethylbenzene (ELCR=7E-06, 6%)
BH-21B	3	1E-04	Naphthalene (HQ=2, 94%)	Naphthalene (ELCR=1E-04, 89%) Benzene (ELCR=9E-06, 8%) Ethylbenzene (ELCR=4E-06, 3%)
BH-19	0.5	6E-05	none identified	Benzene (ELCR=3E-05, 60%) Ethylbenzene (ELCR=2E-05, 30%) Naphthalene (ELCR=6E-06, 10%)
BH-20C	0.3	1E-05	none identified	Naphthalene (ELCR=1E-05, 97%)
BH-29A	0.09	4E-06	none identified	Naphthalene (ELCR=4E-06, 100%)
BH-26B	0.08	4E-06	none identified	Naphthalene (ELCR=4E-06, 100%)

Table 7.1-9
Summary of Location-Specific Risk and Hazard Estimates for Residential Indoor Air Exposure
(Sorted from Higher to Lower Risk)

Well	Noncancer Hazard Index	Excess Lifetime Cancer Risk	Primary Contributors to HI[a]	Primary Contributors to ELCR[a]
BH-18B	0.06	3E-06	none identified	Naphthalene (ELCR=3E-06, 100%)
Q12	0.06	3E-06	none identified	Naphthalene ELCR=3E-06, 100%
BH-29B	0.03	1E-06	none identified	none identified
BH-28A	0.03	1E-06	none identified	none identified
BH-24	0.01	7E-07	none identified	none identified
Q14	0.01	6E-07	none identified	none identified
BH-26A	0.01	5E-07	none identified	none identified
BH-22	0.008	3E-07	none identified	none identified
Q17-W	0.006	2E-07	none identified	none identified
BH-30C	0.0007	3E-08	none identified	none identified
Q1-D	ND	ND	none identified	none identified

Notes:

[a] Primary contributors to the total risk are listed when ELCR > 10-6 or HI > 1.

ELCR - excess lifetime cancer risk
HI - hazard index
HQ - hazard quotient
ND - no chemicals were detected

Table 7.1-10
Summary of Risk and Hazard Estimates for the Occupational Worker Exposure Scenario

Exposure Route	Noncancer Hazard Index	Excess Lifetime Cancer Risk	Primary Contributors to HI[a]	Primary Contributors to ELCR[a]
Exposure to Soil - 0 to 15 feet bgs				
Ingestion	0.4	1E-03	Naphthalene (HQ=2, 74%)	Benzo(a)pyrene (ELCR=1E-03, 75%)
Dermal	0.3	8E-04	2-Methylnaphthalene (HQ=0.2, 10%)	Benzo(b)fluoranthene (ELCR=1E-04, 6%)
Inhalation	1	5E-05		Benzo(a)anthracene (ELCR=1E-04, 6%)
Total Soil Routes	**2**	**2E-03**		Benzo(k)fluoranthene (ELCR=8E-05, 4%)
				Indeno(1,2,3-c,d)pyrene (ELCR=8E-05, 4%)
				Naphthalene (ELCR=5E-05, 3%)
				Chrysene (ELCR=2E-05, 1%)
				Dibenz(a,h)anthracene (ELCR=2E-05, 1%)
				Arsenic (ELCR=8E-06, 0.4%)

Notes:

[a] Primary contributors to the total risk are listed when ELCR > 10-6 or HI > 1.

bgs - below ground surface
ELCR - excess lifetime cancer risk
HI - hazard index
HQ - hazard quotient

Table 7.1-11
Summary of Risk and Hazard Estimates for the Construction/Excavation Worker Exposure Scenario

Exposure Route	Noncancer Hazard Index	Excess Lifetime Cancer Risk	Primary Contributors to HI[a]	Primary Contributors to ELCR[a]
Exposure to Soil - 0 to 15 feet bgs				
Ingestion	1	1E-04	Naphthalene (HQ=2, 55%) 2-Methylnaphthalene (HQ=0.6, 18%)	Benzo(a)pyrene (ELCR=1E-04, 76%) Benzo(b)fluoranthene (ELCR=1E-05, 6%) Benzo(a)anthracene (ELCR=1E-05, 6%) Benzo(k)fluoranthene (ELCR=8E-06, 5%) Indeno(1,2,3-c,d)pyrene (ELCR=8E-06, 4%) Naphthalene (ELCR=2E-06, 1%) Chrysene (ELCR=2E-06, 1%) Dibenz(a,h)anthracene (ECLR=2E-06, 1%)
Dermal	0.4	5E-05		
Inhalation	1	2E-06		
Total Soil Routes	**3**	**2E-04**		
Contact with Trench Groundwater - Based on Maximum Detections from all Well Points				
Dermal	**33**	**1E-05**	2-Methylnaphthalene (HQ=13, 38%) Dibenzofuran (HQ=12, 36%) Benzene (HQ=4, 11%) Naphthalene (HQ=3, 10%)	Benzene (ELCR=1E-05, 81%) Arsenic (ELCR=2E-06, 13%)
Trench Vapor - Based on Maximum Detections from all Well Points				
Inhalation	**486**	**8E-04**	Naphthalene (HQ=451, 93%) Benzene (HQ=31, 6%) Total Xylenes (HQ=3, 0.7%)	Naphthalene (ELCR=7E-04, 86%) Benzene (ELCR=1E-04, 14%) Ethylbenzene (ELCR=3E-06, 0.4%)

Notes:

[a] Primary contributors to the total risk are listed when ELCR > 10-6 or HI > 1.

bgs - below ground surface
ELCR - excess lifetime cancer risk
HI - hazard index
HQ - hazard quotient

Table 7.1-12
Summary of Risk and Hazard Estimates for the Recreational Beach User Exposure Scenario

Exposure Route	Noncancer Hazard Index	Excess Lifetime Cancer Risk	Primary Contributors to HI[a]	Primary Contributors to ELCR[a]
Exposure to Site Nearshore Sediment				
Ingestion	0.004	2E-04	none identified	Benzo(a)pyrene (ELCR=3E-04, 89%)
Dermal	0.01	9E-05		Benzo(a)anthracene (ELCR=1E-05, 5%)
Total Sediment Routes	**0.02**	**3E-04**		Indeno(1,2,3-c,d)pyrene (ELCR=1E-05, 3%)
				Dibenz(a,h)anthracene (ELCR=5E-06, 1%)
				Chrysene (ELCR=3E-06, 1%)
Exposure to Site Surface Water				
Ingestion	0.007	2E-06	none identified	Benzene (ELCR=2E-06, 67%)
Dermal	0.02	2E-06		
Total Surface Water Routes	**0.03**	**3E-06**		
Exposure to Background Sediment				
Ingestion	0.001	2E-06	none identified	Benzo(a)pyrene (ELCR=2E-06, 86%)
Dermal	0.00005	7E-07		
Total Sediment Routes	**0.001**	**3E-06**		

Notes:

[a] Primary contributors to the total risk are listed when ELCR > 10-6 or HI > 1.

ELCR - excess lifetime cancer risk
HI - hazard index

Table 7.1-13
Summary of Risk and Hazard Estimates for the Recreational Fishing Exposure Scenario

Exposure Route	Noncancer Hazard Index	Excess Lifetime Cancer Risk	Primary Contributors to HI[a]	Primary Contributors to ELCR[a]
Fish/Shellfish Consumption (Based on Site-Wide Sediment)				
Ingestion	**0.4**	**2E-04**	none identified	Benzo(a)pyrene (ELCR=2E-04, 65%) Benzo(a)anthracene (ELCR=7E-05, 29%) Dibenz(a,h)anthracene (ELCR=6E-06, 2%) Chrysene (ELCR=6E-06, 2%) Indeno(1,2,3-c,d)pyrene (ELCR=5E-06, 2%)
Exposure to Site-Wide Sediment				
Ingestion	0.008	2E-05	none identified	Benzo(a)pyrene (ELCR=3E-05, 83%) Benzo(a)anthracene (ELCR=5E-06, 13%)
Dermal	0.005	2E-05		
Total Sediment Routes	**0.01**	**4E-05**		
Fish/Shellfish Consumption (Based on Background Sediment)				
Ingestion	**0.0004**	**2E-06**	none identified	Benzo(a)pyrene (ELCR=1E-06, 71%)
Exposure to Background Sediment				
Ingestion	0.0002	7E-08	none identified	none identified
Dermal	0.000001	5E-08		
Total Sediment Routes	**0.0002**	**1E-07**		

Notes:

[a] Primary contributors to the total risk are listed when ELCR > 10-6 or HI > 1.

ELCR - excess lifetime cancer risk
HI - hazard index

Table 7.1-14
Summary of Risk and Hazard Estimates for the Subsistence Fishing Exposure Scenario

Exposure Route	Noncancer Hazard Index	Excess Lifetime Cancer Risk	Primary Contributors to HI[a]	Primary Contributors to ELCR[a]
Fish/Shellfish Consumption (Based on Site-Wide Sediment)				
Ingestion	**3**	**5E-03**	2-Methylnaphthalene (HQ=2, 50%)	Benzo(a)pyrene (ELCR=3E-03, 65%) Benzo(a)anthracene (ELCR=1E-03, 29%) Dibenz(a,h)anthracene (ELCR=1E-04, 2%) Chrysene (ELCR=1E-04, 2%) Indeno(1,2,3-c,d)pyrene (ELCR=9E-05, 2%)
Exposure to Site-Wide Sediment				
Ingestion	0.01	4E-05	none identified	Benzo(a)pyrene (ELCR=5E-05, 83%) Benzo(a)anthracene (ELCR=8E-06, 13%)
Dermal	0.008	3E-05		
Total Sediment Routes	**0.02**	**6E-05**		
Fish/Shellfish Consumption (Based on Background Sediment)				
Ingestion	**0.003**	**4E-05**	none identified	Benzo(a)pyrene (ELCR=3E-05, 71%) Benzo(a)anthracene (ELCR=6E-06, 16%) Indeno(1,2,3-c,d)pyrene (ELCR=2E-06, 6%) Dibenz(a,h)anthracene (ELCR=2E-06, 6%)
Exposure to Background Sediment				
Ingestion	0.0003	1E-07	none identified	none identified
Dermal	0.000002	8E-08		
Total Sediment Routes	**0.0003**	**2E-07**		

Notes:

[a] Primary contributors to the total risk are listed when ELCR > 10-6 or HI > 1.

ELCR - excess lifetime cancer risk
HI - hazard index

Table 7.1-15
Summary of Risk and Hazard Estimates for Human Exposure Scenarios

Exposure Medium	Exposure Route	Residential HI	Residential ELCR	Occupational Worker HI	Occupational Worker ELCR	Construction/ Excavation Worker HI	Construction/ Excavation Worker ELCR	Recreational Beach User HI	Recreational Beach User ELCR	Recreational Fishing HI	Recreational Fishing ELCR	Subsistence Fishing HI	Subsistence Fishing ELCR
Soil (0 to 15 feet bgs)	Ingestion	**1**	**2E-02**	0.4	**1E-03**	**1**	**1E-04**	--	--	--	--	--	--
	Dermal	0.5	**7E-03**	0.3	**8E-04**	0.4	**5E-05**	--	--	--	--	--	--
	Inhalation	**6**	**3E-04**	**1**	**5E-05**	**1**	**2E-06**	--	--	--	--	--	--
	Total	**8**	**3E-02**	**2**	**2E-03**	**3**	**2E-04**	--	--	--	--	--	--
Groundwater	Ingestion	**602**	**8E-01**	--	--	--	--	--	--	--	--	--	--
	Dermal	**175**	**5E-04**	--	--	0.00001	**1E-05**	--	--	--	--	--	--
	Inhalation	**7,218**	**3E-01**	--	--	--	--	--	--	--	--	--	--
	Total	**7,995**	**>8E-01**[a]	--	--	0.00001	**1E-05**	--	--	--	--	--	--
Indoor Air	Inhalation	**280**	**2E-02**	--	--	--	--	--	--	--	--	--	--
Trench Vapor	Inhalation	--	--	--	--	486	**8E-04**	--	--	--	--	--	--
Nearshore Sediment	Ingestion	--	--	--	--	--	--	0.004	**2E-04**	--	--	--	--
	Dermal	--	--	--	--	--	--	0.01	**9E-05**	--	--	--	--
	Total	--	--	--	--	--	--	0.02	**3E-04**	--	--	--	--
Site-Wide Sediment	Ingestion	--	--	--	--	--	--	--	--	0.008	**2E-05**	0.01	**4E-05**
	Dermal	--	--	--	--	--	--	--	--	0.005	**2E-05**	0.01	**3E-05**
	Total	--	--	--	--	--	--	--	--	0.01	**4E-05**	0.02	**6E-05**
Site Surface Water	Ingestion	--	--	--	--	--	--	0.007	**2E-06**	--	--	--	--
	Dermal	--	--	--	--	--	--	0.02	**2E-06**	--	--	--	--
	Total	--	--	--	--	--	--	0.03	**3E-06**	--	--	--	--
Site Fish/Shellfish	Ingestion	--	--	--	--	--	--	--	--	0.4	**2E-04**	**3**	**5E-03**
Background Sediment	Ingestion	--	--	--	--	--	--	0.001	**2E-06**	0.0002	7E-08	0.0003	1E-07
	Dermal	--	--	--	--	--	--	0.00005	7E-07	0.000001	5E-08	0.000002	8E-08
	Total	--	--	--	--	--	--	0.001	**3E-06**	0.0002	1E-07	0.0003	2E-07
Background Fish/Shellfish	Ingestion	--	--	--	--	--	--	--	--	0.0004	**2E-06**	0.003	**4E-05**

Notes:

[a]Due to the very high concentrations found in well Q9 and the inherent limitations quantifying risk at these levels, the ELCR is reported as a "greater than" estimate**.**

Risks to future residents from exposure to groundwater and indoor air were estimated from the maximum single-well risk.

Risks to construction/excavation workers from exposure to groundwater and trench vapor were estimated from maximum detected concentrations from all wellpoints.

bgs - below ground surface

ELCR - excess lifetime cancer risk

HI - hazard index; HQ - hazard quotient

Boldface without highlighting - HQ greater than 1 or ELCR greater than 1E-06

Boldface with highlighting - HQ greater than 10 or ELCR greater than 1E-04

Table J-8-1
Screening of Chemicals of Potential Concern for Ecological Receptors -- Soil

Chemical of Interest	Minimum Screening Criteria	Screening Value	Criteria Unit	Count of Samples	Count of Detected Samples	Count of Non-Detected Samples	Percent Detect	Minimum Value	Maximum Value	Mean Value	Maximum Detected Value	Mean Detected Value	Screening Value Exceedance Factor (Based on Maximum Detection)	COPC?
2,4-Dimethylphenol	R5 Eco. Soil	10	µg/kg	36	3	33	8	60	14000	1,134.11	1300	740.00	130.00	Yes
2-Methylnaphthalene	R5 Eco. Soil	3240	µg/kg	55	29	26	53	25	180000	14,191.87	180000	26,164.52	55.56	Yes
Acenaphthene	R5 Eco. Soil	682000	µg/kg	55	33	22	60	20	600000	23,079.49	600000	38,343.48	0.88	No
Anthracene	R5 Eco. Soil	1480000	µg/kg	55	41	14	75	52	590000	29,707.35	590000	39,490.07	0.40	No
Arsenic	R5 Eco. Soil	5.7	mg/kg	43	21	22	49	5	110	11.79	110	18.05	19.30	Yes
Benzene	R5 Eco. Soil	255	µg/kg	11	0	11	0	5.7	140	19.92				No, DL
Benzo(a)anthracene	R5 Eco. Soil	5210	µg/kg	55	46	9	84	54	1100000	63,071.64	1100000	75,400.04	211.13	Yes
Benzo(a)pyrene	R5 Eco. Soil	1520	µg/kg	55	47	8	85	54	1400000	76,075.82	1400000	89,014.74	921.05	Yes
Benzo(b)fluoranthene	R5 Eco. Soil	59800	µg/kg	55	47	8	85	54	960000	55,611.95	960000	65,067.66	16.05	Yes
Benzo(g,h,i)perylene	R5 Eco. Soil	119000	µg/kg	55	45	10	82	54	1100000	38,867.75	1100000	47,490.93	9.24	Yes
Benzo(k)fluoranthene	R5 Eco. Soil	148000	µg/kg	55	47	8	85	54	660000	40,975.67	660000	47,940.11	4.46	Yes
Cadmium[a]	R5 Eco. Soil	0.00222	mg/kg	4	4	0	100	0.12	0.3	0.20	0.3	0.20	135.14	No, QA1-
Chromium[a]	R5 Eco. Soil	0.4	mg/kg	4	4	0	100	29.3	65.3	50.30	65.3	50.30	163.25	Yes, QA1-; Indicator
Chrysene	R5 Eco. Soil	4730	µg/kg	55	47	8	85	54	1500000	84,455.75	1500000	98,821.04	317.12	Yes
Dibenz(a,h)anthracene	R5 Eco. Soil	18400	µg/kg	55	34	21	62	32	99000000	3,453,119.80	99000000	5,585,841.29	5,380.43	Yes
Dibenzofuran	NV	NV	µg/kg	55	24	31	44	20	34000	2,941.55	34000	6,486.04	NV	Yes, NV
Ethylbenzene	R5 Eco. Soil	5160	µg/kg	11	2	9	18	5.7	920	100.07	920	515.00	0.18	No
Fluoranthene	R5 Eco. Soil	122000	µg/kg	55	47	8	85	54	2200000	116,205.33	2200000	106,188.85	18.03	Yes
Fluorene	R5 Eco. Soil	122000	µg/kg	55	33	22	60	21	350000	15,793.09	350000	26,209.48	2.87	Yes
Indeno(1,2,3-c,d)pyrene	R5 Eco. Soil	109000	µg/kg	55	44	11	80	54	180000000	6,228,615.62	180000000	7,785,652.84	1,651.38	Yes
Lead	R5 Eco. Soil	0.0537	mg/kg	43	41	2	95	2	1120	116.74	1120	122.34	20,856.61	Yes
m,p-Xylene	NV	NV	µg/kg	11	1	10	9	5.7	1600	152.65	1600	1,600.00	NV	Yes, NV
Naphthalene	R5 Eco. Soil	99.4	µg/kg	66	39	27	59	2.9	370000	23,488.47	370000	39,294.52	3,722.33	Yes
Nickel[a]	R5 Eco. Soil	13.6	mg/kg	4	4	0	100	34	53	43.00	53	43.00	3.90	No, QA1-
o-Xylene	NV	NV	µg/kg	11	1	10	9	5.7	640	65.37	640	640.00	NV	Yes, NV
Pentachlorophenol	R5 Eco. Soil	119	µg/kg	36	0	36	0	150	71000	4,917.22				Yes, DL
Phenanthrene	R5 Eco. Soil	45700	µg/kg	55	48	7	87	54	2800000	124,091.64	2800000	142,179.69	61.27	Yes
Pyrene	R5 Eco. Soil	78500	µg/kg	55	49	6	89	54	3200000	160,370.87	3200000	180,000.90	40.76	Yes
Toluene	R5 Eco. Soil	5450	µg/kg	11	3	8	27	5.7	740	89.55	740	308.77	0.14	No
Total 10 of 16 HPAHs (U=1/2)	Eco SSL	1100	µg/kg	60	54	6	90	54	284060000	9,445,799.32	284060000	10,495,326.02	258,236.36	Yes
Total 6 of 16 LPAHs (U=1/2)	Eco SSL	29000	µg/kg	71	57	14	80	2.9	3249600	171,498.30	3249600	213,609.38	112.06	Yes
Total PCBs (U=1/2)[a]	R5 Eco. Soil	0.332	µg/kg	4	0	4	0	37	42	38.75			126.51	Yes, QA1-; Indicator
Total cPAH TEF (7 minimum) (U=1/2)	NA	NA	NA	59	51	8	86	54	28722000	989,113.34	28722000	1,144,259.02	NA	No
Total Xylenes (U=1/2)	R5 Eco. Soil	10000	µg/kg	11	1	10	9	5.7	2240	210.83	2240	2,240.00	0.22	No
Zinc[a]	R5 Eco. Soil	6.62	mg/kg	4	4	0	100	45.1	94.2	71.10	94.2	71.10	14.23	No, QA1-

Notes:

a - Identified as a contaminant of interest (COI) based on QA1- data. COPC screening conducted using QA1- data.
µg/kg - microgram(s) per kilogram
COPC - chemical of potential concern
cPAH TEF - carcingogenic PAH toxicity equivalency factor
DL - COPC based on non-detect concentrations.
HPAHs - high-molecular weight PAHs
LPAHs - low-molecular weight PAHs
mg/kg - milligram(s) per kilogram
NA - not aplicable to ecological exposure.
NV - no value
PAH(s) - polynuclear aromatic hydrocarbon(s)
PCBs - polychlorinated biphenyls
R5 Eco. Soil - EPA Region 5 Ecological Soil Screening Levels
U=1/2 denotes that non-detects were valued at one-half the detection limit for these calculated values.

Table J-8-2
Screening of Chemicals of Potential Concern for Ecological Receptors -- Surface Water

Chemical of Interest	Minimum Screening Criteria	Screening Value	Criteria Unit	Count of Samples	Count of Detected Samples	Count of Non-Detected Samples	Percent Detected	Minimum Value	Maximum Value	Mean Value	Maximum Detected Value	Mean Detected Value	Screening Value Exceedance Factor (Based on Maximum Detection)	COPC?
2-Methylnaphthalene	R3 BTAG SW	4.7	µg/L	51	43	8	84	0.054	17000	515.87	17000	611.68	3,617.02	Yes
Acenaphthene	R3 BTAG SW	5.8	µg/L	57	41	16	72	0.1	10000	234.21	10000	322.73	1,724.14	Yes
Anthracene	R3 BTAG SW	0.012	µg/L	57	15	42	26	0.041	3600	73.42	3600	262.71	300,000.00	Yes
Arsenic	R3 BTAG SW	5	µg/L	39	35	4	90	0.8	389	24.85	389	27.58	77.80	Yes, GW
Benzene	R3 BTAG SW	370	µg/L	71	38	33	54	0.2	31000	770.96	31000	1,439.44	83.78	Yes
Benzo(a)anthracene	R3 BTAG SW	0.018	µg/L	58	12	46	21	0.018	3100	63.38	3100	285.95	172,222.22	Yes
Benzo(a)pyrene	R3 BTAG SW	0.015	µg/L	58	15	43	26	0.01	2000	46.22	2000	160.55	133,333.33	Yes
Benzo(b)fluoranthene	NV	NV	µg/L	58	15	43	26	0.01	1900	43.04	1900	148.19	NV	Yes, NV
Benzo(k)fluoranthene	NV	NV	µg/L	58	15	43	26	0.01	1400	33.87	1400	112.81	NV	Yes, NV
Chrysene	NV	NV	µg/L	58	12	46	21	0.025	2200	48.82	2200	213.13	NV	Yes, NV
Dibenz(a,h)anthracene	NV	NV	µg/L	58	5	53	9	0.01	200	10.41	200	40.57	NV	Yes, NV
Ethylbenzene	R3 BTAG SW	90	µg/L	71	38	33	54	0.2	2900	182.86	2900	341.06	32.22	Yes
Fluoranthene	R3 BTAG SW	0.04	µg/L	57	19	38	33	0.077	10000	194.33	10000	574.45	250,000.00	Yes
Fluorene	R3 BTAG SW	3	µg/L	57	31	26	54	0.1	7300	156.30	7300	283.64	2,433.33	Yes
Indeno(1,2,3-c,d)pyrene	NV	NV	µg/L	58	10	48	17	0.01	760	20.11	760	79.09	NV	Yes, NV
m,p-Xylene	R3 BTAG SW	1.8	µg/L	71	28	43	39	0.4	7500	241.51	7500	608.88	4,166.67	Yes
Naphthalene	R3 BTAG SW	1.1	µg/L	71	58	13	82	0.14	45000	1,748.55	45000	2,140.20	40,909.09	Yes
PAH SPME ESBQ (U=1/2)	TU	1	--	15	15	0	100	1.745	3.562	2.10	3.562	2.10	3.56	Yes
Phenanthrene	R3 BTAG SW	0.4	µg/L	57	28	29	49	0.1	23000	449.81	23000	909.34	57,500.00	Yes
Pyrene	R3 BTAG SW	0.025	µg/L	57	22	35	39	0.065	11000	216.63	11000	555.33	440,000.00	Yes
Toluene	R3 BTAG SW	2	µg/L	71	32	39	45	0.2	19000	555.21	19000	1,227.86	9,500.00	Yes
Total Xylenes (U=1/2)	R3 BTAG SW	13	µg/L	71	38	33	54	0.4	10600	364.42	10600	679.85	815.38	Yes

Notes:
µg/L - microgram(s) per liter
Groundwater and porewater (undiluted) data conservatively used in addition to surface water data in ecological surface water COPC screening.
GW - Indicates that the contaminant of interest (COI) is identified as a COPC because groundwater concentrations > screening value, but surface water and porewater data are < screening value.
NV - Indicates there is no screening value
PAH SPME ESBQ - polynuclear aromatic hydrocarbon solid-phase microextraction equilibrium partitioning sediment benchmark quotient
R3 BTAG SW - EPA Region 3 Biological Technical Assistance Group - Surface Water
TU - toxic unit(s)
U=1/2 denotes that non-detects were valued at one-half the detection limit for these calculated values.

Table J-8-3

Screening of Chemicals of Potential Concern for Ecological Receptors -- Sediment

Chemical of Interest	Minimum Screening Criteria	Screening Value	Criteria Unit	Count of Samples	Count of Detected Samples	Count of Non-Detected Samples	Percent Detected	Minimum Value	Maximum Value	Mean Value	Maximum Detected Value	Mean Detected Value	Screening Value Exceedance Factor (Based on Maximum Detection)	COPC?
2-Methylnaphthalene	R3_BTAG_Sed	20.2	µg/kg	8	6	2	75	6.6	150000	19,158.21	150000	25,541.18	7,425.74	Yes
4-Methylphenol (p-Cresol)	R3_BTAG_Sed	670	µg/kg	14	7	7	50	17	68	25.21	68	30.43	0.10	No
Acenaphthene	R3_BTAG_Sed	6.7	µg/kg	37	29	8	78	6.5	190000	10,126.88	190000	12,914.54	28,358.21	Yes
Acenaphthylene	R3_BTAG_Sed	5.9	µg/kg	37	31	6	84	6.6	3000	199.77	3000	234.69	508.47	Yes
Anthracene	R3_BTAG_Sed	57.2	µg/kg	37	35	2	95	6.6	240000	9,428.44	240000	9,966.74	4,195.80	Yes
Arsenic[a]	R3_BTAG_Sed	9.8	mg/kg	5	0	5	0	10	20	9.00				Yes, QA1- DL; Indicator
Benzo(a)anthracene	R3_BTAG_Sed	108	µg/kg	37	37	0	100	22	260000	14,395.46	260000	14,395.46	2,407.41	Yes
Benzo(a)pyrene	R3_BTAG_Sed	150	µg/kg	37	36	1	97	9.7	140000	10,821.64	140000	11,121.97	933.33	Yes
Benzo(g,h,i)perylene	R3_BTAG_Sed	170	µg/kg	37	37	0	100	9.3	33000	3,176.39	33000	3,176.39	194.12	Yes
Cadmium[a]	R3_BTAG_Sed	0.99	mg/kg	5	3	2	60	0.4	1.3	0.67	1.3	0.87	1.31	No, QA1-
Carbon disulfide[a]	R3_BTAG_Sed	0.851	µg/kg	3	1	2	33	3.4	6.4	3.27	6.4	6.40	7.52	No, QA1-
Chromium[a]	R3_BTAG_Sed	43.4	mg/kg	5	5	0	100	39	44	41.20	44	41.20	1.01	Yes, QA1-; Indicator
Chrysene	R3_BTAG_Sed	166	µg/kg	37	37	0	100	28	340000	17,332.92	340000	17,332.92	2,048.19	Yes
Copper[a]	R3_BTAG_Sed	31.6	mg/kg	5	5	0	100	24.2	46.4	39.66	46.4	39.66	1.47	Yes, QA1-; Indicator
Dibenz(a,h)anthracene	R3_BTAG_Sed	33	µg/kg	37	35	2	95	6.6	17000	1,315.41	17000	1,390.11	515.15	Yes
Dibenzofuran	WA_FW_LAET	399	µg/kg	3	2	1	67	12	430	160.00	430	234.00	1.08	Yes
Ethylbenzene[a]	R3_BTAG_Sed	1100	µg/kg	9	3	6	33	14	290	108.33	180	86.67	0.16	No
Fluoranthene	R3_BTAG_Sed	423	µg/kg	37	37	0	100	24	670000	39,848.27	670000	39,848.27	1,583.92	Yes
Fluorene	R3_BTAG_Sed	77.4	µg/kg	37	28	9	76	6.5	160000	8,729.88	160000	11,529.24	2,067.18	Yes
Indeno(1,2,3-c,d)pyrene	R3_BTAG_Sed	17	µg/kg	37	37	0	100	9.3	34000	3,036.52	34000	3,036.52	2,000.00	Yes
Lead[a]	R3_BTAG_Sed	35.8	mg/kg	5	5	0	100	33	66	47.60	66	74.60	1.84	No, QA1-
Naphthalene	R3_BTAG_Sed	176	µg/kg	37	28	9	76	6.6	150000	4,629.47	150000	6,110.12	852.27	Yes
Nickel[a]	R3_BTAG_Sed	22.7	mg/kg	5	5	0	100	27	34	32.20	34	32.20	1.50	No, QA1-
PAH Total ESBQ (U=1/2)	TU	1	TU	37	37	0	100	0.029	120.628	6.61	120.628	6.61	120.63	Yes
Phenanthrene	R3_BTAG_Sed	204	µg/kg	37	37	0	100	8	720000	38,220.27	720000	38,220.27	3,529.41	Yes
Pyrene	R3_BTAG_Sed	195	µg/kg	37	37	0	100	20	440000	27,665.46	440000	27,665.46	2,256.41	Yes
Sulfide[a]	R3_BTAG_Sed	130	mg/kg	11	11	0	100	26	570	192.37	570	192.37	4.38	No, QA1-
Total 10 of 16 HPAHs (U=1/2)	R3_BTAG_Sed	190	µg/kg	37	37	0	100	187.9	2004000	138,416.69	2004000	138,416.69	10,547.37	Yes
Total 16 PAHs (U=1/2)	R3_BTAG_Sed	1610	µg/kg	37	37	0	100	212.4	2948200	209,741.95	2948200	209,741.95	1,831.18	Yes
Total 6 of 16 LPAHs (U=1/2)	R3_BTAG_Sed	76	µg/kg	37	37	0	100	24.5	1133520	71,325.26	1133520	71,325.26	14,914.74	Yes
Total cPAH TEF (7 minimum) (U=1/2)	NA	NA	µg/kg	37	37	0	100	13.435	177760	14,952.05	177760	14,952.05	NA	No
Total organic carbon	WA_FW_LAET	9.82	percent	61	61	0	100	0.32	24	7.71	24	7.71	2.44	Yes
Zinc[a]	R3_BTAG_Sed	121	mg/kg	5	5	0	100	102	180	144.40	180	144.40	1.49	No, QA1-

Notes:

a = Identified as a contaminant of interest (COI) based on QA1 and/or QA1- data. COPC screening conducted using QA1 and QA1- data. QA1- data conservatively used for risk assessment of Indicator COI.

-- - No data in exposure point dataset (QA2 or better).

µg/kg - microgram(s) per kilogram

COPC - chemical of potential concern

cPAH TEF - carcingogenic PAH toxicity equivalency factor

ESBQ - equilibrium partitioning sediment benchmark quotient

HPAHs - high-molecular weight PAHs

LPAHs - low-molecular weight PAHs

mg/kg - milligram(s) per kilogram

NA - not applicable to ecological exposure.

PAH(s) - polynuclear aromatic hydrocarbon(s)

PCBs - polychlorinated biphenyls

R3_BTAG_Sed - EPA Region 3 Biological Technical Assistance Group - Sediment Value

TU - toxic unit(s)

U=1/2 denotes that non-detects were valued at one-half the detection limit for these calculated values.

WA_FW_LAET - Washington State Freshwater lowest adverse effects threshhold

Appendix 2B
Smoldering Combustion Cost Details

Appendix 2B—Smoldering Combustion Cost Details

This appendix provides additional details used to develop the cost estimate for implementing the smoldering combustion technology at Quendall. As indicated in ROD Table 12-1, the line item cost for smoldering combustion is $14.9 million and includes remedy design, contracting, subcontracting, system installation, shakedown, operation, and project/construction management.

1.0 Basic Assumptions

The estimated costs for implementing smoldering combustion treatment at Quendall were obtained from Savron, the vendor that conducted the Self-sustaining Treatment for Active Remediation (STAR) bench-scale pilot study and field pilot study at Quendall (CH2M, 2018; Savron, 2018). The labor requirements for overseeing drilling and installation of ignition points/thermocouples/vapor extraction points, setup of above ground treatment cell infrastructure, and STAR operational oversight are based on the average labor demands from a site in New Jersey, where STAR was implemented at full-scale for four years. Capital costs for equipment, site construction, and drilling costs were obtained from Savron, based on quotes they received from vendors and subcontractors for similar sized systems at previous sites.

Key assumptions specific to the Quendall STAR treatment estimate included:

- Soil is amenable to STAR treatment (greater than 3,000 milligrams per kilogram [mg/kg] total petroleum hydrocarbons [TPH]);
- Removal of any drilling obstructions (foundations, utilities, wells, etc.) would be performed by another contractor;
- Installation of a vapor barrier (includes grubbing, grading, and barrier material such as asphalt);
- Installation of ignition points (IPs) would occur using a direct push drilling method;
- Sheet-piling will not be required and costs were not included;
- 7-foot radius of influence and 1.4 foot per day propagation velocity (based on the field pilot study (Savron, 2018);
- 8 IPs operating at a time (as a treatment "cell");
- Thickness of 3 to 6-foot impacts can be treated from a single IP depth;
- All costs in 2018 US$;
- Power will be provided by diesel/generator;
- Vapor treatment will be performed by regenerative thermal oxidation;
- Electricity cost of US $0.08 per kilowatt-hour, propane cost of $1.10 per gallon, and diesel cost of $3.00 per gallon has been included;
- Operational cycle time = 7 days per cell (5-day ignition and burn period, 2 days for setup/teardown/contingency);
- Operation will be staffed for 10 hours per day and remotely monitored otherwise;
- Treatment operations and drilling can occur concurrently;
- 25% contingency.

2.0 Site-Specific Assumptions

Site-specific assumptions regarding where smoldering combustion would be applied were developed based on the areas with mobile DNAPL (Railroad Area, May Creek Areas, and Quendall Pond Upland Area)[1] or cumulative DNAPL thicknesses of greater than or equal to 4 feet, as shown in Figure B-1.[2]

Each "OU1 STAR Area" is associated with specific borings, that were mapped using Thiessen polygons to calculate an area and DNAPL depth associated with each boring. The areas and DNAPL depths for Thiessen polygons within the areas shown on Figure B1 were then used to estimate the overall area and depth for smoldering combustion treatment.[3] As indicated in the table on the right side of Figure B-1, the total area of the Thiessen polygons was estimated at 101,495 square feet and the average depth is approximately 19 feet below ground surface.

The treatment area of 101,495 square feet and average depth were used to estimate the number of ignition points (IPs) that would be needed to treat the entire area. This in turn, was used by Savron to estimate the number of treatment cells (clusters of IPs), and the number of sectors (cell clusters).

A radius of influence (ROI) of 7 feet was determined during the field pilot study at Quendall (Savron, 2018). Therefore, it is assumed that IPs would be placed approximately 14 feet apart. Given this spacing, Savron estimated the total number of ignition points at 660. Assuming each treatment cell will include 8 IPs, to be combusted simultaneously, the total number of cells is estimated at 83.[4]

As discussed on the Section 12 of the ROD, for feasibility study (FS)-level cost-estimating purposes, it was assumed that smoldering combustion would destroy 17,000 CY of a total of 30,500 CY of DNAPL-impacted soil (approximately 56 percent) and ISS would be used to treat the remainder of the DNAPL-impacted soil. Even though the total area (acres) treated by smoldering combustion (2.3 acres) is less than the area estimated for ISS (6.7 acres), the areas estimated for smoldering combustion contains greater thicknesses of DNAPL than the areas identified for potential ISS treatment (Figure 12-1).

Based on the areas assumed for treatment, Savron has estimated that treatment would be conducted in 5 sectors, as shown in Figure B-2, and smoldering combustion treatment operating time would be two years. This time could be accelerated by adding a second treatment unit.

3.0 Rationale for Assuming "Base Case"

The cost of $14.9 million for smoldering combustion treatment assumes a "base case" of one IP per location within each treatment cell, which is based on evaluation of data collected during the field pilot study.

The field pilot study findings indicated that, within a given treatment cell with multiple layers of contamination, there is variability even at a small scale (5 to 10 feet) in the distribution of the DNAPL, such that within a cell some projected IP locations within that cell would not need treatment (based on TPH concentrations below 3,000 mg/kg). In other words, the number of IPs that would not need to be installed based on TPH concentrations of less than 3,000 mg/kg is approximately balanced by the number of additional IPs that may be required to address multiple layers of contamination at depth. This is illustrated in Figures B-3 through B-5, based on pilot study data collected between 5 and 10 feet apart

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1 Mobile DNAPL defined as above residual saturation, or observed as "oil-wetted" soil in borings.

2 These areas are the same as those identified for solidification in Quendall Feasibility Study (FS, Aspect and Arcadis, 2016) Alternative 5, detailed in FS Tables E7 (maximum DNAPL depth) and E10 through 12 (square footage for Alternative 5 Thiessen polygons).

3 Thiessen polygons for each of the DNAPL borings were developed and presented in Quendall FS Figure 4-6. These polygons are also depicted in Figure B-3.

4 660 divided by 8 = 82.5.

as part of the field pilot study site characterizations: (1) an area north of Quendall Pond, (2) an area near the former May Creek, and (3) within the pre-design evaluation (PDE) area (where the actual combustion test was performed).

Figures B-3 through B-5 show TPH concentrations from samples collected in the areas noted above. In each figure, the largest circles represent potential IP locations in a treatment cell; and in each there are 6 potential IPs, assuming all locations would be treatable. In the figures, if a circle is black, it means the TPH concentrations are below 3,000 mg/kg and the IP would not be installed at that location. If a circle is red, it means that an IP would be installed. If there are two colored rings at a location, it means two IPs would be installed, and so on.

As shown in Figure B-3 (Quendall Pond area), 3 of the 6 potential IPs would not be installed, while in the other 3 locations, 1 IP would be installed to treat DNAPL at a single depth interval. In other words, 3 fewer IPs would be installed versus what had been planned based on assuming all locations would be treatable. Figure B-4 (May Creek Area) shows 2 of the 6 potential IPs would not be installed, while in the other 4 locations, 2 or 3 IPs would be installed to treat DNAPL at different depths, indicating 4 more IPs would be required than planned. The pilot study data were consistent with the Remedial Investigation (RI, Anchor QEA and Aspect, 2012) DNAPL data indicating that May Creek is an area where multiple DNAPL layers have been observed (discussed in the next paragraph). Figure B-5 indicates that the number of IPs required would be the same as the number of IPs planned. Overall, the data support the assumption that a single IP per location can be used to estimate the treatment cost per cell.

In addition, RI data indicate that only approximately 25 percent of the total DNAPL area may include multiple layers of contamination, as indicated in Figure B-6. The areas currently estimated for smoldering combustion represent a higher proportion of areas with multiple layers; however, the field pilot study demonstrated that treatment occurred up to 7 feet away from the IP location (in a vertical direction) even when separated by low-permeability materials 2.5 feet thick or less.

Overall, the site data suggest that using a “base case” assumption of one IP per location within a treatment cell is reasonable, especially given the FS level cost uncertainty assumption of +50 to -30%.

4.0 Works Cited

Anchor QEA, LLC and Aspect Consulting, LLC (Anchor QEA and Aspect). 2012. *Final Remedial Investigation Report, Quendall Terminals Site, Renton, Washington.* Prepared for U.S. Environmental Protection Agency, Region 10, on behalf of Altino Properties, Inc and J.H. Baxter & Company. September. Accessed July 15, 2018. https://semspub.epa.gov/work/10/500010867.pdf.

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CH2M HILL Engineers, Inc. (CH2M). 2018. *Quendall Terminals Superfund Site, Results from the Self-Sustaining Treatment for Active Remediation Bench-Scale Treatability Study.* Prepared for U.S. Environmental Protection Agency, Region 10. May 30.

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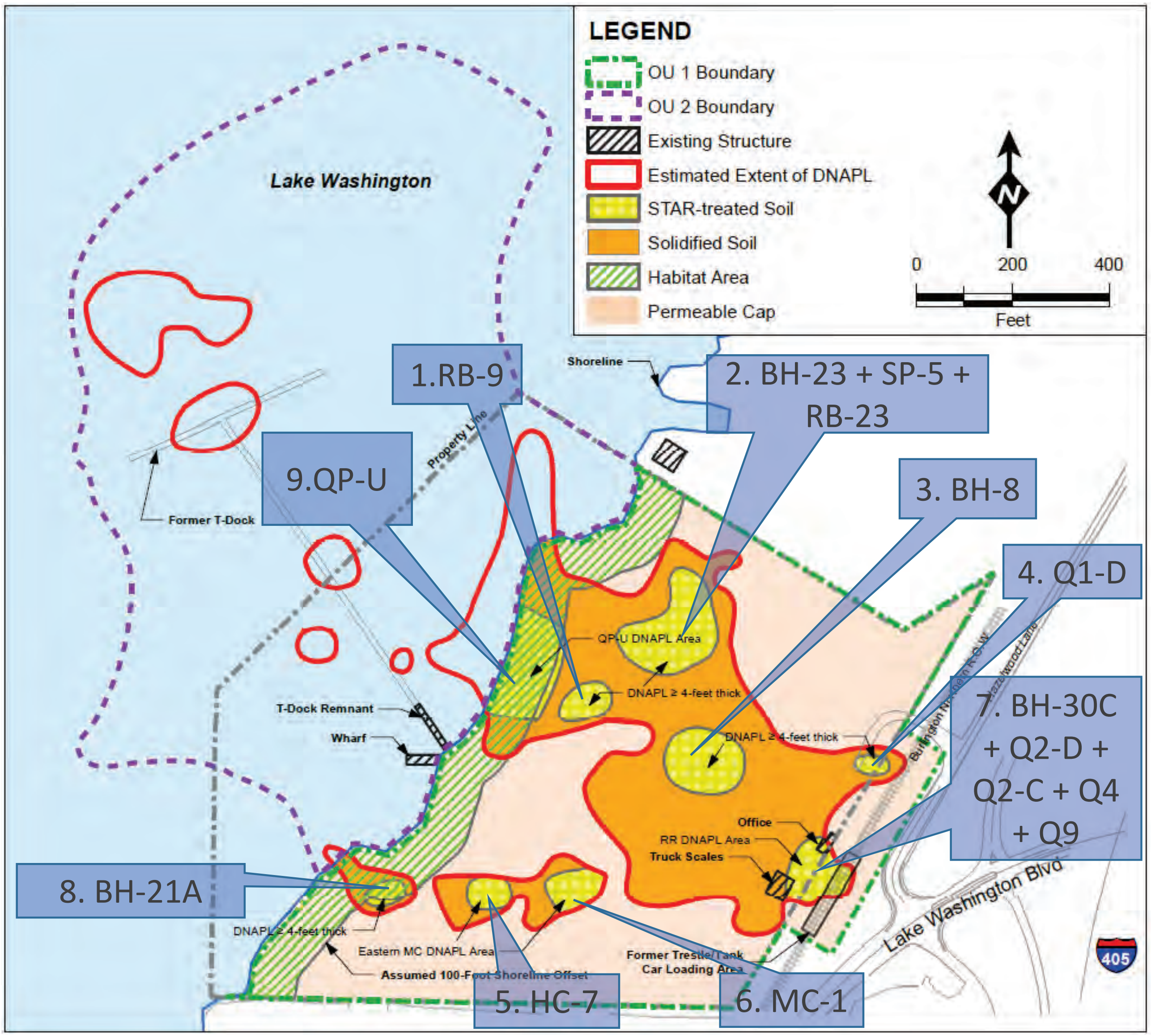
Figures



OU1: STAR Area	Boring ID	DNAPL Bottom Depth (ft)	Thiessen Polygon Area (ft^2)	% of total Area
1	RB-9	20.2	6,694	7%
2	BH-23	24	9,113	9%
2	RB-23	12	6,539	6%
2	SP-5	16	7,037	7%
3	BH-8	12.5	18,456	18%
4	Q1-D	22	5,496	5%
5	HC-7	15	5,455	5%
6	MC-1	31.5	3,840	4%
7	BH-30C	33.7	3,558	4%
7	Q2-C	18	1,868	2%
7	Q2-D	30	1,834	2%
7	Q4	16.5	2,437	2%
7	Q9	25	2,839	3%
8	BH-21A	19	4,773	5%
9	QP-U	18	21,556	21%
		18.7	**101,495**	100%
		Area-weighted DNAPL Bottom Depth	**Total Area**	

Notes:

1. "DNAPL Bottom Depth" data are from FS Table E-7.
2. "Thiessen Polygon Area" data are from FS Tables E-10 through E-12.

Figure B-1

Basis for Smoldering Combustion Treatment Areas

Quendall Terminals Record of Decision

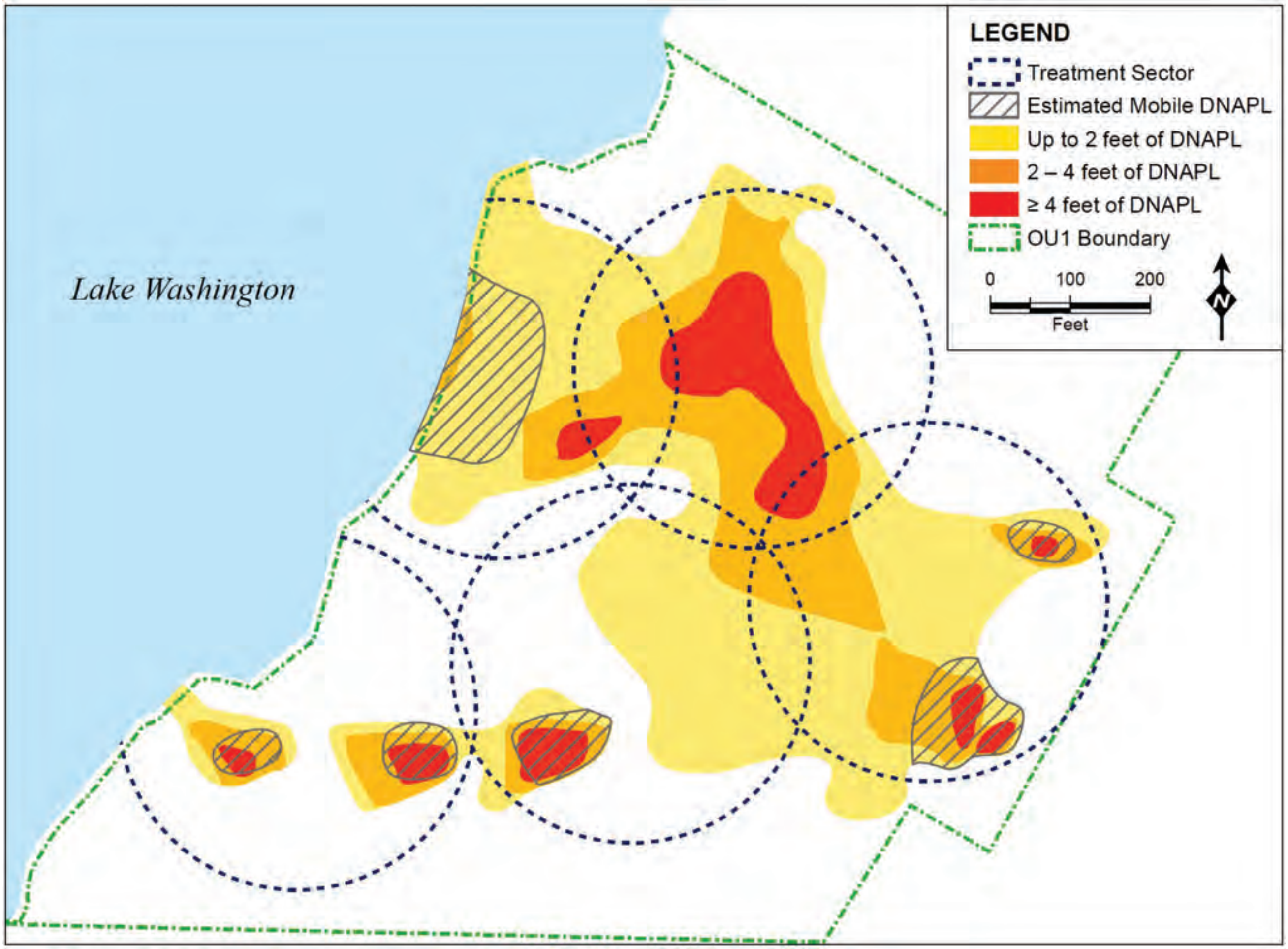
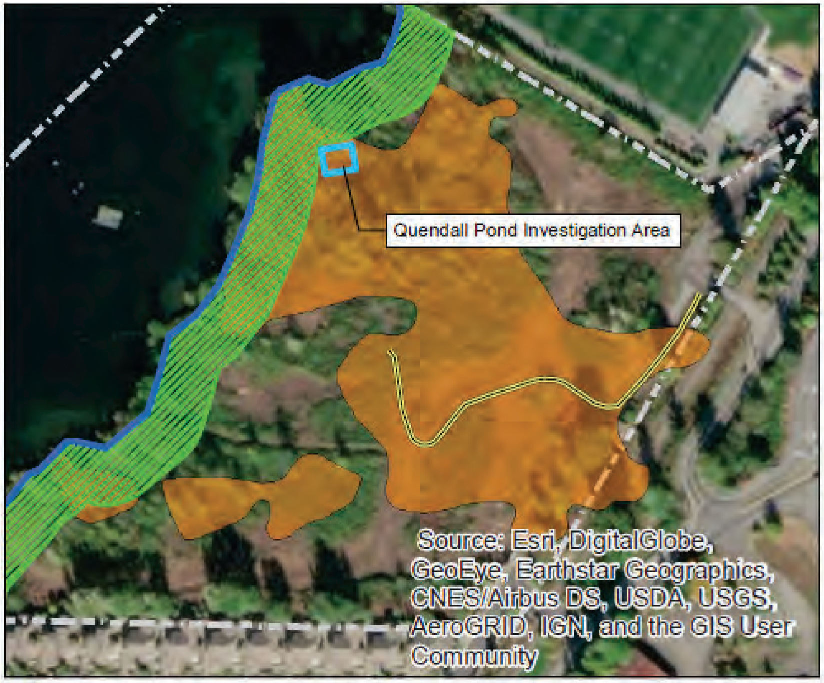
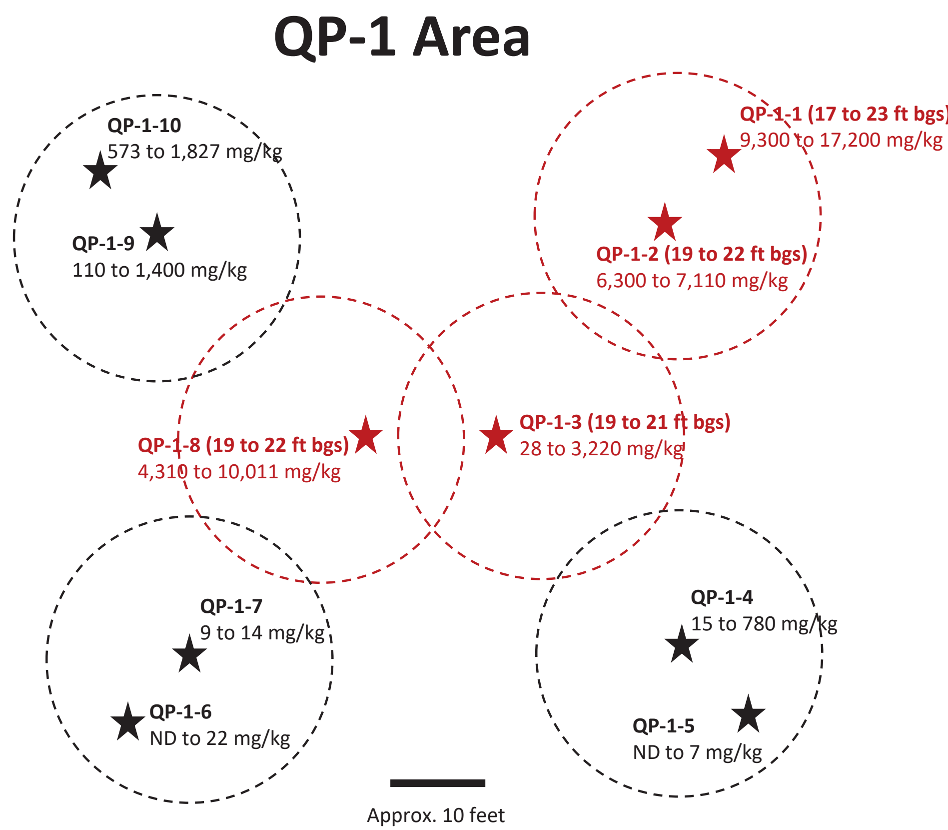


Figure B-2

Smoldering Combustion Treatment Sector Schematic

Quendall Terminals Record of Decision





Base case IPs = 6 (number of circles)
Planned Install IPs = 3

TOTAL = 3 fewer than planned

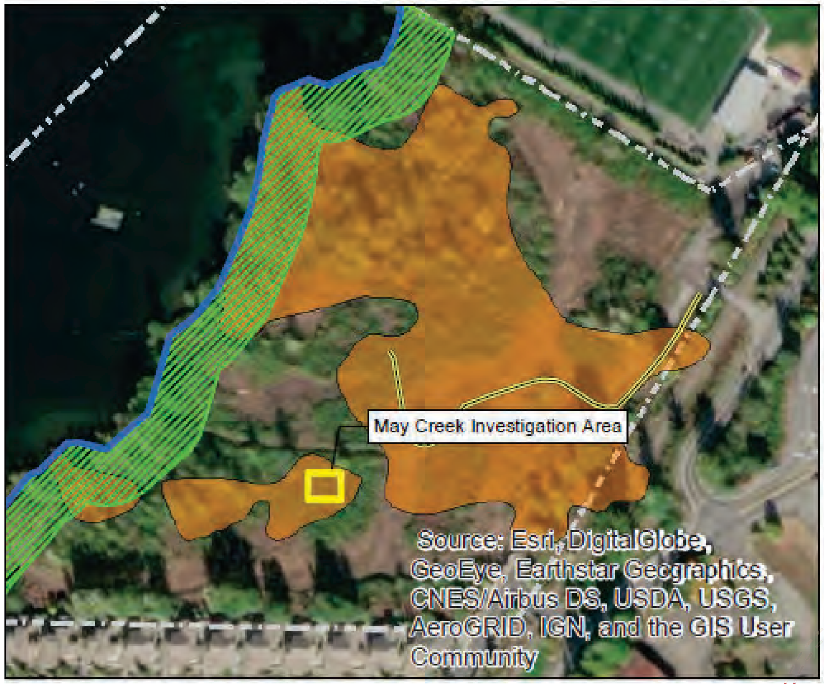
★ Sample with TPH <3,000 ppm

★ Sample with TPH >3,000 ppm

IP = ignition point
TPH = total petroleum hydrocarbons
mg/kg = milligrams per kilogram

= no IP installed
= one IP installed
= two IPs installed, etc.

Figure B-3
Multiple Ignition Point Analysis – Quendall Pond Area
Quendall Terminals Record of Decision

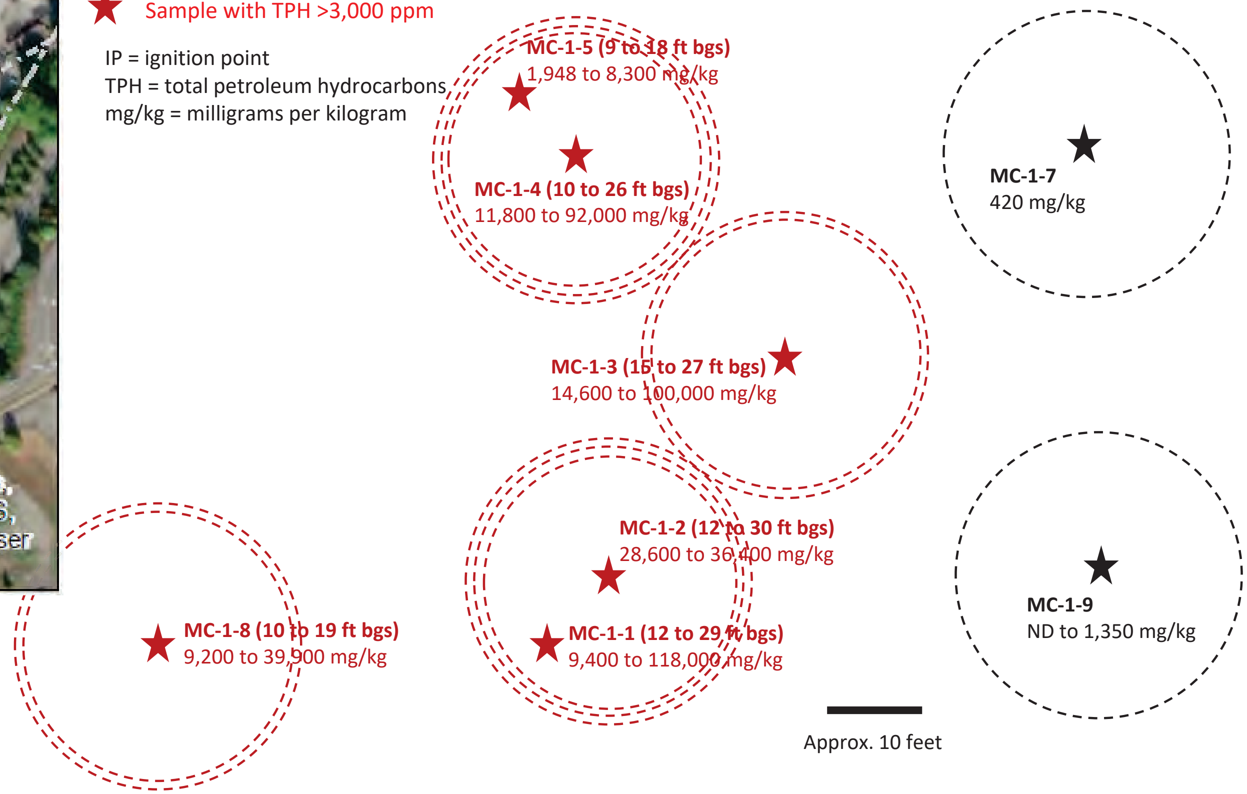


★ Sample with TPH <3,000 ppm

★ Sample with TPH >3,000 ppm

IP = ignition point
TPH = total petroleum hydrocarbons
mg/kg = milligrams per kilogram

MC-1 Area

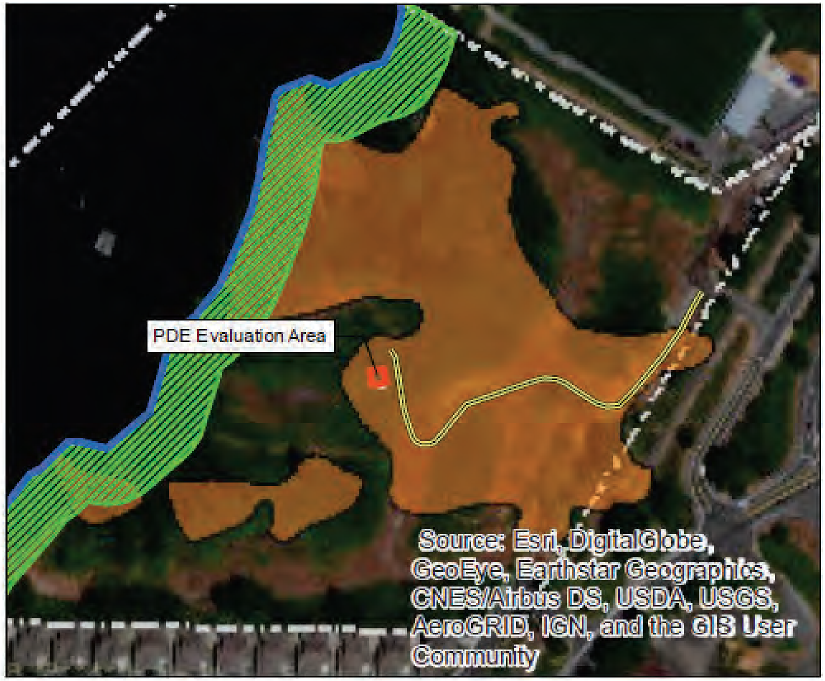


Base case IPs = 6 (number of circles)
Planned Install IPs = 10

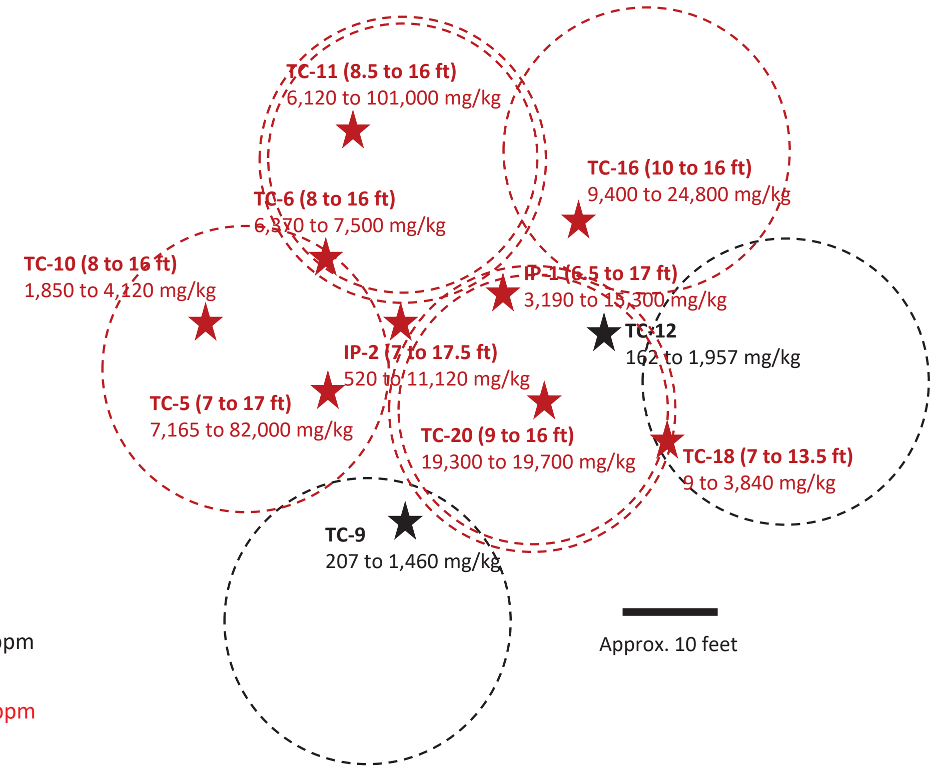
TOTAL = 4 more than planned

= no IP installed = one IP installed = two IPs installed, etc.

Figure B-4
Multiple Ignition Point Analysis – May Creek Area
Quendall Terminals Record of Decision



STAR Pilot PDE Area Schematic



Base case IPs = 6 (number of circles)
Planned Install IPs = 6

TOTAL = same as planned

★ Sample with TPH <3,000 ppm

★ Sample with TPH >3,000 ppm

IP = ignition point
TPH = total petroleum hydrocarbons
mg/kg = milligrams per kilogram

= no IP installed = one IP installed = two IPs installed, etc.

Figure B-5
Multiple Ignition Point Analysis – STAR Pilot PDE Area
Quendall Terminals Record of Decision

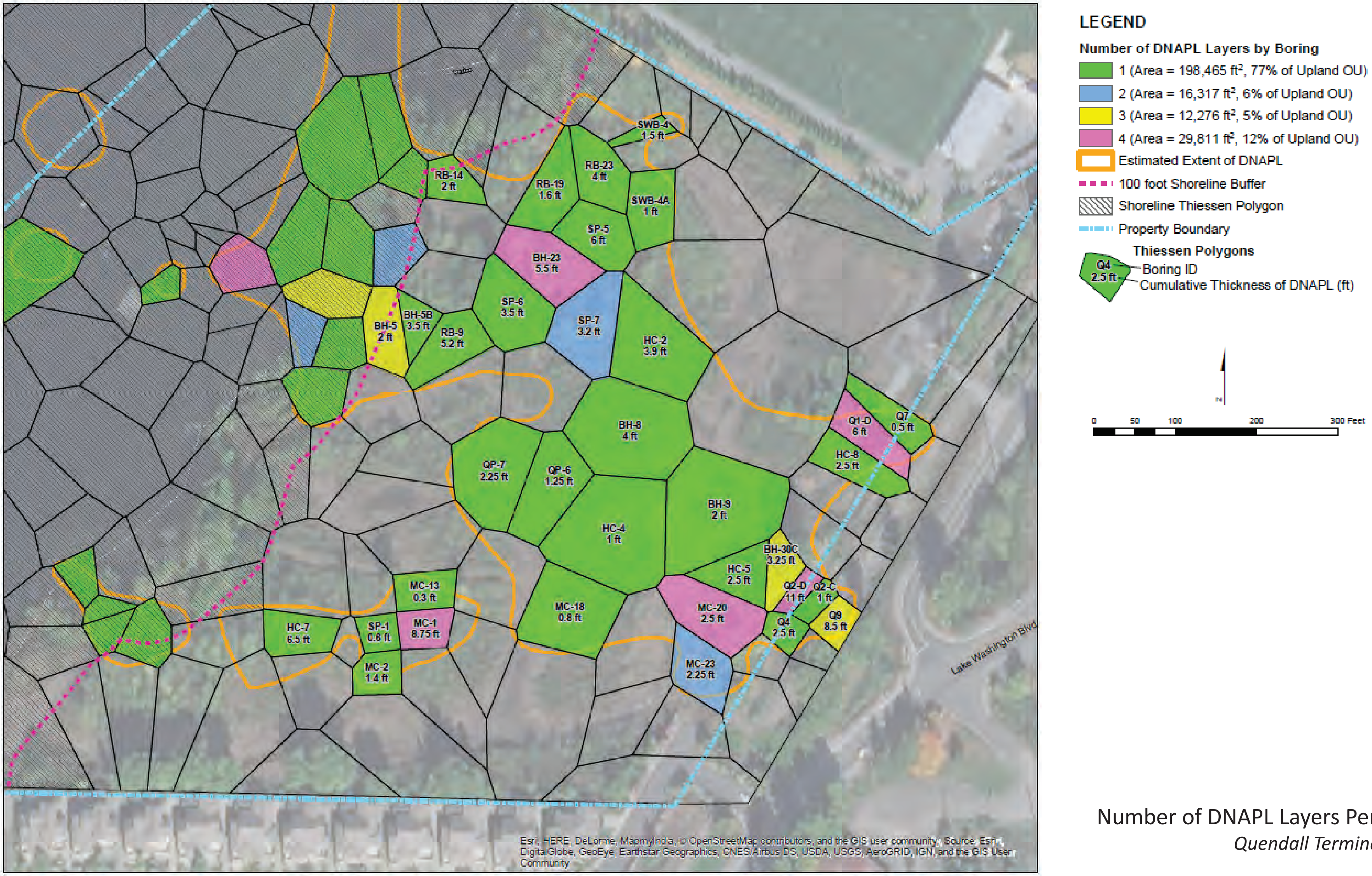


Figure B-6

Number of DNAPL Layers Per Thiessen Polygon

Quendall Terminals Record of Decision

Quendall Terminals Superfund Site Operable Units 1 and 2 Renton, Washington

Part 3—Responsiveness Summary

United States Environmental Protection Agency

U.S. Environmental Protection Agency Region 10

Final
July 2020

PART 3

Responsiveness Summary

The U.S. Environmental Protection Agency (EPA) issued proposed cleanup plans for the two sections of the Quendall Terminals Superfund site (the Site or Quendall Site) on September 9, 2019. Comments on the plans were requested from the public through November 8, 2019.

Robust outreach before and during the public comment period provided the community with opportunities to participate meaningfully in the Superfund decision-making process. See Part 2, Section 3 of this document for a description of EPA's outreach and engagement to the communities around the Site.

During the public hearing, five people provided spoken comments, and overall 27 individuals and organizations provided comments during the 60-day comment period.

Individuals and organizations often included multiple topics within the comments they provided. In order to respond comprehensively to the concerns received, the comments have been grouped by topic and responses are provided to the subcategories within these topics. The main topic categories are:

1. Impacts on the Community
2. Habitat Protection
3. Cost
4. Remedial Technology Selection
5. Smoldering Combustion Technology
6. Groundwater
7. Merits of the Alternatives
8. OU1 Cleanup Timeframe
9. Future Use
10. Miscellaneous

Excerpts from the comments received, and responses, are provided below.

1. Impacts on the Community

A total of seven sets of individual comments on the Quendall Terminals Superfund Site, Operable Unit 1 Proposed Plan (EPA 2019a) and Quendall Terminals Superfund Site, Operable Unit 2 Proposed Plan) (EPA 2019b) (Proposed Plans) were related to impacts on the community. They have been grouped into two subcategories:

- Quality of life
- Controlling emissions and air quality

1.1 Quality of Life

Three sets of comments were received expressing concern for the impact on the community during the cleanup process. Commenters were concerned that a lengthy construction timeframe could affect quality of life as years of traffic, odors, and disruption to the neighborhood may be required.

Commenters noted that they wanted the cleanup conducted in the fastest timeframe possible to restore the Site to a healthy condition for the benefit of the environment and future generations.

#10 *After the underground burning is implemented and doesn't work, EPA will require more than five years of active cleanup construction that will bring more traffic, odors and disruption to the northeast Renton neighborhood.*

#16 *We are looking forward to the hazardous site being restored to a healthy condition to benefit the environment for both animal life and future generations in the area.*

#18 *Act in the fastest timeframe and in a cost-effective manner. We are aware of the huge impact this project will have on the quality of our lives. The time involved to accomplish it matters a great deal.*

EPA Response:

EPA believes the Selected Remedy provides the best balance of protection, effectiveness, and overall cost. EPA also acknowledges that there will be impacts to the community during cleanup, including light to moderate noise, odors, and visual impacts, and a slight increase in traffic from work crews. EPA will coordinate with local residents to limit these impacts to the community.

EPA has tested the smoldering combustion technology and demonstrated that it works at the Quendall Site. Even so, EPA's cleanup strategy allows for the possibility of using in situ solidification (ISS) instead, if smoldering combustion is not successful in the first treatment sector. EPA is committed to complete the cleanup in the fastest timeframe and in a cost-effective manner, to restore the Site to a healthy condition and minimize disruptions to the community. Air monitoring will be conducted during construction and proper measures will be taken as needed.

1.2 Controlling Emissions and Air Quality

Four sets of comments were received regarding odors and air quality during smoldering combustion. Commenters questioned whether emissions from smoldering combustion would be completely captured, or if emissions would cause pollution and odors for the surrounding community.

#3 *I'd like to know how effective that [smoldering combustion] actually is, whether the gases that come up and the byproducts of the burning will actually be completely captured, and if so, where do they go? I'd also like to know if there is a power failure, assuming this is an electrically-operated system, what happens then? The ignition or the burning does not stop if there's a power failure, so I'd like to know that, and so those two things I would like to get some clarity on. Finally, when you talk about odors, what does that mean? How terrible would that be to be nearby and be subjected to the end result of the charcoal type burning? Thank you very much."*

#15 *Smoldering contributes polluting emissions to the surrounding community for long term to achieve the needed elimination of the contaminates. Why add this method of pollution to the population of many homes and commercial sites or anywhere? Isn't that the same as a burning waste dump?*

#17 *Needless to say that when I read your preferred clean-up technique was "smoldering combustion" it caused me great concern. Air quality is very important. How would this smoldering be different than the smoldering we recently experienced?*

#22 *There is no data from the air monitoring of the volatile toxic components of creosote and coal tar in the air near the site. It is assumed that if there are no complains of the odors from neighboring properties there no increase in levels of the toxic components of the creosote and coal tar in the air. The reliance on "odor" complains to assess the level of the toxic components is concerning and it is not enough in this case…The release of toxic components into the air during cleanup activities should be unacceptable in this densely developed area. It is super important that there will be no shortcuts in utilizing all available protective technologies (dust suppression, vapor controls and others) to keep contaminants from leaving the site through the air. The air monitoring at the site needs to be performed to monitor the effectiveness of those protective technologies. Public need to know if the toxic chemicals from creosote and coal tar are detected in the air, at what level and what is the affected radius, even if thereare no complaints of "odors" received. There should be no reliance on just "odors" complains.*

The volatile organic components of creosote and coal tar include highly toxic and carcinogenic chemicals (among them are: benzene, toluene, naphthalene, benzopyrene and hundreds of others). A small increase in levels of those chemicals in the air can pose a risk even before the odor threshold is reached. The CDC website mentions that "most individuals can begin to smell benzene (one of the creosote components) in air at 1.5 to 4.7 ppm. The odor threshold generally provides adequate warning for acutely hazardous exposure concentrations but is inadequate for more chronic exposures". OSHA permissible exposure level for benzene exposure (TWA 8-hour) is 1 ppm. Effects of chronic and repeated exposure to benzene include leukemia, developmental and reproductive problems.

Currently, the contaminants are in thick liquid form concentrated deep in the soil and in the lake sediment. During the cleanup activities, when contaminants will be brought to the surface, the volatile components are expected to get into the air and the "odors" will be produced. It is a real public concern as there is no safe level of exposure to carcinogens, developmental and reproductive toxins.

EPA Response:

EPA is committed to making sure the cleanup process has minimal impact on neighboring communities. Plans for air monitoring, vapor capture, and vapor treatment will be developed during remedial design, and these controls will be implemented during construction. One of the reasons EPA selected smoldering combustion as the primary component for the upland remedy is that the smoldering occurs underground, primarily beneath the water table. The combustion process converts the coal tar and creosote chemicals into carbon dioxide, carbon monoxide, and water, which are then captured and treated as part of the process. It is unlikely that neighbors will notice any significant odors or vapors from the combustion process, which would smell like mothballs from the creosote or diesel from the generators used to power the smoldering combustion treatment. The generators would be used for heating as well as air flow. If the power is interrupted, the air flow stops, and burning will stop.

However, backup generators will be onsite and the ignition process can be restarted, or, a new ignition point (IP) may need to be installed.

To capture and treat the vapors, a vapor barrier (for example, asphalt) will first be installed on the ground surface, then vapors generated underground will be captured using vapor extraction wells installed in the subsurface. The vapors are then piped directly to an onsite treatment system. The exhaust of the onsite treatment system will be monitored and will comply with air quality standards that ensure public safety. No smoldering will be done above the ground surface.

ISS may also be used to treat some of the coal tar and creosote sources at the Quendall Site. During ISS, contaminated materials may be brought to the surface during the mixing process. EPA's experience at other sites where ISS is used to address coal tar and creosote indicates that active vapor management will be required. EPA has planned for that (for example, use of shrouds or temporary structures to surround the mixing augers and allow capture and treatment of vapors).

2. Habitat Protection

Four sets of comments on the Proposed Plans were related to habitat protection. They have been grouped into three subcategories:

- Support for fish populations
- Lake water quality
- Light pollution

2.1 Support for Fish Populations

One comment was related to habitat restoration. The commenter would like to see the Site restored to its natural function that includes supporting salmon habitat.

#14 *We also want to see this site restored to its natural function supporting salmon habitat and the sockeye, coho, and chinook runs that utilize it.*

EPA Response:

The habitat needs of juvenile Chinook salmon were an important focus when EPA evaluated alternatives. Habitat needs will be developed and approved in concert with EPA, the natural resource agencies, and the Muckleshoot Tribe, and documented in remedial design planning documents.

- The following assumptions regarding habitat were made during Operable Unit 2 (OU2) (in-water) alternative development and evaluation:
- The habitat area of Operable Unit 1 (OU1) will consist of a 100-foot-wide corridor along the shoreline.
- In-water work, such as sediment capping, dredging, backfilling, and sheet pile installation, will occur during the allowable in-water work window when Endangered Species Act-protected juvenile Chinook salmon are not migrating through the area.
- Remedy implementation will result in no net loss of aquatic habitat or function. This will be accomplished by maintaining the existing natural contours (bathymetry) near the shoreline. Lake Water Quality.

2.2 Lake Water Quality

Two sets of comments were received focusing on lake water quality. Commenters noted that it is important that the cleanup process does not diminish the quality of the lake water and pose a health risk for people who fish and play in the lake.

#6 *My primary concern is that the clean-up process does not in any way diminish the quality of the lake water during the clean-up or after.*

#18 *Stabilize and control the contamination on behalf of the public and the environment. You have convinced us that there is a health risk here. I watch people fish every day, and they eat the fish. Our children and grandchildren play in the water - we all do.*

EPA Response:

EPA recognizes the value of Lake Washington as an important resource for recreational play and fishing. It is also a Usual and Accustomed fishing ground used by the Muckleshoot Tribe. To that end, EPA is implementing a remedy at the Site that removes coal tar and creosote, in order to provide a long-term and permanent solution to the contamination in the lake from the Quendall Site. Treatment of dense nonaqueous phase liquid (DNAPL) in the uplands will reduce the load of contamination being transported from the uplands to the lake. Removal of DNAPL from the lakebed will ensure that it does not continue to act as a source of contamination to sediment.

Water quality impacts from capping and dredging will be reduced as much as possible. Silt curtain/oil boom controls will be used during hydraulic dredging in the aquatic area. Barrier containment with sheet piles will be placed around mechanical dredge areas in the inner harbor.

As with all active construction projects, there will be some short-term tradeoffs during the process that may impact water quality during construction. In-water work will comply with regulations designed to protect surface water during construction and best management practices will be employed to minimize these short-term impacts.

2.3 Light Pollution

One comment was received concerning potential light pollution impacting salmon during and after development.

#14 *We are also concerned about potential light pollution impacting salmon during and after development. We want to limit or eliminate that pollution. I know this will be more directly impacted after the site is cleaned up and as it's developed.*

EPA Response:

During the cleanup, light pollution will be held to a minimum. Some degree of lighting will be needed during night-time hours during the smoldering combustion implementation because the process is continuously operated.

While EPA's selected cleanup remedy will make the Site suitable for redevelopment, EPA does not have jurisdiction over redevelopment decisions. Those activities are managed at the local level.

3. Cost

A total of 25 sets of comments on the Proposed Plans were related to remedy costs. They have been grouped into four subcategories:

- Cost difference between alternatives
- Cost burden
- Delay of development
- Uncertainty/underestimated costs

3.1 Cost Difference Between Alternatives

Five sets of comments were received suggesting that the Selected Remedy would cost significantly more than other alternatives that were equally protective.

Aspect Comments #26 *However, ISS has often been implemented in similar settings with no special odor control without causing unacceptable vapor impacts. Even if odor control were required, the cost for such controls (e.g., contained, temporary structures with air collection and treatment) would be much lower than EPA estimates (approximately $5M for Alternative 7, rather than the $22M EPA included). If a more reasonable cost estimate for ISS were applied and a reasonable contingency included, Alternative 7A would be significantly more costly than Alternative 7 – approximately $23M more.*

#4 *I've dealt with a couple different sites where we had contaminant, one with gasoline in Seattle that was cleaned up prior to our purchase at the cost of millions of dollars. Then after we purchased it, we spent millions of dollars hauling that same material back out that had been filled in. It makes no sense to clean this up without a development being done at the same time. That's the way we developed the Barby Mill community into 113 homes, but if I had it to do all over again with what I was run through with DOE and EPA at the last minute before we were delivering homes, I wouldn't do it again. There was a lot of moving of the goal post at the last minute that prevented people from moving into their homes on time, et cetera.*

#8 *Cost. EPA's preferred alternative will cost three times the amount of other EPA-approved alternatives, exceeding the value of the property and making redevelopment difficult if not impossible.*

#10 *EPA agrees that cleanup alternatives costing one-third as much are protective of human health and the environment and would facilitate the cleanup and redevelopment in a reasonable timeframe.*

#25 *The only way this property will be cleaned up is if the development process can help to cover the costs.*

EPA Response:

EPA's Selected Remedy for OU1 (Alternative 7a) is estimated at $66.1 million versus estimated costs ranging from $100 million to $309 million for Alternatives 8 through 10. Only Alternative 7, estimated at $66.0 million, is estimated to be less costly, but only slightly so.

Based on experience at other coal tar/creosote sites, EPA reevaluated costs associated with ISS following completion of the Feasibility Study (FS) (Aspect and Arcadis 2016), prior to issuing the Proposed Plan for OU1. These revised ISS costs were used to update Alternative 7 and create Alternative 7a cost estimates. Through that evaluation, EPA determined that, given the close proximity of the residential and commercial properties adjacent to the Site, a number of additional safeguards and provisions consistent with other Superfund sites in residential areas would be needed to minimize construction-related impacts to the public. These include the following assumptions:

- During this operation, a vented shroud would be used over each mixing column to actively collect (via vacuum) and direct volatile contaminants and nuisance odor to a treatment unit. Considering the nature of Site contaminants, use of a thermal oxidizer to treat recovered vapors during mixing is assumed. It is further assumed that ISS operations would be supported by a small standalone thermal oxidizer sized to accommodate a vapor flow of 1,000 to 2,000 standard cubic feet per minute.
- As assumed by the FS, an 8-foot-diameter mixing auger would be used for ISS operations. This equipment would be used with a vapor extraction shroud that is 1 to 2 feet greater in diameter than the mixing auger. Consistent with costing assumptions used in the FS, the daily ISS production rate was estimated to be 600 cubic yards on average with a projected project duration of 24 months. As required at the completion of each working day, a coating of foam would be applied to control emissions and odors in the ISS work areas.
- Another provision for vapor control was also developed for ISS of areas near property boundaries or areas where contaminants are present in greater thicknesses. Nuisance odor generated by ISS operations in these areas would be controlled through the use of a portable enclosure. It was assumed that ISS of 10 percent of the total volume of ISS-treated materials would occur within a temporary enclosure.
- During ISS and operations, it is assumed real-time air monitoring would be required within the work area. At the Site perimeter, an ambient air monitoring program would be established for discrete sample collection with offsite laboratory analysis. It is assumed that 24 months of air monitoring will be required. A total of ten air monitoring stations would be deployed, five real-time within the work area and five at the perimeter of the Site. Air sampling would be conducted monthly from five stations during ISS operations.

In addition, subsurface conditions at the Site are highly heterogenous. Physical obstructions including reinforced concrete foundations, structural steel, piping, and general debris are likely to be encountered during ISS operations. Obstructions large enough to prevent ISS equipment operation are presumably present based on available boring log and test pit observations. For this reason, provisions to remove obstructions as encountered during ISS operations were integrated into the unit cost development. For the purposes of estimate development, it was assumed that ISS of 15 percent of the total volume of ISS-treated materials would require obstruction removal. Unit costs for obstruction removal factor equipment and labor to remove and manage the subsurface obstruction plus movement and downtime for the ISS operation.

Finally, comments stating that cleanup alternatives costing one-third as much (about $20 million) have been approved by EPA and are protective are presumably referring to Alternatives that were presented in the FS that were not carried forward into the Proposed Plan. These include Alternatives 2 through 6, which ranged from containment (capping) to various degrees of targeted DNAPL treatment or removal.

EPA determined Alternatives 2 through 6 did not meet the RAO to restore groundwater to its highest beneficial use (OU1, RAO 2) and associated ARARs. These alternatives were not carried forward into the Proposed Plan.

3.2 Cost Burden

Six sets of comments were received regarding the cost burden of the cleanup. Commenters were concerned with how costs would be allocated to both the public taxpayer and to the current owner. Commenters suggested that the high cost could bankrupt the owner and would halt development.

#30	*My specific concern is of the costs related to the clean up, the 66.1M associated with Alternative 7a, and 39.9M under Alternative D. How are these costs to be allocated?*
#2	*No matter who's expected to pay this cost, whether it be the property owners, the past owners, some grant fund, the original polluters or we the taxpayers working with the EPA, this solution must be cost effective. Otherwise, it will never be implemented. If the plan is adopted, the likelihood of this site getting cleaned up and redeveloped is yet again dead. We all need an implementation solution*
#10	*The company originally responsible for the contamination (Reilly Tar & Chemical/Vertellus) went bankrupt in large part because of EPA's outrageous approach to this site. As a result, the local family businesses that own and want to develop the property (but never caused the contamination and can't pay for the cleanup) cannot do so.*
#13	*Can you or someone else tell me of the 106M or so cost to implement the EPA cleanup plans what will the current owners liabilities be out of the total cost? I have read and spoke with several friends who work in the environmental field along side the EPA that Mr. Cugini's holding company and partner owners would only be liable for around 10% of the total cost?"*
#20	*Or does it become a burden on EPA and ultimately the taxpayer? will there be a fund required from any potential post-cleanup owners to mitigate future claims regarding the site?*
DNR #19	*DNR should not be a potentially responsible party. This is evident upon close examination of the history of ownership and management of State owned aquatic land (SOAL) within the Site boundary. About two thirds of the aquatic land included within the boundary of Operable Unit 2 (OU2) is owned by the State of Washington.* *Please provide an estimate of the cost of the preferred remedy on SOAL. Include supporting documentation, such as unit cost assumptions and calculations.*

EPA Response:

The Proposed Plans and the Record of Decision (ROD) provide the basis for and description of the remedy for the Quendall Site. They do not address issues of liability or enforcement. EPA agrees that parties responsible under the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), commonly known as Superfund, should pay for the cleanup, consistent with EPA's long-standing "polluter pays" policy. Limited appropriated (taxpayer) funds for cleanups are typically used for sites where there are no viable responsible parties. Under CERCLA, EPA searches for parties legally responsible for the contamination and seeks to hold those parties accountable for the costs of investigations and cleanups, requiring them to perform or fund the necessary investigations and remediation. EPA has followed this approach for Quendall Terminals.

EPA continues to support a comprehensive allocation of liability by the responsible parties at the Site to facilitate settlements that implement the selected cleanup actions. Separate cost estimates that may be allocated to different responsible parties will not be provided in the ROD.

3.3 Delay of Development

Seven sets of comments were received expressing frustration with the cost of the remedy and its effect on the development timeline. Commenters suggested that the high cost of the Selected Remedy is not economically feasible, and the cleanup cannot be funded without redevelopment within a reasonable timeframe.

#2	*Two, the estimated cost of the cleanup is egregiously impractical and will never happen.* By simply dividing the estimated sum of 106 million into the net developable area, that which you can actually work with, which is approximately 18 and a half acres, one can *quickly see that the cleanup cost is 5.7 million dollars per acre or $130 per square foot. We have nothing in our region that comes to those kinds of per square costs.*
#8	*EPA's preferred alternative will take too long to implement, which will delay and potentially imperil the redevelopment of the property. The development plans for the property have been approved by the City of Renton, but time is of the essence because the right to develop the site will expire if the site is not cleaned up and 51 percent occupied by 2027….The cleanup of the site cannot be funded without the redevelopment of the property. EPA's preferred alternative will stymie redevelopment because its alternative is too expensive, too uncertain as to cost and schedule, and doesn't offer any flexibility to a developer.*
#10	*After decades of investigation, the environmental community deserve a cleanup plan that can be implemented quickly and effectively. Unfortunately, EPA's plan will only further delay site remediation, natural habitat restoration and upland economic development. The site has languished too long and the community deserves a cleanup that can occur within a reasonable timeframe and at a cost that will avoid lengthy litigation and delay of future economic development. EPA's proposed plan will take too long to implement, cause terrible disruption to the community, delay the future development and costs three times more than other alternatives that are also protective.........EPA's preferred alternative far exceeds the value of the property. EPA is choosing an alternative it knows can't be implemented anytime soon….Before a developer will commit over one-half billion dollars in resources, it must have confidence that the cleanup and habitat restoration can be accomplished in a timely manner and at a verifiable and reasonable cost.* *The cleanup and redevelopment are closely linked — the cleanup cannot be implemented without the funding from a buyer that will develop the property. A recent prospective buyer walked away because EPA is proposing a cleanup that is too expensive and too uncertain as to cost and schedule.*
#18	*All consideration should be afforded the property owners. They did not cause the contamination and they are asking to be allowed to clean-up the site.* *We ask that the EPA reconsider and select the containment clean-up method. This can be accomplished in a much shorter time frame and for half the costs.*
Tim Flynn #5	*The high cost of this proposed remedy is just not economically feasible for site redevelopment, and that has been the aim at least of the ownership group for some time.*
Robert Cugini (Oral) #1	*… there is no way for us to market this property and therefore provide funds for the cleanup. One potential owner has already pulled out of negotiations on this property due to EPA's unwillingness to recognize what it takes to actually make a brown field opportunity of this magnitude a reality….We deserve an alternative that can be implemented, paid for in part by the sale of the property and constructed in the next few years.*
Robert Cugini (Written) #21	*EPA's preferred alternative far exceeds the value of the property and as a result, the remedy will not be implemented anytime soon….The cleanup and redevelopment are closely linked — the cleanup cannot be implemented without the funding from a buyer that will develop the property. A recent prospective buyer walked away because EPA is proposing a cleanup that is too expensive and too uncertain as to cost and schedule. No developer will commit over one-half a billion dollars in resources, unless it can have confidence that the cleanup and habitat restoration can be accomplished in a timely manner and at a verifiable and reasonable cost.*

EPA Response:

Under CERCLA, EPA must choose a remedy that is protective and complies with applicable or relevant and appropriate requirements (ARARs). Of the alternatives that meet these threshold criteria, Alternatives 7 and 7a are the least expensive and can be completed in approximately 5 years, including remedial design. Alternative 7a is considered by EPA to be more permanent in the long-term as it destroys contaminants rather than sequestering contaminants with solidification. By comparison, under Alternatives 8 through 10, the construction duration would likely double the costs of 7 and 7a.

3.4 Uncertainty/Underestimated Costs

Seven sets of comments regarding cost uncertainties or underestimation were received. Several commenters expressed concern for the general uncertainty of smoldering combustion and the impact those uncertainties would have on total cost of implementation. More specifically, commenters noted that the radius of influence of smoldering combustion, the heterogeneity in subsurface conditions, and the total number of IPs were all uncertainties that have cost implications for the remedy. Lastly, several commenters were concerned that if smoldering combustion was not effective, then the area would have to be retreated using ISS, resulting in high costs.

Geosyntec Comments #28 *The PP should provide a more comprehensive analysis of the cost bounds and potential duration of remedy implementation. The PP should provide the basis for the assumed proportions treated by STAR versus ISS and evaluate the implications of uncertainty in the assumed distribution of DNAPL proportions addressed, the potential need for additional ignition points either laterally or vertically, and the potential need for multiple STAR applications on the cost bounds for Alternative 7a. This analysis should accurately reflect the findings of the STAR pilot study.*

Similarly, the cost implications of potential changes in the volume and areas targeted by STAR versus ISS are not discussed in the PP. Table B-2 in Appendix B shows the assumed volumes to be treated by STAR or contained by ISS, but volumes do not appear to overlap; i.e., the PP does not consider cost increases due to any required application of ISS in areas already treated by STAR, which the PP states may be needed. Additionally, no technical justification is given for assuming that ISS will be used in areas with DNAPL thickness less than 4 feet, while— presumably—STAR will not be applied in those areas, yet the areas included in the STAR sectors encompass areas with DNAPL thickness less than 4 feet.

Additionally, the PP does not discuss the cost implications of SAVRON's strategy for addressing uncertainty regarding the total number of ignition points required for treatment at the site or for the potential need for multiple rounds of treatment. The STAR pilot study report noted that "there are two key uncertainties that will affect the total number of ignition points required for treatment at the Site: variability in the distribution of contaminant concentrations sufficient for self- sustaining smoldering (i.e., greater than 3,000 to 5,000 mg/kg for IP installation) [which also influences the radius of influence of individual ignition points], and presence of multiple layers of contamination requiring more than one ignition point (IP) installation depth at a given location." The total costs for STAR treatment may increase or decrease from the base case, depending on the balance of these two uncertainties across the Site.

Geosyntec also recommends the PP accurately reflect the findings of the STAR pilot study and explicitly consider the potential need for more STAR ignition points in areas of heterogeneous DNAPL distribution in the calculation of overall costs.

Aspect Comments #26 *The cost estimate is based on flawed technical and implementation assumptions that are inconsistent with the pilot testing results and heterogeneity of the subsurface conditions and contaminant distribution at the site. It also lacks appropriate contingencies, and the timeframe does not include time for mobilization, installation, and decommissioning or the likely application of in situ stabilization (ISS) in areas that do not achieve adequate treatment.*

The STAR cost estimate is highly uncertain because (1) It is sensitive to radius of treatment and the radius of treatment assumed was not confirmed during the pilot test. (2) It failed to consider the multiple layers of DNAPL that will require a significant number of additional ignition points (see Attachment G).

	Rather, the STAR estimate assumes a very optimistic basis for cost estimating considering the STAR-specific uncertainties identified in the STAR Pre-Design Evaluation Report (e.g., variability of contaminant concentrations and need for multi-level injection points). For instance, Table B-3 uses a STAR treatment area of 101,495 square feet, approximately 25 percent of the full-scale treatment approach in the STAR Pre-Design Evaluation Report, which assumed a treatment area of 420,865 square feet …there are more general uncertainties (e.g., the delineation of DNAPL occurrences and the total soil volume requiring treatment) that require characterization during pre-design or design studies. In the FS cost estimate, an overall contingency was added to each technology to account for these uncertainties, varying between 25 percent and 35 percent depending on the technology. If a 30 percent contingency were included (which was included for ISS), this would add $6 million (M) to the cost estimate. Given the uncertainty in the STAR cost and the high potential that STAR-treated soil will need to be solidified to meet EPA's objectives, a much higher contingency is warranted further increasing the cost estimate.
Landau Comments #27	*There are also significant variations in the unit cost for stabilization, depending on which admixture is required to adequately stabilize DNAPL-affected soil and protect groundwater. Costs for FS remedial alternatives that include solidification are based on a generic cost for auger mixing with cement. If cement is not effective or not selected due to the reasons stated above, stabilization costs could be $1M to $10M higher than estimated in the FS cost estimates if an admixture other than cement (such as activated carbon or organoclay) is required.*
#8	*Uncertainty. The extra cost and time associated with the unproven STAR technology creates a level of uncertainty that will make it difficult to attract a developer willing to undertake the remediation of the site.*
#10	*Because the effectiveness of STAR is unknown, the actual cost of EPA's plan is expected to be significantly higher than the $100 million estimate and take three times longer than other protective alternatives.* *After STAR is implemented and does not work, EPA will essentially end up with the same result (treatment of potentially mobile contamination and containment) but only after wasting tens of millions of dollars.*
Robert Cugini (Written) #21	*Because the effectiveness of STAR at this site is questionable based on pilot test results, the actual cost of EPA's plans are expected to be significantly higher than the $100 million estimate and take three times longer than other protective alternatives.*
Tim Flynn #5	*The STAR cost estimate is low and based on very optimistic implementation assumptions that do not account for the potential need of coming back in with solidification in areas that STAR is ineffective, whereas the solidification costs we believe are high.*

EPA Response:

Appendix 2B of the ROD provides the basis for smoldering combustion costs of $14.9 million presented in the Proposed Plan. The appendix details the rationale for estimating the proportions of the DNAPL area that would be treated by smoldering combustion versus ISS and the rationale for the number of IPs given the presumption that in some areas, multiple IPs will be needed to treat DNAPL at depth. The data and findings presented in Appendix 2B are based on the results of the Self-sustaining Treatment for Active Remediation (STAR [smoldering combustion]) pilot study conducted at Quendall in 2018. The radius of treatment (called radius of influence) and smoldering front propagation rates used in the cost estimate were determined based on pilot study results, as reported in the *Self-sustaining Treatment for Active Remediation (STAR) Pre-Design Evaluation (PDE) Report* (Savron 2018).

As described in Appendix 2B, the Proposed Plan cost estimate assumed that smoldering combustion would be applied in areas with mobile DNAPL (Railroad Area, May Creek Areas, and Quendall Pond Upland Area) and cumulative DNAPL thicknesses of greater than or equal to 4 feet. Pretreatment characterization (as described in ROD Part 2, Section 12.2.1) will be used to identify the actual areas amenable to smoldering combustion treatment.

EPA understands that a key concern from commenters is that areas treated with smoldering combustion may need to be retreated with ISS. The ROD clarifies that pretreatment characterization data will be used to delineate separate treatment sector boundaries for smoldering combustion and ISS. Therefore, retreatment (with multiple technologies) would not be considered a factor that would increase the implementation costs or timeframe.

Appendix 2B in the ROD also specifically addresses concerns with the estimated cost of treating multiple layers. The field pilot study findings indicated that, within a given treatment cell with multiple layers of contamination, there is variability even at a small scale (5 to 10 feet) in the distribution of the DNAPL, such that within a cell, some IP locations within that cell would not need treatment (based on total petroleum hydrocarbon [TPH] concentrations below 3,000 ppm). In other words, the number of IPs that would not need to be installed based on lower TPH concentrations is approximately balanced by the number of additional IPs that may be required to address multiple layers of contamination at depth. Appendix 2B includes figures showing the data used to support this conclusion.

Costs for mobilization, installation, and decommissioning are included in the $14.9 million estimate for smoldering combustion; however, the time for these items is not included in the operational estimated schedule from the vendor. It is assumed that mobilization and installation/shakedown would be accomplished in about 2 months, which is within the general uncertainty around the construction timeframe. A contingency of 25 percent was also included for STAR as part of the $14.9 million estimate.

The basis for the STAR treatment area of 101,495 square feet used for the Proposed Plan cost estimate is also detailed in Appendix 2B and, as noted above, is based on areas with mobile DNAPL or cumulative DNAPL thickness greater than or equal to 4 feet. As a commenter noted, the *Self-sustaining Treatment for Active Remediation (STAR) Pre-Design Evaluation (PDE) Report* (Savron 2018) includes a section that presents a "conceptual approach" full-scale implementation within the entire region defined as the "estimated extent of DNAPL" that encompasses 420,865 square feet. This conceptual approach section was included in the STAR PDE Report as a starting point used for development of the strategy presented in the Proposed Plan. The Proposed Plan assumed that some subareas within the 420,865-square foot DNAPL area would be more conducive to smoldering combustion treatment, and other areas may either be more conducive to ISS, or not require treatment based on high-resolution site characterization (HRSC) pretreatment data. The ROD includes incorporation of pretreatment characterization using an HRSC method, such as TarGOST, as specifically suggested in the STAR PDE Report.

Regarding the concern that the "STAR sectors encompass areas with DNAPL thickness less than 4 feet": a treatment sector simply defines the area that can be reached by a single STAR treatment unit. It does not imply that all of the areas within the sector will be treated. The areas for treatment within each sector are defined by whether or not TPH concentrations are above 3,000 milligrams per kilogram.

EPA agrees that costs for ISS could increase if more complex admixtures (amendments) are needed to address DNAPL and contaminant leaching. To address uncertainties related to ISS, EPA adjusted the assumptions for ISS during the development of the Proposed Plan to account for additional vapor capture and treatment, and associated monitoring. The 30 percent contingency calculated based on the higher ISS unit cost may encompass unexpected costs related to amendments.

The concern that this remedy will cost more and take 3 times longer than other "protective alternatives" presumably refers to alternatives that were presented in the FS that were not carried forward into the Proposed Plan. These include Alternatives 2 through 6, which ranged from containment (capping) to various degrees of targeted DNAPL treatment or removal. EPA determined Alternatives 2 through 6 did not meet the RAO to restore groundwater to its highest beneficial use (OU1, RAO 2) and associated ARARs. These alternatives were not carried forward into the Proposed Plan for OU1. Of the alternatives carried into the Proposed Plan, Alternative 7a provides the best tradeoff in terms of overall protectiveness, cost, and construction timeframe.

4. Remedial Technology Selection

A total of 27 sets of comments on the Proposed Plans were related to remedial technology selection. They have been grouped into seven subcategories:

- Baseline data
- DNAPL treatment
- Dredging
- In situ solidification
- Capping
- Selected remedy versus other alternatives
- Miscellaneous

4.1 Baseline Data

One comment was received asking why there is no baseline data at this point in the process.

#4	*I don't understand why there's no baseline data yet and why that's the start of this process after 20 to 30 years in the process*

EPA Response:

The Quendall Site has been well characterized in terms of understanding the general extent of DNAPL and associated contaminants of concern in upland soil and lake sediment, and the extent of contaminants in groundwater beneath the Site. However, once a remedy is selected, it is not uncommon to need to collect additional data to refine assumptions during remedial design.

Note that EPA has refined the baseline (pretreatment) characterization approach in the ROD to include collection of HRSC data instead of groundwater mass flux data. The HRSC is needed to decide where to install smoldering combustion IPs and will also be very useful in deciding which areas may require treatment by ISS.

The refined pretreatment characterization approach is detailed in Section 12 of the ROD and discussed as a refinement in Section 14 of the ROD.

4.2 DNAPL Treatment

Five sets of comments were received focusing on the treatment of DNAPL at the Site. Commenters noted that although Region 10 states all principal threat waste (PTW), such as DNAPL, will be treated, specific situations may limit the use of treatment, such as nonmobile contamination or low-toxicity. Commenters suggested that active treatment of all DNAPL at the Site is not warranted given its low mobility, and containment is more applicable than active treatment.

Aspect Comments #26	*Not all DNAPL-impacted materials require active treatment. EPA's plan to treat or remove all dense non-aqueous phase liquid (DNAPL)-impacted materials overestimates the actual risks posed by these materials. Much of the DNAPL at the site can be reliably contained while providing less impact to the community and workers than extensive removal or treatment.* *Region 10 has broadly defined principal threat waste (PTW) as all creosote- and coal tar- impacted materials, regardless of their potential mobility and risk of exposure, and has included in the Proposed Plan active treatment of all PTW. This is inconsistent with EPA policy and application at other sites (see Attachment F) and leads to a much more aggressive remedy than is warranted. Most DNAPL at the Site has low mobility and can easily and safely be contained in place. In fact, more aggressive techniques—such as ISS under the OU1 Proposed Plan or the extensive dredging called for by the OU2 Proposed Plan—will result in more significant impacts to the community and the natural environment than if these materials were contained.*

Landau Comments #27	*Although the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) has a stated expectation that principal threat wastes (PTWs), such as the DNAPL present at the Site, be treated, the EPA recognizes that specific situations may limit the use of treatment, including sites where the extraordinary volume of material or the complexity of the site makes implementation of treatment technologies impracticable (EPA 1991). Both of these situations are present at the Site. The Site lends itself to containment of upland contamination with more active remediation limited to the vicinity of the shoreline and within lake sediment. Given these considerations, the proposed remedial plan should focus on reducing or eliminating the migration of shallow upland near-shore DNAPL, DNAPL- affected soil, and contaminated groundwater to lake sediment, to the extent ongoing releases are determined to be occurring.*
Tim Flynn #5	*EPA's proposed remedy includes active treatment of all DNAPL materials in the site in the uplands and offshore. That's irrespective of the risk to human health and the environment it poses, which we believe is not consistent with the National Contingency Plan nor is it consistent with EPA's application of its own principal threat waste policy applied to other Superfund sites essentially containing creosote or DNAPL.* *First, classification of all creosote or DNAPL impacted soil sediment as principal threat waste was done regardless of the quantity, mobility or location and is not considered the actual risk posed by the site contaminants. There were some questions raised about the nature of the DNAPL. It's very old, some of which is quite immobile. It is very weathered and is not apt to be mobile. Active treatment of all DNAPL is not warranted given low risk of much of the DNAPL at Quendall Terminals. Just to illustrate, of the 43 EPA sites involving creosote -- this is throughout the United States -- only five of the 43 had designations of all DNAPL as principal threat waste. The others do not. In all cases the remedies were less aggressive and generally include a containment, some degree of containment, particularly for the weathered material that is not mobile.*
Robert Cugini (Written) #21	*For example, Region 10 continues to take the position that all PTW must be treated even though the PTW Guidance provides that treatment is not required for non-mobile contaminated or low toxicity source materials that can be reliably contained. This selective application of the PTW Guidance is exactly the concern that prompted the President's recent Executive Order on Promoting the Rule of Law Through Improved Agency Guidance Documents.*
#4	*What's the natural rate of the DNAPL decomposition? Has that been looked at? Is there a reason to remove that DNAPL that's down underneath the site once it's been capped and it can't migrate?*

EPA Response:

Many of these comments relate to the interpretation of PTW and whether or not DNAPL at Quendall can be reliably contained.

EPA makes PTW determinations on a site-specific basis consistent with provisions in CERCLA, the National Oil and Hazardous Substances Pollution Contingency Plan, and existing Superfund program guidance. In its guidance document, *A Guide to Principal Threat and Low Level Threat Wastes* (OSWER 9380.3- 06FS, NTIS: PB92-963345INZ, November 1991), EPA defines PTW for purposes of that policy document as "those source materials considered to be highly toxic or highly mobile that generally cannot be reliably contained or would present a significant risk to human health or the environment should exposure occur."

At the Quendall Site, EPA Region 10, with support from EPA headquarters, determined that the Site's DNAPL, including all oil-coated and oil-wetted soil/sediment, is PTW. In making this determination, EPA evaluated the Site's constituents of concern taking into account the following characteristics throughout the Site:

- **Highly toxic, significant risk**: Benzene, naphthalene, other cancer-causing compounds in soil and groundwater contribute to human health risk at the 10^{-1} level, which exceeds the acceptable risk range of 10^{-4} to 10^{-6} excess carcinogenic risk for residential exposure by orders of magnitude. The identified risks are associated with both oil-wetted and oil-coated soil and sediment.
- **Highly mobile, cannot be reliably contained**: The Site's DNAPL can readily move through the soil, acting as a contamination source to both groundwater and Lake Washington.

In addition to the Site' s PTW-contaminated soils and sediment, EPA has determined that a large volume of the Site's free-product can be characterized as highly mobile and/or highly toxic. This determination applies to the free product located in thin layers, which provides a constant and continuing source of contamination to the groundwater.

Consistent with CERCLA and the National Oil and Hazardous Substances Pollution Contingency Plan, there is a preference for treatment to the maximum extent practicable for the PTW at the Site. In line with that preference for treatment, EPA has considered factors like accessibility and technical feasibility, and has determined the extent to which the PTW at the Site can be removed and/or treated. PTW at Quendall is generally present in the upper 20 feet, in alluvial materials, making the material easily accessible for removal and/or treatment.

The way DNAPL and chemicals in DNAPL move and become degraded over time was evaluated during the RI (Anchor QEA and Aspect 2012). This information was then used for assessing the effectiveness of technologies and remedial alternatives in the FS. DNAPL can degrade very slowly over time as the chemicals in the DNAPL dissolve into and cause contamination to groundwater. This can occur via a combination of chemical, biological, or physical processes. Creosote manufacturing at Quendall stopped in 1969 (over 50 years ago), and creosote DNAPL is still present in significant quantities (estimated in the hundreds of thousands of gallons in the RI/FS reports) and remains an ongoing source of contamination to groundwater. Therefore, EPA has selected a remedy that actively treats this DNAPL source.

4.3 Dredging

Four sets of comments were received focusing on dredging. One of the commenters recommended dredging/removing all contaminated sediment, while three commenters recommended reducing the dredging component in favor of more capping, ISS, or application of reactive core mats. The commenters in favor of reducing the amount of dredging believe that alternative technologies would be equally protective and reduce costs and impacts from dredging.

Aspect Comments #26 *We also note that since the preparation of the FS, advances in ISS have included application of that technology in sediments. We recommend that in addition to reducing the scope of dredging in the OU2 Proposed Plan, EPA should consider applying ISS in the nearshore area (contiguous with the ISS treatment area in the upland) to reduce the cost and odor impacts associated with dredging*

Landau Comments #27 *The depths and extent of sediment dredging identified in the EPA Plan are based on a flawed CSM (see comment #1) and are not necessary to be protective of human health and the environment….Capping contaminated sediment in place is the aquatic remedy most*

protective of human health and the environment because of the difficulty in dredging NAPL-affected sediment without significant redistribution of NAPL and NAPL-affected sediment during dredging. However, if dredging is required in some areas to maintain current sediment mudline elevations, it does not appear that dredging to the depths proposed in most of the alternatives is required to protect human health and the environment, particularly if dissolved- phase migration via groundwater is not a source of shallow lake sediment contamination (per LAI's previous comments on the Site CSM). A combined dredging and capping approach should be considered in those areas where dredging is required to minimize the amount of material dredged and the potential for releases of NAPL and NAPL-affected sediment to currently unaffected areas of Lake Washington sediment.

#11 *I would like to suggest a combination of both C and D. We all know dredging leads to its own issues and that doing as little as possible is ideal. Unfortunately, it must be done but targeted dredging over the overall site (not just shallow water areas) may reduce the negative externalities of large-scale dredging. I do not know the cost associated with RCMs, but this seems like something that should be utilized more for this project.*

#15 *I am of the opinion removing all soils on land and in the lake bed are the best avenues to restore these ground soils to acceptable clean levels for human usage*

EPA Response:

As indicated in the Proposed Plan for OU2, EPA considered a wide range of alternatives that included both capping and dredging for addressing DNAPL in the lake sediments. Use of ISS in the lake was not considered during the feasibility study but could be evaluated during remedial design.

EPA selected dredging as the best technology for addressing DNAPL-impacted sediment over amended caps or reactive core mats because there is limited long-term performance data available for these capping technologies. For example, EPA's National Remedy Review Board was concerned with the long-term reaction capacity of the subsurface reactive barrier treatment material, the possibility of the barrier clogging and the need to replace these materials, and their impact on critical habitat.

Dredging will be conducted in a manner that will minimize water quality impacts. To manage residual contamination, dredging is coupled with the placement of reactive covers over dredged areas. Hydraulic dredging could be used for shallow DNAPL along the former T-dock. Short-term impacts will be reduced by containing the aquatic dredge areas within oil-sorbent booms and/or silt curtains. The deeper inner harbor sediments will need to be removed using a mechanical dredge with an environmental bucket. A temporary sheet pile enclosure will be installed around the inner harbor removal area to isolate the dredging activities from the lake as well as support removal of sediments at depth. Best management practices, including water quality monitoring, will be conducted during dredging to minimize impacts due to the construction of the remedy.

4.4 In Situ Solidification

One comment was received regarding the use of ISS at the Site. The commenter was concerned that improper mixture formulation for ISS may not adequately bind or encapsulate DNAPL, and that solidification could make certain contamination at the Site worse.

Landau Comments #27 *The risks of use and reliance on in situ soil stabilization (ISS) in many of the remedial alternatives have not been adequately evaluated and addressed. There is significant uncertainty in performance and cost for stabilizing DNAPL and DNAPL- affected soil. Additionally, there are risks that ISS could actually exacerbate certain contamination at the Site, and potentially create detrimental conditions at the Site. Improper admixture formulations may not adequately bind or encapsulate DNAPL, may create conditions that exacerbate migration of certain contaminants, and/or stabilization costs may greatly exceed the costs upon which stabilization is evaluated for remedy selection*

EPA Response:

EPA agrees that reliance solely on ISS to control migration of contaminants of concern, especially for heavily contaminated DNAPL-containing soils, may be challenging. For this reason, the smoldering combustion technology was evaluated, tested, and ultimately added to Alternative 7, to create Alternative 7a. In addition to adding smoldering combustion as a technology, EPA also reassessed the feasibility study unit costs for ISS (for Alternatives 7 and 7a) and revised them upward to account for vapor capture and treatment, and associated monitoring, based on experience at other creosote DNAPL sites using ISS. Costs for ISS could also increase if more complex admixtures (amendments) are needed to address DNAPL and contaminant leaching. Testing to determine the appropriate admixtures will be conducted as part of remedy design. The costs for ISS provided in Section 12 in the ROD includes a 30 percent contingency that could account for additional testing of admixtures.

4.5 Capping

Two sets of comments focused on upland capping. Commenters felt that capping upland soils would be equally protective as the alternatives that include DNAPL treatment and should be more utilized in the Selected Remedy. One commenter stated that a vertical barrier in conjunction with a low-permeability cap would be effective in containing DNAPL.

Landau Comments #27 *The use of capping of upland soils with a low-permeability cover material, which may be equally as protective as other more aggressive remedial alternatives (including EPA's proposed final remedy), has not been adequately considered or evaluated as a primary component of the remedial alternatives. The presence of laterally and vertically discontinuous deposits of sand, silt, peat, and clay in dipping deltaic deposits that comprise the Upper Alluvium Unit suggest that containment using a vertical barrier in conjunction with a low-permeability cap would be effective in containing DNAPL and contaminated groundwater, potentially with limited to no groundwater extraction required for hydraulic control. Based on the distribution of contamination and geologic conditions at the Site, it appears that a vertical barrier would need to extend about 30 feet below ground surface. The need for, and required extent of, these containment technologies should be based on a more thorough evaluation of free-phase DNAPL presence and groundwater quality in the Fill Unit and upper portion of Upper Alluvium Unit at the shoreline. Although containment is not considered as permanent a remedial technology as removal, destruction, or solidification, it remains an effective and acceptable technology for large sites where treatment or removal is not practicable and does not substantively reduce site risk. Site conditions are consistent with the circumstances that justify reliance on containment for remediation of upland contamination in that there is a very large mass of upland contamination that cannot be practicably treated or removed, and doing so would not appreciably reduce Site risk. If groundwater discharging from the Fill Unit and upper portion of the Upper Alluvium Unit to Lake Washington surface water is determined to be contaminated, a low-permeability cap over most, if not all, of the contaminated areas of the Site should be a primary component of remedial alternatives that do not include removal of DNAPL and DNAPL- affected soil*

#4 *I would like to know what the percentage of the area to be covered with impervious surfaces is and if that has been taken into account. It makes more sense for me to cap the site and do other remediation that can be done.*

EPA Response:

The use of a containment remedy was evaluated in the FS in Alternative 2, and the use of a vertical barrier was evaluated in the FS, in Alternatives 3 through 6. After evaluation, Alternatives 2 through 6 (all of which leave DNAPL untreated in the environment) were excluded from the Proposed Plan because they would not meet the RAO to restore groundwater.

The argument that groundwater does not pose risk (i.e., no one will be drinking the water) is not consistent with what is required under State and Federal regulations. Although not currently used as a drinking water source, groundwater beneath the Quendall Site is classified by the State of Washington as potable (a potential source of drinking water) under Washington Administrative Code (WAC) 173-340-720(2). The State of Washington further states that groundwater cleanup levels are to be established based on ingestion of drinking water and other domestic uses (WAC 173-340-720(1)(a).

The remedial action objective (RAO) for groundwater at the Quendall Site is based on maximum contaminant levels (MCLs), which are set by EPA for the protection of drinking water quality.

Additionally, under 40 *Code of Federal Regulations* 300.430(a)(1)(iii)(F), "EPA expects to return usable ground waters to their beneficial uses wherever practicable, within a timeframe that is reasonable given the particular circumstances of the site." Further EPA has determined that DNAPL at the Site cannot be reliably contained because any vertical barrier/treatment wall that would be installed at the Site could only be a "hanging" wall, potentially allowing contaminants to travel below the wall. There is no continuous aquitard in which to anchor a barrier/treatment wall. Finally, treatment or removal of DNAPL are considered practicable at this Site because DNAPL is primarily within the top 20 feet of the Site and can be reasonably treated or removed using the identified technologies.

4.6 Selected Remedy versus Other Alternatives

Twelve sets of comments were received voicing support for OU1 alternatives other than Alternative 7a, the Selected Remedy. Commenters stated that there are other less expensive and less disruptive alternatives that are equally protective of human health and the environment. Several commenters stated that the Proposed Plan deviated from the FS and they did not think that the alternatives in the FS should have been rejected. Commenters expressed support for solidification, removal of all contaminants (OU1 Alternatives 8 through 10, and OU2 Alternative E), and FS Alternative 4a.

Geosyntec Comments #28	*The PP significantly deviates from the remedial action that was approved by the Remedy Review Board.* *The PP overstates the effectiveness of the selected remedy (Alternative 7a: STAR+ISS) by asserting that the proposed remedy is expected to achieve groundwater cleanup goals in a reasonable time frame and for the same cost as Alternative (7: ISS only), but provides no technical basis to support the conclusion that inclusion of STAR favorably impacts the overall remedy effectiveness, cost or duration.*
Aspect Comments #26	*There are better alternatives. There are many alternative approaches that would be protective, meet EPA threshold requirements, and reduce impacts to the community. A more cost-effective alternative would allow the cleanup to proceed in a timely manner so that the Site can be redeveloped, and the property put back into productive use in accordance with Superfund Task Force objectives.* *There are better alternatives. As described above, FS Alternatives 2 through 6 are viable alternatives that should be considered in the Proposed Plan. The FS acknowledged this in Section 8.1.3: "Alternatives 2 through 10 satisfy the overall protection of human health and the environment criterion, and would meet all ARARs if a TI waiver is granted for COCs in groundwater that do not achieve MCLs. Therefore, Alternatives 2 through 10 are carried forward in the Balancing Criteria comparison."*
Landau Comments #27	*EPA should not have eliminated Alternatives 2 through 6 from consideration as potential remedies. The EPA's rationale for disqualifying FS Alternatives 2 through 6 as viable options would also be applicable to Alternatives 7 through 10.*
#4	*I am opposed to the current cleanup preferred alternative plan because I don't think it's practical and it's too expensive. …*
#25	*Faster, less expensive, more proven methods of clean up exist and I urge the implementation of those methods.*
Tim Flynn #5	*We still believe this is an appropriate remedy. We advanced what is called Alternative 4A, and it is described in the feasibility study. It is not described in the proposed plan. That alternative and others are protective, meet regulatory requirements, reduce impacts to the community and allow redevelopment to proceed in a timely manner. Alternative 4A can be implemented as an example if that alternative can be implemented at cost of about 40 million dollars versus the proposed plan by EPA is over a hundred million dollars*
Robert Cugini (Oral) #1	*EPA has rejected other alternatives which are just as protective by its own acknowledgment and could actually get implemented.*
Robert Cugini (Written) #21	*EPA's own Feasibility Study confirms that there are other less expensive and less disruptive alternatives that are protective of human health and the environment.*
#17	*It seems to me that the solidification process would be a better choice for the environment. From your chart it seems that it would take about the same amount of time and costs a bit less.*
#24	*…the best method to clean up the site would be by dredging, as it would be better than doing the underground burn as that technique would leave too much waste behind.*
#15	*Offsite treatment of these soils is quicker method of removing contaminates. Of course, it is more costly and disruptive to the neighboring community but the future proposal for development of the same land is even more so. All contaminants in this section of land and water should be removed completely for the next generations of people to use safely and should be the goal of this government agency.* *The contamination to soils, ground water and drainage is a major concern to short term remediation (5 years) of this designated land. I believe Alternatives 8-10 would result in the aggressive clean up necessary for such deep and long-term existing contamination. Even then the results may not eliminate decades of embedded chemicals of all sorts.*
#20	*Regarding the remediation efforts proposed for OU1 and OU2, Alternative 10 and E are the preferred options to mitigate as much of the issue as possible.*

EPA Response:

Sitewide Alternative 7, including ISS of upland DNAPL and soil capping (OU1), and dredging of DNAPL in OU2 (Alternative D, EPA's Selected Remedy for OU2) was reviewed by the National Remedy Review Board in 2014. The Board raised two concerns regarding implementation of ISS at a large-scale in the uplands at Quendall: (1) whether ISS would be an effective technology for treating the organic contaminants at the Site, and (2) whether potential ponding and flooding on the Site could occur due to the restriction in groundwater flow that may be caused by large-scale ISS implementation. EPA responded to these concerns by testing smoldering combustion as a potential remedy component for addressing significant DNAPL sources in the uplands without creating a large solidified block. The successful field pilot testing conducted onsite in 2018 prompted EPA to add smoldering combustion as an upland remedy component.

Smoldering combustion treatment (referred to as STAR in the comments), was added following completion of the FS, to address concerns such as those described above. Smoldering combustion permanently destroys DNAPL. Additional modeling, conducted by EPA after the FS was completed, indicates that once the significant DNAPL sources are destroyed residual concentrations within treated source areas will allow for restoration of groundwater in 25 to 30 years. The groundwater restoration timeframe is based on numeric groundwater flow and transport modeling using the maximum residual concentrations in post-combustion treatment cores at Quendall as well as the maximum concentration in areas below the target threshold for smoldering combustion treatment.

Feasibility Study Alternatives 2 through 6 (including Alternative 4a, referenced in the comments) only partially address DNAPL and they were excluded from the Proposed Plan because they would not meet the RAO to restore groundwater. They also would not be eligible for a technical impracticability (TI) waiver since it is not technically impracticable from an engineering perspective to treat the DNAPL at this Site. The DNAPL is shallow (primarily in the top 20 feet), therefore accessible at the Site, and can be reasonably treated using identified technologies (in other words, it is not impracticable). In short, Alternatives 2 through 6 might be considered as interim remedies, but not final remedies, and only a final remedy will allow for Site redevelopment following remedy construction completion.

The cost and construction duration of Alternative 7a are similar to Alternative 7. However, Alternative 7a is considered more effective in both the short-term and long-term because high strength source area contaminants (DNAPL) are destroyed rather than solidified in place.

The duration and cost to implement Alternatives 7 and 7a are very similar, especially when considering that construction time and costs are high-level estimates that will be further refined during remedial design. Alternative 7a is considered by EPA to have fewer potential environmental impacts because smoldering combustion treatment would occur underground, and vapors would be captured underground and then piped into an aboveground treatment system. The lesser contaminated areas would be treated with ISS. Alternative 7, which only includes ISS for treatment of DNAPL, would require mixing DNAPL and contaminated soil in place, bringing some of the contamination to the surface, and creating more challenges for capturing odors and vapors.

Alternative 7a was chosen by EPA to be the Selected Remedy for OU1 because it is the most practical of the upland alternatives in terms of construction timeframe, cost, and impacts to the community.

Excavation and treatment of upland DNAPL and contaminated soil would take longer and cost more, with minimal added benefit to the environment. Alternative D is also considered the most practical of the in-water alternatives, as it removes DNAPL, and costs less than half of Alternative E.

4.7 Miscellaneous

Two sets of comments were received that do not readily fit into the comment categories above and are therefore being addressed here.

#4 *We've got an affordable housing problem here, and every time we do something like this it exacerbates that. I do know that once streets are in, buildings are built, that people aren't going to come in contact with the earth there. There may be an issue with what's out there in the lake, but I do also know that the background level for arsenic contamination was higher than the level that we were supposed to clean the site up to. It was 26 parts per billion, and the cleanup level was designated at 13 parts per billion. That's naturally occurring, so I don't believe that some of the standards are appropriate.*

EPA Response:

EPA's Selected Remedy for OU1 will clean up the Site such that it is safe for a variety of uses including residential redevelopment. EPA has determined that a "containment only" remedy that would simply cap the contamination in place is not consistent with State and Federal regulations that require groundwater be restored to its highest beneficial use (drinking water). Therefore, Alternative 7a was selected by EPA as the most cost-effective remedy for addressing the DNAPL source causing groundwater contamination.

As described in the Proposed Plan, arsenic is believed to have been released from natural soil deposits to the groundwater as the groundwater conditions changed in response to the presence of creosote and coal-tar, and due to naturally occurring organic delta deposits. It may also be present in groundwater because of arsenic-containing weed control products used at the Site. Arsenic in deeper groundwater may also be coming from the Barbee Mill property from the South. The ROD cleanup level for soil at Quendall is the state background value of 7.4 milligrams per kilogram or parts per million (ppm). The ROD cleanup level for arsenic in groundwater is the MCL of 10 micrograms per liter or parts per billion as there are no Site-specific background value for arsenic. As noted in the Proposed Plan, groundwater monitoring will also include an evaluation of background arsenic concentrations.

DNR #19 *Please expand the description of each remedy type to include the sediment depth and area on SOAL that must remain undisturbed, the extent to which disturbance is allowed in future years, the length of time use restrictions are required, and the conditions under which they can be removed in the future. If institutional controls are not required for a particular remedy, please clearly state that no uses are prohibited. Since DNR is representing the State's interest as owner of aquatic lands, and since the fifth amendment prohibits the government from taking property without just compensation, DNR maintains that CERCLA exemptions are not applicable to State land use agreements. The Quendall Terminals cleanup will probably require an access agreement for construction, a long-term use authorization for ENR encumbrances if applicable, and recordation of institutional controls from DNR.*

EPA Response:

These details will be developed during remedial design. The OU2 remedy will comply with ARARs. EPA will consult with the Department of Natural Resources (DNR) as appropriate.

5. Smoldering Combustion Technology

A total of 26 sets of comments on the Proposed Plans were related to use of the smoldering combustion technology for OU1. They have been grouped into eight subcategories:

- Uncertainty
- Practicality and effectiveness of cleanup
- Science
- Success of technology at depth
- Performance criteria and preliminary remediation goals
- Ability of technology with many thin layers

- Pilot study effectiveness
- Smoldering combustion's effect on organic matter

5.1 Uncertainty

Ten sets of comments were received focusing on the uncertainty and riskiness of smoldering combustion as the Selected Remedy. Commenters stated that smoldering combustion (referred to in the comments as STAR) is an experimental technology that is unproven for full-scale implementation.

Commenters indicated uncertainty that an unproven technology would meet the treatment objectives for the Site.

Geosyntec Comments #28 *EPA appears to assume STAR will be successful even in areas that were found to pose problems for sustained combustion during the field pilot study. Data from the RI suggest that DNAPL distribution at most of the site is more consistent with the unsuccessful pilot location and, therefore, extrapolation of the results from the successful pilot location to the entire Site is speculative. No basis is provided for the assumed percent of DNAPL that is anticipated to be destroyed by combustion or contained by ISS and no analysis of the cost implications is included.*

Aspect Comments #26 *STAR will not achieve EPA's objectives. The OU1 remedy relies on this unproven technology that will not meet EPA's treatment objectives and is costly, resource intensive, and time consuming with no tangible benefit.*

The STAR pilot study did not achieve EPA's remedial objectives for contaminant reduction (see Attachment G). Furthermore, STAR has not been demonstrated at any site to restore groundwater and is unlikely to given the residual concentrations of leachable contaminants measured during the STAR pilot study (Attachment G). Based on the results of the pilot study and EPA's objectives for cleanup, it is highly likely that the areas treated by STAR would also be solidified later and, even then, would not achieve EPA's objective of restoring groundwater.

Landau Comments #27 *EPA's proposed use of smoldering combustion technology has not been adequately evaluated and EPA's associated criteria for implementation, success, and contingent actions has not been adequately defined.*

#2 *Further, your recommendation includes using the still experimental solution of smoldering combustion. I know one might claim that this STAR technology is proven, but there remains so much caution in its use that even the plan in its current form recommends 100 years of monitoring. I find that disconcerting.*

#8 *Risky and Unproven Technology. EPA's preferred alternative relies on a risky and unproven technology (STAR), when better cleanup options are available and are just as protective of human health and the environment.*

#10 *EPA has chosen a risky and unproven technology (STAR) to burn-in-place more than 100 years of underground waste when better cleanup options are available and just as protective of human health and the environment according to EPA's own studies.*

After more than 15 years of environmental studies, EPA determined there were several options that are less disruptive to the neighborhood but have decided to ask the public to agree with their decision to experiment with technology that is not proven on a large-scale project.

The public, and the neighboring homeowners and fans who visit the adjacent Seahawks training facility are not likely to support the use of smoldering remediation. The extra costs and time associated with this type of science experiment creates a level of uncertainty that will destroy any possibility of redevelopment.

#12 *Some directly refuted the unknown results of smoldering combustion while others referred to the always changing requirements forced upon the cooperative owners who for decades have been trying to get the job done.*

Tim Flynn #5 *There is a series of contingencies built in the proposed plan in the event that the proposed remedy is not effective, and those are just not tenable to site redevelopment.*

Robert Cugini (Oral) #1 *…but even with that the science experiment of STAR treatment for the upland unit leaves so much doubt and uncertainty.*

Robert Cugini (Written) #21

EPA is further misleading the public by claiming that this experimental technology is proven and has been implemented full scale on a similar project when it has not.

After STAR is implemented and does not work, EPA will essentially end up with the same result (treatment of potentially mobile contamination using proven in-situ solidification and containment) but only after wasting several years and tens of millions of dollars.

EPA Response:

EPA is committed to complete the cleanup in the fastest timeframe and in a cost-effective manner, to protect and restore the environment as well as public health and minimize disruptions to the community.

EPA has tested the smoldering combustion technology (referred to as STAR in the comments) and demonstrated successful implementation at the Quendall Site. The success of the smoldering combustion pilot study was especially significant in that:

- It was conducted near the center of the Quendall Site in one of the two areas that was tested as part of a smoldering combustion bench-scale study that was considered a less-than-ideal location for smoldering combustion (in other words, a location without thick layers of mobile DNAPL), but considered to be representative of conditions across much of the Site.
- The IP used for the pilot test was installed in a zone with a TPH concentration near the minimum threshold for the smoldering combustion technology and treatment was still achieved in multiple permeable layers separated by a 2.5-foot silty clay layer, to a distance of 7 feet from the IP (a 7-foot radius of influence).

Areas of the Site with higher TPH concentrations and more abundant DNAPL are expected to be even more amenable to smoldering combustion treatment.

The ROD defines performance objectives for smoldering combustion that are based on the technology and the expectation that destruction of DNAPL will occur where TPH concentrations exceed 3,000 ppm. Post-treatment soil concentrations measured during the pilot study did not always achieve direct contact cleanup levels for soil. Because some surface soil concentrations outside of the targeted DNAPL treatment area also may exceed these cleanup levels, the ROD indicates that a soil cap will be placed over areas of the Site where soil concentrations are above surface soil cleanup levels, following DNAPL source treatment.

Additional modeling conducted by EPA after the FS was completed indicates that once the significant DNAPL sources are destroyed, residual concentrations within treated source areas will allow for restoration of groundwater in 25 to 30 years. The groundwater restoration timeframe is based on a numeric groundwater flow and transport modeling using the maximum residual concentrations in STAR post-treatment cores at Quendall and in areas outside those targeted for DNAPL source treatment.

EPA understands that a key concern from commenters is that areas treated with smoldering combustion may need to be retreated with ISS. The ROD clarifies that pretreatment characterization data will be used to delineate separate treatment sector boundaries for smoldering combustion and ISS. Therefore, retreatment (with multiple technologies) would not be considered a factor that would increase the implementation costs or timeframe. EPA’s cleanup strategy also allows for the possibility of using ISS instead, if smoldering combustion is not successful after each treatment sector.

Although smoldering combustion is an innovative technique for applying a thermal technology, thermal treatment has been shown to reliably meet cleanup standards at many sites across the country.

Smoldering combustion was implemented in full-scale at a DuPont site in New Jersey, which began in 2014 and was completed, with regulatory certification for site closure and land transfer, in September

2019. The pilot test at Quendall achieved similar contaminant reduction percentages with a similar radius of influence (7 feet) to the full-scale implementation and other pilot studies. A smoldering combustion pilot test at a Navy site in Virginia, with similar characteristics to Quendall, was successfully completed in 2016. The subsurface at this site is highly variable and the pilot study demonstrated treatment both above and below clay layers bisecting the contaminated zone (similar permeability layering as observed in some areas at Quendall), with a radius of influence of 7.5 feet (similar to Quendall).

The ROD includes several refinements to the implementation and monitoring strategy contingencies based on concerns expressed by commenters. EPA's plan for the Quendall Site is to complete the remedial action for upland DNAPL sources and establish a groundwater monitoring program to evaluate progress toward achieving groundwater cleanup levels over time. Once the DNAPL source treatment is complete and the monitoring well network is established, no additional source removal is expected to be required and the Site will be available for redevelopment to move forward. If groundwater monitoring within the first 5 years following DNAPL treatment indicates that cleanup levels will not be met within 25 to 30 years, then a focused study will be conducted to identify alternatives to meet groundwater cleanup levels.

Please note, detailed technical responses to Attachment G of Comment #26 (November 14, 2018, letter from Robert Cugini to Cami Grandinetti/EPA) are provided as Appendix 3A to this Responsiveness Summary.

5.2 Practicality and Effectiveness of Cleanup

Two sets of comments were received questioning the practicality and effectiveness of the cleanup. Commenters expressed concern for the implementability of smoldering combustion, and how it would be used in conjunction with ISS. A commenter recommended further consideration for when and how smoldering combustion and ISS would be used.

Geosyntec Comments #28 *EPA provide the basis for the assumed proportions treated by STAR versus ISS and evaluate the implications of uncertainty in the assumed proportions of DNAPL soil volumes addressed, the potential need for additional ignition points either laterally due either to smaller radii of influence or vertically due to layered contamination, and the potential need for multiple STAR applications on the cos bounds for Alternative 7a. Geosyntec further recommends that the proposed remedy apply STAR only in highly impacted source areas and provide flexibility in how, when and where STAR or ISS is used based on development plans/commitments (i.e. saturated zone was treated with STAR or ISS and planned development includes capping of the overlying soils). We see no justification for using ISS in areas where STAR is applied.*

Geosyntec recommends the that the selected remedy provide for consideration of the conceptual site model and overall soil characterization results, in addition to a TPH criterion, and that the TPH criterion be based on the average concentration over a specified volume, to decide whether to treat or not treat a particular location with STAR, and leave to the discretion of the implementing party whether to conduct an additional round of smoldering, contain using ISS, or consider other alternatives based on cost effectiveness and lifecycle impacts.

Landau Comments #27 *The PP should either provide the technical basis for the conclusions in the PP regarding remedy effectiveness and, particularly, for changing the conclusions provided in the FS approved by Region 10 or revise the conclusions.*

EPA Response:

Appendix 2B details the rationale for estimating the proportions of the DNAPL area that would be treated by smoldering combustion versus ISS and the rationale for the number of IPs given the presumption that in some areas, multiple IPs will be needed to treat DNAPL at depth. The data and findings presented in Appendix 2B are based on the results of the smoldering combustion (STAR) pilot study conducted at Quendall in 2018. The radius of treatment (called radius of influence) and smoldering front propagation rates used in the cost estimate were determined based on pilot study results, as reported in the *Self-sustaining Treatment for Active Remediation (STAR) Pre-Design Evaluation (PDE) Report* (Savron 2018).

As described in Appendix 2B, the Proposed Plan cost estimate assumed that smoldering combustion would be applied in areas with mobile DNAPL (Railroad Area, May Creek Areas, and Quendall Pond Upland Area) and cumulative DNAPL thicknesses of greater than or equal to 4 feet. Pretreatment characterization (as described in ROD Part 2, Section 12.2.1) will be used to identify the actual areas amenable to smoldering combustion treatment. Section 12 of the ROD further notes an adaptive management approach will be used throughout the source treatment process to optimize the implementation and fine-tune the treatment sector boundaries for each technology and provide some flexibility and discretion in view of the conceptual site model and overall soil characterization results.

EPA agrees there is no justification to using ISS in areas where smoldering combustion is applied. The ROD clarifies that pretreatment characterization data will be used to delineate separate treatment sector boundaries for smoldering combustion and ISS. Therefore, retreatment (with multiple technologies) would not be considered a factor that would increase the implementation costs or timeframe.

Smoldering combustion treatment was added following the FS, to address concerns raised by the National Remedy Review Board regarding implementation of ISS at a large-scale in the uplands at Quendall including: (1) whether ISS would be an effective technology for treating the organic contaminants at the Site, and (2) whether potential ponding and flooding on the Site could occur due to the restriction in groundwater flow that may be caused by large-scale ISS implementation. EPA responded to these concerns by testing smoldering combustion as a potential remedy component for addressing significant DNAPL sources in the uplands without creating a large solidified block, and then adding it as an upland remedy component based on successful field pilot testing conducted onsite in 2018.

5.3 Science

Three sets of comments were received stating that EPA's Selected Remedy is not supported by science and lacking technical support.

Geosyntec Comments #28	*The PP's proffered approach for implementing STAR and evaluating its effectiveness at the site is technically inadequate.*
Robert Cugini (Oral) #1	*EPA has made a decision that can't be supported by the science and is punitive to my community.*
Robert Cugini (Written) #21	*We know when you dig into the issues raised in this letter, you will clearly see that EPA's proposed remedy is not supported by science and not supported by our community (every speaker at the recent public meeting testified against the Proposed Plans) and it certainly does not reflect this administration's commitment to reclaim, restore and reuse Quendall Terminals.*

EPA Response:

EPA believes that the Selected Remedy is supported by science. EPA conducted a thorough evaluation (pilot study) of smoldering combustion (STAR) at Quendall, in an area viewed as representative of DNAPL conditions at the Site (thin, discontinuous layers). As part of the pilot study, additional characterization was conducted to evaluate small-scale variability in other areas of the Site to further inform EPA's decision to add smoldering combustion as a remedy component for OU1. The pilot study results were used to determine a treatment radius of influence of 7 feet and a smoldering front propagation rate of 1.4 feet per day, which were used to develop a cost estimate and construction timeframe based on Site-specific data.

5.4 Success of Technology at Depth

One comment was received concerning the success of the smoldering technology at depth.

#11 *One area I was confused with was it seemed to say after 7 feet, the technique had a pretty large drop in success. With the primary accumulation of creosote and its associated compounds presumed to be at depths of 12-15 feet below surface, will this technique be very successful that deep?*

EPA Response:

The field pilot study at Quendall demonstrated that treatment was achieved 7 feet away from where the IP was placed in the subsurface, both horizontally away from the IP and vertically from the IP. During the pilot study, an IP was placed at a depth of 16 to 17 feet below ground surface. The term "radius of influence" is used to describe the zone of soils that can be treated with a single IP. The study showed treatment of samples collected 7 feet away (radially) from the location of the IP, in other words, treatment was seen in a boring that was drilled 7 feet away from the boring used to install the IP. Treatment was also seen near the IP location at shallower depths, starting at 9 feet below the ground surface. Given that the treatment was applied at a depth of 16 feet, treatment of contamination at 9 feet also shows that treatment was accomplished 7 feet in the vertical direction.

5.5 Performance Criteria and Preliminary Remediation Goals

Two multifaceted comments regarding performance criteria and preliminary remediation goals (PRGs) were received. Commenters were concerned with both the criteria for determining where smoldering combustion would be implemented, and the criteria for determining if smoldering combustion was successful. Commenters suggested that EPA clarify the decision process and criteria for defining 'success', specifically recommending that mass flux be removed as a performance criterion. Commenters also suggest additional clarification is needed with the decision matrix for using smoldering combustion or ISS, requesting that areas treated with smoldering combustion would not need to be retreated using ISS.

Geosyntec Comments #28 *The PP introduces new, undefined mass flux performance criteria for evaluating the ability of proposed remedy to meet site RAOs.*

Geosyntec recommends that mass flux monitoring be removed as a performance criterion for the remedy. In addition, site specific soil leaching-to-groundwater PRGs should be developed for the site that can provide a basis for determining the extent of applying the mass removal/containment technologies. This provides implementation flexibility and provides a basis for setting decision criteria on when to terminate source removal/containment.

Alternatively, if mass flux monitoring continues to be included as a performance evaluation criterion, Geosyntec recommends that EPA provide details about how, where, and when mass flux monitoring will be applied and used. Geosyntec further recommends that EPA clarify the decision process and the criteria that define "success". Additionally, Geosyntec recommends that the flow chart and text of the plan provide flexibility in remedy selection based on cost effectiveness and project lifecycle impacts, including remedy transition criteria that would allow for consideration of natural attenuation as a component of the remedy.

The PP proposes a "mass flux" evaluation as the basis for determining whether additional treatment with STAR or ISS is needed but offers no details on where or how mass flux is to be calculated or what constitutes "acceptable" mass flux and over what timeframe. Additionally, the text of the PP and the various management decision flow charts provide contradictory *information. In the text, groundwater mass flux is discussed as a criterion for determining the need for ISS, but in the flow chart the ISS remedy appears to be automatically required, with flux measurements shown only as data supporting the remedy design. In effect, mass flux serves as an added RAO that is not consistent with ARARs, is subject to significant uncertainty, and may pose a major roadblock to redevelopment.*

However, the PP offers no details on how or where or when either baseline flux or post- treatment flux will be monitored, what target mass flux criteria will be used to determine whether Phase 2 (ISS) is required and how it will be monitored or calculated. It also is not clear where and over what time frame the target mass flux criteria will need to be achieved in order to stop active remediation. Finally, it is not clear how soil characterization data will be considered.

The PP should clarify that the conceptual site model and overall soil characterization results will be considered in addition to a TPH criterion, based on the average concentration over a specified volume, to decide whether to treat or not treat a particular location with STAR, and leave to the discretion of the implementing party whether to conduct an additional round of smoldering, contain using ISS, or consider other alternatives based on cost effectiveness and lifecycle impacts.

Geosyntec further recommends that EPA provide clarification on the applicability of soil PRGs in STAR-treated areas or consider a variance in those areas. Geosyntec notes that the proposed soil PRGs are set at levels to preclude risk via contact and ingestion and are orders of magnitude lower that levels protective of the soil leaching-to-groundwater pathway. Capping and redevelopment will address potential exposures due to contact with surface and near surface soils. The proposed soil PRGs should, therefore, not apply to the deeper saturated zones that will be targeted by STAR combustion. In addition, remedy flexibility and a technically defensible set of decision criteria for remedy implementation is required due the limitations of STAR as noted above.

The PP should provide clarification on the applicability of soil PRGs in STAR-treated areas or consider a variance in those areas. Geosyntec notes that the proposed soil PRGs are set at levels to preclude risk via contact and ingestion and are orders of magnitude lower that levels protective of the soil leaching-to-groundwater pathway. Capping (or similar alternatives that would be expected to be deployed during property redevelopment) will address potential exposures due to contact with surface and near surface soils. The proposed soil PRGs should, therefore, not apply to the deeper saturated zones that will be targeted by STAR combustion.

Geosyntec further recommends that EPA clarify the decision process and the criteria that define "success", specifically the metrics for determining when treatment of a sector is considered complete and successful and include an exit strategy. Geosyntec recommends that ISS be implemented only in areas not treated by STAR and only if the mass flux criterion is not met in those areas. Additionally, Geosyntec recommends that the flow chart and text of the plan provide flexibility in remedy selection based on cost effectiveness and project lifecycle impacts, including defining explicit decision criteria that would allow for consideration of natural attenuation as a component of the remedy.

Landau Comments #27

Evaluation of the Self-Sustaining Treatment for Active Remediation (STAR) smoldering combustion thermal destruction process was not originally included in the FS. EPA has now considered and pilot-tested the STAR technology for remediation of the DNAPL hydrocarbons at the Site, and included STAR as a primary technology for Site cleanup under Alternative 7a.

While this technology could have beneficial application for cleanup in some areas of the Site under the right conditions, PSE has significant concerns related to using STAR based on EPA's criteria for implementing STAR, the results of the STAR pilot study, and EPA's poorly defined metrics or criteria for determining whether cleanup using STAR is successful and/or whether contingent soil stabilization will be implemented after the STAR treatment.

EPA's Plan indicates that "suitable zones" for STAR treatment would be defined as areas where "soil total TPH concentration [are] >3,000 ppm." A concentration threshold necessary to sustain a smoldering reaction, is not an adequate criteria for determining suitability for implementation by itself. The criteria for determining where the use of STAR is suitable should include considerations such as: a) ensuring there is sufficient volume and continuity of contaminants to be technically feasible and cost effective (e.g., sufficient continuous DNAPL mass/volume to provide a reasonable vertical and horizontal combustion radii of influence without requiring excessive numbers and density of ignition points); and b) there being an actual risk driver for potential impact to environmental pathways and receptors from the contamination due to mass/volume and proximity. The presence of small, isolated DNAPL stringers that happen to have a total TPH concentration of >3,000 ppm in a minimal volume of soil, are unlikely to present any risk to human or ecological receptors, unlikely to have a risk of contributing to groundwater contamination, and would not be cost effective (if even technically feasible) to clean up using STAR. In other words, it would be *disproportionately costly to implement STAR to clean up these limited areas of contamination due to the negligible environmental benefit such a cleanup would provide.*

EPA's poorly defined metrics for determining how the success of STAR will be defined and in determining whether ISS will be used as a contingent or supplemental remedial measure to STAR could result in extensive unnecessary, redundant, inadvisable, and impracticable extra cleanup work.

The EPA needs to very clearly define and detail the methodology by which the need to "further reduce source strength following combustion" will be determined, and exactly how "passive flux monitoring and soil characterization data" will be evaluated to define if "additional source treatment following combustion" is necessary. Without a clearly defined plan, data quality objectives, and decision-making criteria around these issues, the potentially liable parties may be subject to millions of dollars in uncertain and undefined liability.

EPA Response:

In response to comments regarding use of groundwater mass flux data as a performance measure, EPA has refined the approach for deciding whether ISS is needed such that it can be determined during pretreatment characterization using a HRSC tool such as TarGOST. The pretreatment characterization data will be used to define separate sector boundaries for smoldering combustion treatment and ISS. Areas with soil TPH concentrations greater than 3,000 ppm would be identified for smoldering combustion treatment, and areas with soil TPH concentrations less than 3,000 ppm would be considered for ISS treatment. The pretreatment characterization data evaluation will consider the aggregate DNAPL thickness at each location, the areal extent of DNAPL occurrence, and the magnitude of the HRSC measured values. This refined remedy implementation approach is detailed in Section 12 of the ROD and discussed as a refinement in Section 14 of the ROD.

For evaluating the success of DNAPL source treatment on groundwater, following remedy implementation, a long-term monitoring program will be designed and implemented, as described in the Proposed Plan. Treatment of the DNAPL source is expected to immediately and substantially reduce contaminant concentrations and allow for achievement of cleanup levels in groundwater in a reasonable timeframe (25 to 30 years). The decision diagram for groundwater presented indicates that, if after 5 years of monitoring, the data indicate cleanup levels will not be met in a reasonable timeframe, a focused study will be conducted to identify alternatives to meet groundwater cleanup levels.

The ROD further clarifies that smoldering combustion performance standards will be used to assess the successful implementation of smoldering combustion technology. Each combustion sector will be evaluated against the performance criteria to determine if the combustion treatment for the sector is complete. The performance standard is based on post-treatment soil concentration of TPH based on an average concentration for a given treatment cell. The number of samples will be determined by the size of the treatment area and will be refined as part of the remedial design. In general:

- If post-treatment concentrations in the target treatment interval are above 3,000 ppm TPH, retreat with smoldering combustion.
- If concentrations are below 3,000 ppm TPH, smoldering combustion treatment for that cell is complete.

In line with an adaptive management approach, the post-treatment data evaluation will consider the magnitude and areal extent of post-treatment TPH concentrations above 3,000 ppm.

The approach for implementing the Selected Remedy for OU1 in the ROD clearly defines metrics for deciding which areas of the Site will be targeted for smoldering combustion and which areas might be targeted for ISS treatment, how the success of smoldering combustion will be defined, and the path forward for groundwater following source treatment.

5.6 Ability of Technology with Many Thin Layers

Three sets of comments were received regarding the ability of smoldering combustion to address DNAPL within thin layers at the Site. Commenters noted that RI data indicate, in general, the presence of DNAPL at the Site within discrete soil layers and lenses, with most DNAPL occurring in layers less than 1 foot in thickness. Commenters expressed concern that smoldering combustion will not effectively target and treat these thin layers of DNAPL.

Geosyntec Comments #28 *The PP fails to consider the likelihood that variability in key factors governing the implementability of STAR and/or ISS likely will increase overall remedy implementation costs and duration, and as a result community desired redevelopment of the upland area will be at significant risk of failure.*

It should be noted that the Remedial Investigation (RI) (Section 4.4) indicates that, in general, DNAPL is found within several discrete soil layers or thin lenses rather than in one continuous pool. These site-specific data do not support EPA's conclusion that STAR is expected to destroy the significant sources of DNAPL contamination. Rather, the STAR pilot test results indicate that, while STAR may remove some DNAPL mass in some areas, substantial fractions may remain.

Aspect Comments #26 *DNAPL that is inaccessible, thin, and immobile represent a greater risk during treatment than if these were contained onsite.*

Tim Flynn #5 *When I say site conditions, probably the most telling issue or particular issue at this site is that the DNAPL is present in very thin disbursed layers of material over a large area of the site. It is not sort of well-behaved or concentrated in any one area. Including STAR in the proposed plan greatly increases that uncertainty in terms of the ability of that technology to target and effectively combust all of these thin layers of DNAPL over a 19- to 23-acre site resulting in high cost and very long construction duration. Our basis for that is the technology has not been field tested at this scale.*

…the majority of the DNAPL is present in thin layers. Just to give you a sense of this, over 40 percent of the DNAPL occurs in layers that are less than one foot in thickness, and approximately 76 percent of the DNAPL occurs in two-foot thickness or less. These are very thin layers. Consequently, the actual duration of work is expected to be significantly higher than the estimate provided by EPA due to the challenges of treating such thin discontinuous layers.

EPA Response:

The distribution of DNAPL in thin layers is well documented in the RI and was further studied during implementation of the smoldering combustion (STAR) field pilot study, where additional sampling was conducted at a much higher resolution (5 to 10 feet between samples) versus the characterization that had been completed during the RI. The additional sampling conducted during the STAR pilot study confirmed the high degree of small-scale variability in the DNAPL architecture.

The STAR pilot study was conducted in an area of the Site known to contain multiple thin layers of DNAPL and the pilot study demonstrated treatment was achieved in multiple permeable layers separated by silty clay. This was especially significant because it was accomplished by setting the IP in a zone with a TPH concentration of 3,270 ppm, which is near the minimum threshold concentration of 3,000 ppm for self-sustaining smoldering combustion.

During full-scale implementation, where it is assumed that a cell of 8 IPs will be implemented simultaneously (see ROD Figure 12-3), it is expected that higher initial TPH concentrations will produce a more robust convective heat transfer and contaminants may be reached from multiple directions by IPs within a cell.

As detailed in Appendix 2B, well-documented small-scale variability in the DNAPL distribution was used for estimating the construction duration and cost of the remedy. Characterization done ahead of smoldering combustion treatment will also allow for optimization of the remediation strategy with respect to smoldering combustion and ISS (if ISS is needed). In addition, pretreatment characterization will allow for refinement of construction timeframes and development of cost estimates based on actual design and current vendor quotes. The data collected during the RI and the STAR pilot study support the FS (+50/-30 percent) level cost estimate for the Selected Remedy.

5.7 Pilot Study Effectiveness

Four sets of comments were received questioning the results and effectiveness of the pilot study. Commenters suggested that the pilot study did not achieve the remedial objectives for contaminant reduction and was not effective at treating DNAPL and contaminants of concern within the treatment zone. Additionally, commenters suggested that the pilot study was only successful in one of the two test areas.

Geosyntec Comments #28 *However, the STAR pilot study conducted at the site was able to achieve sustained combustion in only one of two test areas. Sustained combustion and TPH reduction of 73% to 99% were achieved in one area; combustion was limited and TPH reductions were considerably lower in the other area. Test results in both areas showed many COCs remained above the soil PRGs listed in PP Table 6-1 even in the area of "successful STAR" implementation. For example, naphthalene remained above its soil PRG of 3.8 mg/kg by factors ranging up to 25 times higher than the PRG in 10 out of 12 of the "successfully-treated" post treatment soil samples.*

Landau Comments #27 *The analytical results for post-STAR confirmation sampling locations indicated that within the treatment zone:*

- *TPH concentration reductions ranged from approximately 73 percent to more than 99 percent; Polycyclic aromatic hydrocarbon (PAH) concentration reductions ranged from approximately 77 percent to more than 99 percent in all but two of the sampling locations—lower reductions of 51 percent and 64 were observed in the two locations where initial concentrations were relatively low; and*
- *Concentrations of benzene, toluene, ethylbenzene, and xylenes (BTEX) were reduced by more than 95 percent in the sampling locations where initial BTEX concentrations were greater than 4 mg/kg.*
- *Concentration reductions were generally observed to be higher where initial concentrations were higher.*

These results indicate that while reasonable TPH mass removal rates and concentration reductions are achievable (e.g., the highest remaining TPH concentrations in the treatment zone after STAR treatment were less than 1,800 mg/kg), STAR was unable to meet its cleanup objectives.

Aspect Comments #26 *The STAR pilot study did not achieve EPA's remedial objectives for contaminant reduction (see Attachment G).*

The estimated cost and timeframe of the remedy, when applied as proposed by EPA, is not realistic. The conceptual implementation plan for treating 63 percent of DNAPL using STAR is inconsistent with the pilot testing results.

Tim Flynn #5 *In fact, EPA's pilot study indicated severe limitations in its ability to fully treat principal threat waste at Quendall, so we disagree with the conclusion that it is quite effective at this site. There is no technical basis for the assumption that 60 percent of the DNAPL at the Quendall Terminal site can be effectively treated using STAR.*

EPA Response:

The smoldering combustion (STAR) pilot study was conducted in one test area of approximately 50 by 50 feet, not two test areas as one commenter suggests. The pilot study included installation of two IPs in the center of the area, spaced 5 feet apart, at depths of approximately 16 feet below ground surface. It is the standard procedure of Savron (the STAR vendor) to install two IPs during pilot studies to provide a backup IP in the event it is needed. In the case of the Quendall pilot study, a heater fuse failure prompted the use of the second IP (5-feet away). Therefore, the second IP was used to conduct the full pilot test.

The soil PRGs in Proposed Plan Table 6-1 were based on direct contact exposure, whereas the goal of smoldering combustion is DNAPL destruction. The commenters are correct that the post-treatment concentrations measured during the pilot study did not always meet the PRGs. Because of this, and because some surface soil concentrations outside of the targeted DNAPL treatment area also may exceed surface soil cleanup levels, the ROD states following DNAPL source treatment, a soil cap will be placed over areas of the Site where soil concentrations are above cleanup levels.

Appendix 2B of the ROD includes details on the rationale for the conceptual implementation plan and cost assumptions. EPA maintains the assumption that approximately 60 percent of the DNAPL at the Site can be treated using smoldering combustion is supported by the pilot study. The smoldering combustion pilot study was conducted in an area of the Site known to contain multiple thin layers of DNAPL. The IP for the pilot study was set in a zone with a TPH concentration near the minimum threshold for the technology and treatment was still achieved in multiple permeable layers separated by silty clay.

Please note, detailed technical responses to Attachment G of Comment #26 (November 14, 2018, letter from Robert Cugini to Cami Grandinetti/EPA) are provided as Appendix 3A to this Responsiveness Summary.

5.8 Smoldering Combustion's Effect on Organic Matter

One comment was received asking about the short- and long-term effects of the smoldering combustion technique to naturally-occurring organic matter.

#11 *What is the short- and long-term effects of the smoldering combustion technique to organic matter not being targeted ? I ask this question primarily wondering if the microbes and other helpful critters living in the ground will remain unharmed.*

EPA Response:

Temperatures reached within the smoldering treatment zone can cause a significant reduction of microbial life. However, microbes from areas surrounding the treatment zone would reinfiltrate with the influx of groundwater following treatment. Robust communities would likely take time to reestablish.

6. Groundwater

A total of ten sets of comments on the Proposed Plans were related to groundwater at the Site. They have been grouped into two subcategories:

- Ability to Reach Cleanup Levels
- Long-term Monitoring

6.1 Ability to Reach Cleanup Levels

Nine sets of comments were received focusing on groundwater cleanup levels. Several commenters state that EPA's objective of groundwater restoration is infeasible and there is no technical basis that groundwater PRGs will be met. Commenters noted that even if goals were reached, city regulations do not allow domestic use of groundwater. Commenters also suggested that a groundwater restoration TI waiver would likely be needed for all remedial alternatives.

Geosyntec Comments #28 *The PP overstates the effectiveness of the selected remedy (Alternative 7a: STAR+ISS) by asserting that the proposed remedy is expected to achieve groundwater cleanup goals in a reasonable time frame, but provides no technical basis to support that conclusion….The PP contradicts conclusions in the Feasibility Study (FS) approved by Region 10, specifically the FS conclusion that none of the alternatives evaluated in the FS would achieve groundwater restoration goals in a reasonable time frame, without providing the technical basis or other justification for the change in conclusions.*

Geosyntec additionally recommends the PP include the FS language recognizing the likely need for a TI waiver for groundwater.

Aspect Comments #26	*EPA's objective of groundwater restoration is infeasible. The assumption that the OU1 Proposed Plan can restore groundwater is inconsistent with the modeling and other technical analysis in the FS and leads to an overly aggressive remedy that is costly and time consuming but still does not achieve this objective.* *EPA's objective of groundwater restoration is infeasible. The ability of potential remedies to restore groundwater was exhaustively evaluated in the Groundwater Restoration Potential Technical Memorandum (Aspect and Anchor QEA, 2011) and in the FS (Aspect and Arcadis, 2016). None of the remedies are predicted to restore groundwater across the Site to drinking water levels in less than 100 years. In finalizing the FS, EPA acknowledged that the most aggressive alternatives – FS Alternatives 7, 8, 9, and 10 -- would reduce the groundwater plume footprint but would not completely restore groundwater (Attachment E).*
Landau Comments #27	*EPA improperly eliminated FS Alternatives 2 through 6 based on a rationale that would also apply to Alternatives 7 through 10; specifically, none of the nine FS alternatives would meet remedial action objectives (RAOs) related to groundwater cleanup without a technical impracticability waiver.* *EPA's proposed upland remedy unnecessarily focuses on treatment of site-wide dense non-aqueous phase liquid (DNAPL). Because it is technically impracticable to restore groundwater at the Site to drinking water standards (see #2 above), the proposed remedial action for the Site should focus on addressing those migration pathways and exposure routes that present the greatest risks at the Site; specifically focus remedial actions on shallow shoreline releases and minimizing leaching to groundwater.* *It is clear from the nature and extent of contamination and the complexity of Site geology, and, as stated in the FS, that a groundwater restoration TI waiver will be required for all remedial alternatives to meet statutory requirements for selecting a remedial action. If restoration of upland groundwater is determined to be impracticable, protection against direct contact in the Site uplands and releases to Lake Washington sediment and surface water become the only remaining potential exposure pathways that the remedial alternatives must address for the Site uplands.* *Restore groundwater to its highest beneficial use (drinking water) by meeting PRGs [preliminary remediation goals] in the shallow alluvium and deeper alluvium aquifers within a reasonable period of time (see "Decision Diagram for Groundwater")." A note in the Decision Diagram for Groundwater suggests that a reasonable period of time is "25 to 30 years."…"it is technically impracticable to restore groundwater at the Site to* *drinking water standards; therefore, the proposed remedial action for the Site should focus on achieving RAOs 1 (reduce contaminant migration from DNAPL to groundwater), 3 (reduce human soil direct contact and incidental ingestion risks), 4 (reduce terrestrial wildlife soil direct contact and incidental ingestion risks), 5 (reduce human inhalation of vapor risks), and 6 (reduce contaminant migration from soil to surface water) by addressing shallow shoreline releases.*
#8	*In choosing its prefers ed alternative, EPA focused only on alternatives that EPA asserts could possibly restore groundwater to di inking water' standards. However, even with the most aggressive and expensive cleanup, EPA estimates that groundwater would never be cleaned up to drinking level standards. EPA's preferred alternative, therefore, incorporates a goal for groundwater that is unrealistic no matter how much money is spent.*
#10	*Despite what EPA implies in its plan, none of the alternatives can accomplish the EPA policy goal of restoring groundwater to federal drinking water standards. EPA estimates even with the most aggressive cleanup, groundwater would not be cleaned up for more than 100 years, if ever.* *The groundwater is not a source for domestic use (and can't be under local Renton City laws); and the groundwater contamination also doesn't impact Lake Washington. Therefore, EPA can and should choose a remedy that treats potentially mobile contamination as well as contamination near the lake and adds safeguards to ensure any residual contamination remains contained.*
#12	*Alternatives 7a and D are not only cost prohibitive but the uncertain goal to restore ground water is without reason as it is illegal in Renton to use that water for domestic use.*

Tim Flynn #5 — *None of the alternatives, even the most aggressive alternative evaluated in the feasibility study, achieve groundwater restoration within a reasonable timeframe. Consequently, there is no technical basis presented in the proposed plan for eliminating Alternatives 2 through 6 -- these are alternatives from the feasibility study -- from any further consideration in developing this preferred remedy. The assertion is those Alternatives 2 through 6 were eliminated based on the assumption that more aggressive alternatives would achieve groundwater restoration, and we disagree with that assertion.*

Robert Cugini (Oral) #1 — *There's no reason to select this alternative. Groundwater is not a pathway to contamination to human health, and none of your options, even the chosen one will ever restore it for human use. Even if it could happen, local city regulations won't allow for the use of groundwater, so let me be clear. Even the most aggressive remedy in the list, one that is not even proposed for this site, will not achieve groundwater remediation.*

Robert Cugini (Written) #21 — *Despite the unsubstantiated claims in EPA's plans, none of the alternatives, not even the most aggressive alternative, can accomplish the EPA policy goal of restoring groundwater to federal drinking water standards. EPA agreed with that conclusion when it approved the Feasibility Study and yet, in the Proposed Plans, EPA leads the public to believe that the STAR technology will restore groundwater.*

EPA Response:

It is important to first clarify that although groundwater beneath the Quendall Site is not currently used as a drinking water source, it is classified by the State of Washington as potable (a potential source of drinking water) under WAC 173-340-720(2) and that groundwater cleanup levels are to be established based on ingestion of drinking water and other domestic uses (WAC 173-340-720(1)(a).

The RAO for groundwater at Quendall is based on MCLs, which are set by EPA for the protection of drinking water quality. Additionally, under 40 *Code of Federal Regulations* 300.430(a)(1)(iii)(F), "EPA expects to return usable ground waters to their beneficial uses wherever practicable, within a time frame that is reasonable given the particular circumstances of the site." Therefore, the argument that groundwater is not a pathway for human health (i.e., no one will be drinking the water) is not consistent with what is required under State and Federal regulations.

Many of the commenters refer to the statement repeated in the FS: "…all applicable or relevant and appropriate requirements (ARARs) would be met, with the exception of meeting MCLs everywhere in groundwater," which is made for all of the alternatives (Alternatives 2 through 10). These statements were made based on a groundwater model presented in the FS that predicted timeframes for reducing groundwater plume volumes for each contaminant of concern. As described in the FS, EPA concluded that the results of the groundwater model over-estimate the plume volume and mass of each contaminant of concern at the Site, leading to an over-estimate of the time to achieve MCLs or risk-based concentrations, and thus was overly conservative.

Specifically, EPA outlined the following concerns:

- The preremediation estimates of the plume boundaries from the model are significantly larger than the plume boundaries observed using actual groundwater concentration data.[1]
- Given that coal tar/creosote production stopped in 1969 (50 years ago), it is reasonable to assume that the groundwater plumes are in steady state or reducing (i.e., they would not grow to the sizes predicted by the groundwater model). This is supported by groundwater data presented in the RI Report (Anchor QEA and Aspect 2012) that shows either steady or decreasing concentrations in shoreline monitoring wells.

[1] DNAPL source strength was set as a constant over the 100-year plume propagation period (i.e., no depletion of the source was included); (2) degradation rates (half-lives) may be considered conservative; and (3) the model used arithmetic averages of measured chemical concentrations as a starting point, as opposed to log-normal averages, which would result in lower starting concentrations.

Although there are significant uncertainties, the FS model was still considered a useful tool for comparing the degree to which progress is made toward achieving groundwater restoration – and it showed that the results are vastly different among the alternatives. For example, the FS model indicates the volume of groundwater exceeding MCLs after 100 years would be reduced up to 93 percent with alternatives that address DNAPL more fully (Alternatives 7 through 10), and only up to 50 percent with less aggressive alternatives (Alternatives 2 through 6). EPA has consistently maintained that alternatives that only partially address DNAPL (Alternatives 2 through 6) would certainly fail to meet the goal of restoring groundwater to its highest beneficial use. For this reason, they were not carried forward in the Proposed Plan for OU1.

Smoldering combustion treatment (referred to as STAR in the comments), added following the FS, permanently destroys DNAPL. Additional modeling conducted by EPA after the FS was completed indicates that once the significant DNAPL sources are destroyed, residual concentrations within treated source areas will allow for restoration of groundwater in 25 to 30 years. The groundwater restoration timeframe is based on a numeric groundwater flow and transport modeling using the maximum residual concentrations in STAR post-treatment cores at Quendall and in areas outside those targeted for DNAPL source treatment.

EPA's plan for the Quendall Site is to complete the remedial action for upland DNAPL sources and establish a groundwater monitoring program to evaluate progress toward achieving groundwater cleanup levels over time. Once the DNAPL source treatment is complete and the monitoring well network is established, no other source removal is expected to be required and the Site will be available for redevelopment to move forward. If groundwater monitoring within the first 5 years following DNAPL treatment indicates that cleanup levels will not be met within 25 to 30 years, then strategies for long-term groundwater plume management will be evaluated, including the possibility of a TI waiver.

Alternatives 2 through 6 (that only partially address DNAPL) were excluded from the Proposed Plan because they would not meet the RAO to restore groundwater. They also would not be eligible for a TI waiver because more work could be done to address DNAPL, which is shallow and accessible at the Site (i.e., it is not impracticable). In short, Alternatives 2 through 6 might be considered as interim remedies, but not final remedies, and only a final remedy will allow for Site redevelopment following remedy construction completion.

The possibility exists that groundwater restoration may not be achieved even with implementation of the more aggressive Alternative 7a. However, that possibility cannot be used as a rationale for not addressing the significant sources of DNAPL contamination in the uplands. The Selected Remedy addresses the DNAPL source and provides explicit benefits including a reduction in human health risks and adverse ecological impacts, as well as a decrease in the plume longevity. The DNAPL is primarily within the top 20 feet of the Site and can be reasonably treated using the identified technologies.

6.2 Long-term Monitoring

One comment was received about the potential need for long-term monitoring.

#15 *I believe Alternatives 8-10 would result in the aggressive clean up necessary for such deep and long term existing contamination. Even then the results may not eliminate decades of embedded chemicals of all sorts. A 100 yr monitoring of this land would be appropriate without structures.*

EPA Response:

EPA's selection of smoldering combustion as the primary means to clean up DNAPL in the uplands was evaluated as the best solution in terms of protection of human health and the environment, while using treatment to permanently destroy contaminants, and doing so at a significantly reduced cost as compared to Alternatives 8 to 10. EPA has assumed that 100 years of groundwater monitoring would be required with any of the alternatives to ensure that groundwater cleanup levels are met and sustained.

EPA will ensure that a proper groundwater monitoring well network is installed and will not be compromised in a future development scenario.

7. Merits of the Alternatives

A total of six sets of comments on the Proposed Plans were related to the merits of the alternatives. They have been grouped into two subcategories:

- Support for EPA's cleanup
- Need for a thorough cleanup solution

7.1 Support for EPA's Cleanup

Three sets of comments were received expressing support for EPA's Selected Remedy.

#30	*"As a long-time resident of the area, I appreciate efforts to remediate past industrial activities at this site, and would like to express support for OU1 Alternative 7a and OU2 Alternative D. Both have been identified as the Preferred Alternatives for future action.*
#13	*I would like to fully endorse the suggested proposals made by the EPA and hopefully they can be approved and work begun as soon as possible.*
DNR #19	*DNR supports all remedies that fully remove contaminant sources (DNAPL) from SOAL and provide a high degree of certainty that SOAL will not be decontaminated from upland contaminant sources. DNR is pleased to see that EPA's preferred alternative D appears to meet these criteria. Per the OU2 Cleanup Plan, 67,600 gallons of DNAPL will be removed from aquatic land which is 100% of the total.*

EPA Response:

EPA appreciates support for the Selected Remedy.

7.2 Need for a Thorough Cleanup Solution

Three sets of comments were received stressing the importance of a thorough cleanup. One commenter noted that the cleanup time should not be a factor, as it is more important to protect the public resources and provide a permanent and thorough solution.

#29	*Please find a way clean the land and allow it to be developed.*
#6	*I support the plan that most effective plan for protecting the water and public resource that is Lake Washington. This pollution has been here for many, many decades. The time to effectively clean up the site should not be a factor. If it takes 2 decades that is a blink of the eye in the lifetime of the lake and the generations of people, fish and animals who enjoy Lake Washington and its waters.*
#16	*I believe it is important the cleanup of the site provide a permanent and thorough solution. Once construction on the site is in place, subsequent additional cleanup actions would be severely compromised if not made impossible. Consequently, please put the priority on doing the cleanup completely before any further development of the property is begun.*

EPA Response:

EPA agrees that a thorough cleanup solution is needed for the Quendall Site. The Selected Remedy is designed to be a final remedy that will provide long-term and permanent protection of human health and the environment, and allow for the Site to be redeveloped without the need to "go back" and do more.

8. OU1 Cleanup Timeframe

Nine sets of comments were received that focus on the length of time to complete the cleanup, noting that the timeline was too long and would hinder development. Several commenters also stated that the timeline for the Selected Remedy was not realistic and would take longer to implement.

Aspect Comments #26	*EPA estimated an implementation time—including design—of five years, which is not realistic. It is expected to take several years just to complete the necessary design studies to delineate DNAPL occurrences and define the soil volume requiring treatment. EPA indicates that the STAR operating period would be two years, but additional time would be needed to install, test, and decommission the equipment and injection points. STAR and ISS would need to be implemented in sequence, not in parallel, because the application of ISS would depend on the ultimate effectiveness and extent of STAR. In a best-case scenario, in which STAR is implemented in parallel with ISS and no retreatment is needed, the upland remedy would take approximately 7.4 years. As noted above, it is highly likely that more STAR injection points would be needed and/or areas treated by STAR would need re-treatment by ISS to achieve EPA's objectives. Considering these factors, we estimate that the OU1 Proposed Plan would take at least eight to nine years to implement.*
#2	*One, I'm starting to realize that I might not live long enough to see the final cleanup.*
#8	*I urge EPA to reconsider those alternatives in place of its preferred alternative, so that the site can be cleaned up and redeveloped in a reasonable timeframe.*
#10	*The development plans for the property have been approved by the City of Renton; but time is of the essence because the development agreement will expire if the site is not cleaned up and 51 percent occupied by 2027.*
#12	*I was therefore, dismayed and frustrated as I listened to the EPA's preferred alternatives for cleaning up the site, which most certainly means it will not get cleaned up in my lifetime.*
#25	*There have been too many delays already, with Government Agencies missing promised deadline after deadline; to now present a 10-year cleanup plan is unacceptable."*
Tim Flynn #5	*The schedule of approximately six years in our view is unrealistic. Based on the pilot study, we anticipate more like eight to nine years to implement STAR. That is not accounting for the fact that if STAR is ineffective at treating DNAPL, EPA may choose to come back in and use solidification in those same areas, so that just adds more to the timeframe.*
Robert Cugini (Oral) #1	*EPA is basically eliminating the possibility of this property to be developed in any realistic timeframe.*
Robert Cugini (Written) #21	The development plans for the property have been approved by the City of Renton but time is of the essence because the development agreement will expire if the site is not cleaned up and 51 percent occupied by 2027. We are exploring ways to encourage a public-private partnership with local governments and a land conservation nonprofit to maximum the habitat and recreational opportunities for the property. However, these opportunities will be lost unless EPA choses a reasonable cleanup plan that is protective and allows for development.

EPA Response:

EPA is committed to an efficient, well-managed cleanup at the Quendall Site. Estimated completion timeframes associated with all the alternatives, including the selected alternative, include a degree of uncertainty. The estimate of 5 years to complete the Selected Remedy for OU1 presented in the Proposed Plan is based on the following assumptions:

- Pretreatment characterization planning – 6 months
- Pretreatment characterization – 2 months
- Data interpretation/presentation/design planning – 4 months
- Design – 1.5 years
- Implementation – 2.5 years (assumes 2 years of operational time for smoldering combustion, to be overlapped with ISS

EPA's plan for the Quendall Site is to complete the remedial action for upland DNAPL sources and establish a groundwater monitoring program to evaluate progress toward achieving groundwater cleanup levels over time. Once the DNAPL source treatment is complete and the monitoring well network is established, no other source removal is expected to be required and the Site will be available for redevelopment.

EPA understands that a concern from commenters is that areas treated with smoldering combustion may need to be retreated with ISS. The ROD clarifies that pretreatment characterization data will be used to delineate separate treatment sector boundaries for smoldering combustion and ISS. This has been clarified in the ROD. Therefore, retreatment (with multiple technologies) would not be considered a factor that would increase the implementation costs or timeframe.

There are ways to gain efficiencies in the schedule, but those schedule efficiencies can sometimes include tradeoffs with cost and certainty. Some possible efficiencies that may be pursued include the following:

- Performing pretreatment Site characterization at the same time as implementation of smoldering combustion
- Designing the remedy implementation to optimize overlap of remedial action activities
- Mobilizing multiple rigs, treatment units, and/or other equipment during characterization and remedy implementation
- Working closely and openly with the agency teams to help expedite the review processes

The schedule will be heavily controlled by the project implementation team, with EPA oversight. EPA will support the timely and efficient cleanup of the Quendall Site.

9. Future Use

A total of ten sets of comments on the Proposed Plans were related to future use of the Site. They have been grouped into three subcategories:

- Park and public access
- Environmental justice
- Breaching of soil cap

9.1 Park and Public Access

Five sets of comments were received expressing support for public park space and public access at the Site. Commenters would like the natural habitat and shoreline to be restored.

#7 *I want this property to be cleanup up and made into a public park.*

#9 *I often ride the bike trail along the lower east side of Lake Washington. The Quendall Terminals area has the potential to be another pearl in the string pearls of lovely parks encircling Lake Washington. It can go from being an eyesore to something comparable to Gene Coulon Park. Please consider this when making your plans for cleaning up this site.*

I am writing in my capacity as a resident of King County and an avid bicyclist to urge the EPA to work aggressively to clean up the Quendall Terminals area of Lake Washington. I would like to see immediate efforts to reclaim this land and repurpose it to allow for public access and habitat restoration.

#14 *My main concern for the Port Quendall property is that the natural shoreline of Lake Washington and the public's access to it be restored and preserved.*

#23	*Why can't the land simply be donated to the City of Renton? Or sold to the Seahawks who could definitely afford to clean it up and create a beautiful Seahawks Wildlife Park there.* *This land should remain wild and never be developed. The soil under Lake Washington and the land should be cleaned up and turned into a public park, like Gasworks Park, or like the gorgeous Union Bay Natural Area right near the University of Washington. The 74-acre Union Bay Natural Area is a public wildlife area and natural restoration laboratory. It has had more than 30 years of restoration that continues to this day, and this former landfill has been turned into a diverse system of meadows, woods, and wetlands. It is one of the best bird-watching areas in the city with over 200 species of birds calling it home throughout the year.*
Robert Cugini (Oral) #1	*All the public benefits and access, habitat restoration will be lost due to the unconscionable tab you hope to pin on potential responsible parties with this proposed remedy.*

EPA Response:

EPA appreciates comments expressing the desire for the Site to be made into a public park; however, the Site is privately-owned, and EPA does not have jurisdiction over redevelopment decisions, including public access. Those activities are managed at the local level.

The cleanup will make the Site safe for a variety of uses, including residential or public use, and future development will need to comply with regulations related to habitat, including mitigation for loss of wetlands and aquatic habitat function.

9.2 Environmental Justice

Three sets of comments were received stating concern for environmental justice during and after the cleanup process. Specifically, public commenters were worried that private development would reap the benefit while the public bears the burden of the cleanup. Commenters stated that the cleanup priority should be public protection, not economic interests.

#30	*Who is to benefit from a successful remediation of ill-informed past environmental practices? If – in the end – the public bears most of the burden while private development interests reap the benefit, the project is a failure. If – as the most cursory Internet search indicates – this results in a residential waterfront development opportunity for the affluent, while the public is burdened with the costs – the project fails. It is the Environmental Justice aspects of this proposal that I find most troubling.*
#6	*No development economic interest should overwhelm the greater Seattle area public interest in clean water for now and future generations of people and wildlife.*
#22	*In conclusion, the area is densely populated and there are private residences just on the border with the site. Imagine a child living next to the site who will grow up being long term exposed to all those toxins through the air it breathes. Therefore, it is a priority to protect the public from exposure to highly toxic creosote and coal tar chemicals through the air during the multiyear cleanup.*

EPA Response:

The public is not expected to bear the burden for the Site cleanup. EPA agrees that parties responsible under CERCLA should pay for the cleanup, consistent with EPA's long-standing "polluter pays" policy. Under CERCLA, EPA searches for parties legally responsible for the contamination and seeks to hold those parties accountable for the costs of investigations and cleanups, requiring them to perform or fund the necessary investigations and remediation. EPA has followed and will continue to follow, this approach for Quendall Terminals.

EPA is committed to completing the cleanup in the fastest timeframe possible and in a cost-effective manner, to restore the Site to a healthy condition and minimize disruptions to the community. During construction, air monitoring will be conducted, and proper measures will be taken to mitigate risks.

EPA does not have jurisdiction over redevelopment or future access decisions.

9.3 Breaching of Soil Cap

Two sets of comments were received regarding the effect of future building foundations on the proposed soil cap. The commenters expressed concern that the building foundation would disturb the cap and cause exposure to contaminants.

#15 *The buildings would require considerable depth for foundations thereby disturbing the suggested capping methods and the underground contamination could still pollute by exposure and seepage.*

#20 *And finally, the current proposed use for the site includes a number of multi-story buildings. Wouldn't the construction efforts (sub-surface pilings and foundation) breach the "Soil cap" and expose workers/tenants/residents to the trapped contaminates?*

EPA Response:

EPA's Selected Remedy is intended to address DNAPL-containing subsurface soil that could be problematic for foundations requiring deep pilings. Future building designs must ensure they are compatible with the cleanup actions and minimize exposure to contaminants. Institutional controls would restrict disturbing the caps. Areas where contaminated soils are solidified are not expected to require a soil cap but would require prohibitions against any action that may compromise the integrity of the solidified soil.

10. Miscellaneous

DNR #19 *Multiple Figures: Within the legend of most figures, please change "DNR dry dock concrete hulls" to "Dry Dock Concrete Hulls." The hulls were abandoned without authorization on SOAL by a private party. DNR removed as much of the dry dock structure as was feasible utilizing State resources under the DNR Derelict Vessel Program. All work was done in coordination with cleanup authorities and with sensitivity to existing contamination.*

EPA Response:

The figures in the ROD have been updated as requested.

11. Works Cited

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U.S. Environmental Protection Agency (EPA). 2019a. *Quendall Terminals Superfund Site, Operable Unit 1 Proposed Plan*.

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Acronyms and Abbreviations

ARAR	applicable or relevant and appropriate requirement
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (commonly known as Superfund)
COC	contaminant of concern
DNAPL	dense nonaqueous phase liquid
EPA	U.S. Environmental Protection Agency
FS	Feasibility Study
HRSC	high-resolution site characterization
IP	ignition point
ISS	in situ solidification
MCL	maximum contaminant level
OU1	Operable Unit 1
OU2	Operable Unit 2
PDE	Pre-Design Evaluation
ppm	parts per million
PRG	preliminary remediation goal
Proposed Plans	Quendall Terminals Superfund Site, Operable Unit 1 Proposed Plan (EPA 2019a) and Quendall Terminals Superfund Site, Operable Unit 2 Proposed Plan) (EPA 2019b)
Quendall Site	Quendall Terminals Superfund Site
RAO	remedial action objective
RI	Remedial Investigation
ROD	Record of Decision
Site	Quendall Terminals Superfund Site
STAR	Self-sustaining Treatment for Active Remediation
TI	technical impracticability
TPH	total petroleum hydrocarbon
WAC	Washington Administrative Code

Appendix 3A
Supplemental Comments

November 14, 2018

VIA ELECTRONIC MAIL

Cami Grandinetti
EPA Region 10
1200 Sixth Avenue, Suite 900
Seattle, WA 98101

Re: Quendall Terminals - STAR Pilot Study and Proposed Plan

Dear Cami,

We appreciate Region 10 sending us a copy of the Savron STAR pilot study report and understand EPA is evaluating whether to utilize the STAR technology as part of the proposed plan for Quendall Terminals (Site) in Renton, Washington. We are very surprised, based on the pilot study results and feedback from potential developers, that EPA is still considering STAR as a component of the Quendall Terminals remedy. As we have noted in the past, the use of STAR adds cost, effectiveness, and schedule uncertainties to the remedy that are unacceptable to a potential developer. The pilot study results clearly indicate that the STAR technology will not achieve remedial action objectives previously identified by EPA. The data also indicate that if it were implemented, the costs would be substantially higher than suggested by the vendor' s full-scale implementation plan.

The STAR pilot study demonstrated the following:

- Contaminant concentrations over most the Site will not support self-
- sustaining combustion;
- Post-treatment concentrations exceed EPA' s remedial action objectives for the Site; The pilot study did not determine key parameters needed for evaluating the effectiveness and cost of implementing STAR at the Site;
- The design assumptions for full-scale implementation at the Site are deeply flawed, as they were not consistent with findings in the pilot study report; and
- The inclusion of STAR in the Proposed Plan at this late point, without rigorous evaluation through the Feasibility Study (FS) process, is inappropriate.

These points are discussed further below.

Contaminant concentrations over a majority of the DNAPL area will not support self-sustaining combustion. Similar to the bench study, which only had a 50 percent success rate, the pilot study only achieved the fundamental goal of self-sustaining ignition at one of two tested locations. Although the vendor attributed the failure to an equipment failure, they also acknowledged that the failure to sustain combustion after 44 hours of heating was likely due to the lower concentrations of TPH present at the IP-2 well screen (up to 3,500 mg/kg) (Savron 2018b p. 9). However, these " lower concentrations of TPH" are not unique to the IP-2 well screen; they are found throughout the characterized DNAPL areas, including the pilot study area. The vendor provides a minimum range of 3,000 to 5,000 mg/kg TPH to sustain combustion (Savron 2018b p.16), and the poor performance at IP-2 suggest that the lower portion of this range is not adequate. Of the pre-STAR samples in the treatment zone of the pilot study area, less than half (10 of 25) exceeded the 5,000 mg/kg threshold. In two DNAPL areas further investigated during the pilot study, only one had a majority of TPH concentrations high enough to sustain combustion. These observations match with the 50 percent "success" rate of the pilot study and the 50 percent "success" rate of the bench study. We are surprised that EPA might consider a 50 percent success rate adequate.

EPA Response:

It is inaccurate to characterize the bench-scale test and field pilot test as having a 50% success rate for the following reasons:

- *The bench-scale study tested soil from two areas (TP-1 and TP-2). Only soil from TP-1 (near RI boring BH-30C) had sufficient TPH concentrations for self-sustaining smoldering combustion (pre-treatment samples ranged from 94,000 to 97,000 mg/kg). The soil from TP-1 was successfully smoldered resulting in bench-scale post-treatment TPH concentrations ranging from 141 to 190 mg/kg (>99% reduction). Soil from TP-2 (between RI borings QP-6 and QP-7) had TPH concentrations that ranged from 1,080 to 1,380 mg/kg, discovered to be well below the minimum threshold of 3,000 mg/kg needed to sustain combustion using this technology. As stated in the STAR Pre-Design Evaluation (PDE) Report (p.5), the boring logs for QP-6 and QP-7 indicated that higher contaminant concentrations were likely to be present at depths below the water table, at depths that could not be reached using a backhoe.*
- *EPA selected the QP-6/QP-7 as the location for the PDE even though shallower soils from this area did not exceed the 3,000 mg/kg threshold, because this area, with lower concentrations and the presence of thin DNAPL layers, was considered to be most representative of conditions across the Site. The PDE included installation of two ignition points (IPs) in the center of the area, spaced 5 feet apart, at depths of approximately 16 feet below ground surface. It is the standard procedure of Savron to install two IPs during pilot studies to provide a backup IP in the event it is needed; however, the intention is to operate at a single IP only. In the case of the Quendall pilot study, a heater fuse failure prompted the use of the second IP (5-feet away), therefore, the second IP was used to conduct the full pilot test.*

The success of the STAR pilot study was especially significant in that:

- *It was conducted in an area of the Site known to contain multiple thin layers of DNAPL and demonstrated treatment was achieved in multiple permeable layers separated by silty clay.*
- *It was accomplished by setting the ignition point in a zone with total petroleum hydrocarbon concentration of 3,270 milligrams per kilogram (mg/kg), which is near the minimum*

threshold concentration of 3,000 mg/kg for self-sustaining smoldering combustion.

- *It is expected that higher initial TPH concentrations will produce a more robust convective heat transfer and contaminants may be reached from multiple directions by IPs within a cell.*

Post-treatment concentrations exceed EPA's remedial action objectives for the Site. Throughout the remedy selection process, EPA has insisted that the selected remedy fully treat all Principal Threat Waste (defined as DNAPL-containing material). In the bench study, EPA established treatment goals based on EPA' s Regional Screening Levels Protective of Groundwater (Savron 2018a). The results of the pilot study indicate that STAR cannot achieve either of these objectives. In particular:

- As discussed above, much of the DNAPL area does not contain concentrations supportive of self-sustaining combustion. The vendor acknowledges that the technology is not likely applicable to these areas, including the QP-1 investigation area and "fringe areas". Even within areas exhibiting higher DNAPL concentrations, there is substantial spatial variability, indicating that there is a high likelihood that pockets of DNAPL will not be treated, or will be only partially treated (Savron, 2018b, p.23).
- After treatment, layers of product were observed at four (PT-3, PT-6, PT-8, and PT-10) of the nine post-STAR borings that are located within the estimated radius-of-influence from the ignition point. That layers of product were still visible post-treatment indicates treatment objectives were not reached in these areas.
- Even within the area of "treatment", the measured concentrations greatly exceed both Site Preliminary Remediation Goals (PRGs) and the bench study treatment goals, as shown in the attached Table 1. In particular, naphthalene concentrations within 2 feet of the ignition point remained at concentrations up to 110 mg/kg (PT-02-11). For comparison, the Site PRG is 3.8 mg/kg, and the bench study treatment goal was 0.05 mg/kg.

EPA Response:

The variability in the distribution of DNAPL was well documented in the RI and was further studied and confirmed during implementation of the STAR PDE, where additional sampling was conducted at a much higher resolution (5 to 10 feet between samples) than the RI. For this reason, the remedy implementation approach described in the Proposed Plan and further refined in the ROD assumes that pre-treatment characterization data will be collected prior to initiation of DNAPL source treatment to identify separate compartments for smoldering combustion treatment and ISS, if needed. If the pre-treatment characterization data indicate that there are significant DNAPL sources with TPH concentrations less than 3,000 mg/kg, these areas will be evaluated for treatment with ISS (described in Section 12 of the ROD).

Examination of boring logs from PT-3, PT-6, PT-8, and PT-10 indicate that with one exception, all of the observations of product were at or beyond the treatment radius of influence (ROI) of 7 feet:

- *PT-3: A "thin band of product" was located from 6-7 feet below ground surface (bgs), approximately 10 feet above the ignition point (IP) depth of 16-17 feet bgs in IP-1, beyond the ROI of 7 feet (in the vertical direction).*
- *PT-6: a "thin stringer of product" was observed from 7 to 7.5 feet bgs, approximately 9 feet above the IP depth of 16-17 feet bgs in IP-1, beyond the ROI of 7 feet.*
- *PT-8: "Peat, product" was observed from 15'4" to 15'7" bgs. 5 feet from IP-1. This boring was located approximately 5 feet from IP-1. As the 7-foot ROI is approached, it is possible that some areas experience partial treatment from the single IP; however, the sample collected from 14.5-15.25 feet in this boring had a pre-treatment TPH concentration of 19,300 mg/kg that was reduced to 130 mg/kg (>99% reduction). It is expected that contaminants may be reached from multiple directions by IPs within a cell.*
- *PT-10: "Product" was observed from 5'3" to 5'8" bgs, approximately 10 feet above the IP depth of 16-17 feet, beyond the ROI of 7 feet.*
- *PT-10: "Product stringers" were observed from 9'8" to 10'7", approximately 7 feet above the IP depth of 16-17 feet, at the ROI of 7 feet.*

The pilot study treatment goals in Table 1 and the Preliminary Remediation Goals (PRGs) in Proposed Plan Table 6-1 were based on direct contact exposure, and are applicable to surface soil, whereas the goal of smoldering combustion is DNAPL destruction. The statement is correct that not every post-treatment concentration measured during the pilot study met the PRGs. These results were expected due to the variability in DNAPL architecture. Surface soil concentrations outside of the targeted DNAPL treatment area may also exceed surface soil cleanup levels. The ROD states that following DNAPL source treatment, a soil cap will be placed over areas of the site where soil concentrations are above cleanup levels.

The pilot study did not determine key parameters needed for evaluating the effectiveness and cost of implementing STAR at the Site. A number of objectives of the pilot study were not met. For example:

- Inadequate vapor recovery occurred (Savron 2018b p.10) due to the lack of a surface cap, which prevented both a proper evaluation of contaminant mass destroyed versus volatilized and a clear estimation of off-gas treatment costs. The vendor estimated the mass volatilized based on the collected vapor data; however, as they acknowledge that limited capture was achieved, this estimate is likely highly inaccurate.
- Temperature readings indicated a very small area of influence, with combustion temperatures only detected within 2 feet of the ignition point. The vendor attributed the lack of better temperature data to heterogeneity and estimated the area-of-influence based on measured concentration reductions and visual observations but, as noted above, concentration reductions were incomplete and variable. This has an enormous effect on full-scale implementation; the vendor's estimate of 2,740 ignition points with a 7-foot radius of influence would increase to 5,370 points for a 5-foot radius of influence and 33,565 points for a 2-foot radius of influence.

EPA Response:

The PDE provided valuable information regarding key parameters for evaluating effectiveness and cost.

While less than optimal vapor recovery occurred, estimates of effectiveness were primarily made using field observations and comparison of pre- and post-treatment soil data. This also prompted the inclusion of a surface cap to improve vapor capture in the STAR cost estimate provided in the Proposed Plan and further detailed in Appendix 2B of the ROD.

Similarly, while temperature data were of limited use, combustion gas data proved to be a more reliable measure of sustained combustion, ultimately corroborated by field observations and comparison of pre- and post-treatment soil data.

The design assumptions for full-scale implementation at the Site are deeply flawed. The assumptions used in developing the full-scale treatment approach are not consistent with the findings and recommendations within the report. In particular:

- The full-scale design proposes treating the entire region of upland DNAPL. However, as discussed above, a significant portion of this area does not have sufficient DNAPL mass or concentration to support self-sustaining combustion.
- The full-scale design assumes "the entire thickness of impacts can be treated from an IP installed at a single depth." This is clearly a false assumption, as proven by the monitoring data within the pilot area (where layers of product remained after treatment) and by the vendor's own analysis of the MC-1 area (Savron, 2018b, p.19). The proposed full-scale implementation does not account for the need for multi-depth installations or describe how such installations affect the implementation, performance, and treatment time for the remedy, except to say that it would result in increased costs (Savron 2018b, p.21).
- The vendor's strategy is to design to treat the entire Site at one depth and "adjust during operations to account for Site uncertainty". There is no discussion about the sensitivity in cost or remediation time that may occur from this approach, but the variability in the final system is potentially enormous. The vendor's estimate for a single-depth ignition-point network is operation of 2,270 ignition points over 2.5 years. Based on the layering at the Site, two, three, or even more, layers of ignition points may be needed at many locations. Factoring these in with other uncertainties--such as area of influence discussed above--the proposed adaptive design approach could result in order-of-magnitude uncertainties in time and cost, which is not an appropriate level of accuracy for decision making. No developer is going to sign up for a remedy that involves the enormous uncertainties in the effectiveness, cost, and time to implement STAR.

EPA Response:

The PDE Report (Savron 2018) includes a section that presents a "conceptual approach" for full-scale implementation within the entire region defined as the "estimated extent of DNAPL" that encompasses 420,865 square feet. This conceptual approach section was included in the

STAR PDE Report as a starting point used for development of the strategy presented in the Proposed Plan and ROD. EPA understands that some sub-areas within the 420,865-square foot DNAPL area will be more conducive to smoldering combustion treatment, and other areas may either be more conducive to ISS, or not require treatment. The ROD states that these decisions will be made based on pre-treatment high-resolution site characterization (HRSC) data, such as TarGOST®, as specifically suggested in the STAR PDE Report. The STAR pilot study demonstrated that treatment can be achieved in multiple permeable layers separated by lower permeability units, even when TPH concentrations are near the minimum threshold concentration of 3,000 mg/kg for self-sustaining smoldering combustion. Therefore, EPA has determined that significant areas of the Site can be treated successfully with STAR.

Appendix 2B in the ROD specifically addresses concerns with the estimated cost of treating multiple layers. The PDE findings indicated that, within a given hypothetical treatment cell with multiple layers of contamination, there is variability even at a small scale (5 to 10 feet) in the distribution of the DNAPL, such that within a cell, some IP locations within that cell would not need treatment (based on TPH concentrations below 3,000 mg/kg). In other words, the number of IPs that would not need to be installed based on lower TPH concentrations is approximately balanced by the number of additional IPs that may be required to address multiple layers of contamination at depth. Appendix 2B includes figures showing the data used to support this conclusion.

The inclusion of STAR in the Proposed Plan at this late point, without rigorous evaluation through the FS process, is inappropriate. Alternatives including STAR were not evaluated as part of the feasibility study. Selection of STAR as a remedy component should consider carefully the benefits and disadvantages of the technology at the same level of rigor as applied in the FS. No cost estimates were included with the full-scale treatment approach; based on the uncertainties in design, such as the assumption of a single-depth point application, we are doubtful a cost estimate at an FS-level of accuracy (-30/+50%) can be developed. The experimental status of this technology leads to many questions on its effectiveness, permanence, short-term impacts, and cost that were not answered by the pilot test. Introducing such uncertainties will deter timely Site cleanup and redevelopment.

EPA Response:

EPA evaluated STAR as a potential remedy component based on concerns raised by the National Remedy Review Board regarding implementation of ISS at large-scale in the uplands at Quendall. The successful STAR bench-scale and field pilot test prompted EPA to add smoldering combustion as a remedy component to Alternative 7 (resulting in Alternative 7a) during development of the Proposed Plan. The effectiveness, permanence, and short-term impacts of Alternative 7a were discussed in the Proposed Plan and are detailed further in the ROD for the Selected Remedy.

The basis for the STAR treatment area of 101,495 square feet used for the Proposed Plan cost estimate as well as other assumptions are also detailed in ROD Appendix 2B. The ROD clarifies that the actual areas for smoldering combustion treatment and ISS (if needed) will be based on pre-treatment characterization data and implementation details will be developed during remedial design.

EPA estimated costs presented in the ROD are commensurate with an FS-level of accuracy (-30/+50%). The ROD clarifies that the actual areas for smoldering combustion treatment and ISS (if needed) will be based on pre-treatment characterization data.

In summary, EPA tested the smoldering combustion technology and demonstrated that it can be successful at the Quendall Site. Additionally, EPA's cleanup strategy allows for the possibility of using ISS instead, if smoldering combustion is not successful in the first treatment sector. EPA is committed to complete the cleanup in the fastest timeframe and in a cost-effective manner, to restore the site by meeting the cleanup objectives, and minimize disruptions to the community.

We appreciate your consideration of these comments.

Sincerely,

Robert Cugini

Enclosure

cc: Steven Cook
Sheryl Bilbrey
Ted Yackulic
Georgia Baxter
Lynn Manolopoulos
Jim Benedict

Table 1 - Comparison of Post-Treatment Soil Sampling Results to Quendall Terminals PRGs and Pilot Study Treatment Goals

Analyte[2]	PRG[3]	Pilot Study Treatment Goal[4]	Post-Treatment Soil Sampling Results Inside Treatment Zone[5]	
			Average[6]	Maximum
Total Petroleum Hydrocarbons				
Gasoline-Range Organics		100	**204**	**1,000**
Diesel-Range Organics		2,000	445	1,400
Motor Oil-Range Organics		2,000	57.1	75
Polycyclic Aromatic Hydrocarbons				
2-Chloronaphthalene		3.9	0.0393	<0.2
2-Methylnaphthalene	240	0.185	**9.50**	**56**
Acenaphthene		5.5	**5.60**	**22**
Anthracene		58	2.73	9.2
Benzo(a)anthracene	0.16	0.05	**5.24**	**36**
Benzo(a)pyrene	0.016	0.235	**6.43**	**44**
Benzo(b)fluoranthene	0.16	0.3	**12.6**	**90**
Benzo(k)fluoranthene	1.6	2.9	**4.45**	**34**
Chrysene	16	9.1	8.37	**62**
Dibenzo(a,h)anthracene	0.016	0.096	**1.79**	**10**
Fluoranthene		89	8.98	46
Fluorene		5.5	3.69	**14**
Indeno(1,2,3-cd)pyrene	0.16	0.98	**5.01**	**32**
Naphthalene	3.8	0.05	**32.5**	**110**
Pyrene	1,800	13	7.97	**38**
BTEX				
Ethylbenzene	5.8		0.430	2

PRG Preliminary Remediation Goal

Notes:

1) All concentrations are in milligrams per kilogram (mg/kg).
2) Only analytes for which a PRG and/or a pilot study treatment goal have been established are included in this table.
3) PRGs are based on human health risk assessment, as summarized in Table 4-8 of the *Quendall Terminals Feasibility Study* (Aspect, 2016).
4) The pilot study treatment goals are the *Lowest Project Criterion* listed in Table 2-3 of the *Quality Assurance Project Plan* (CH2M, 2018).
5) Analytical results for the twelve post-treatment soil samples are summarized in Table 4 of *Self-sustaining Treatment for Active Remediation (STAR) Pre-Design Evaluation (PDE) Report* (Savron, 2018). Shaded values exceed the PRG. Bolded values exceed the pilot study treatment goal.
6) Incalculating the average concentrations, undetected analytes were assumed to be present at one-half the detection limit.