Site characterization/focused feasibility study report

ExxonMobil/ADC Property, Ecology Site ID 2728
Everett, Washington
Project # 6103180009, ExxonMobil Oil Corporation/American Distributing Company

Prepared for:

ExxonMobil Oil Corporation
Oakland, California

American Distributing Company
Marysville, Washington

August 23, 2019

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August 23, 2019

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µg/L	microgram per liter
1996 Order	Agreed Order DE-95TC-N402
1998 Order	Agreed Order DE-98TCP-N223
2010 Order	Agreed Order DE-6184
ADC	American Distributing Company
AGRA	AGRA Earth & Environmental, Inc.
AO	Agreed Order
ARAR	applicable or relevant and appropriate requirement
Aspect	Aspect Consulting
AST	aboveground storage tank
bgs	below ground surface
BNSF	BNSF Railway Company
BTEX	benzene, toluene, ethylbenzene, and xylenes
CFR	Code of Federal Regulations
Chevron	Chevron Corporation
cm/sec	centimeter per second
COC	constituent of concern
CLARC	Cleanup Levels and Risk Calculation
cPAH	carcinogenic polycyclic aromatic hydrocarbon
CPOC	conditional point of compliance
CSM	conceptual site model
CSO	combined sewer overflow
CSTO	California Street/Terminal Avenue Overcrossing
CY	cubic yard
DCAP	Draft Cleanup Action Plan
DO	dissolved oxygen
Ecology	Washington State Department of Ecology
EPA	Environmental Protection Agency
ESA	Endangered Species Act
Eurofins	Eurofins Calscience
ExxonMobil	ExxonMobil Oil Corporation
°F	degrees Fahrenheit
FFS	focused feasibility study
FS	feasibility study
GAC	granular activated carbon
ISS	in situ soil stabilization
ITRC	Interstate Technology and Regulatory Council
KC	Kimberly-Clark Corporation
LNAPL	light nonaqueous-phase liquid
LPH	liquid-phase petroleum hydrocarbons
mg/kg	milligram per kilogram
MLLW	mean lower low water
MNA	monitored natural attenuation
Mobil	Mobil Oil Corporation
MTBE	methyl tertiary-butyl ether
MTCA	Model Toxics Control Act
NAVD88	North American Vertical datum of 1988

NPV	net present value
NRWQC	National Recommended Water Quality Criteria
ORP	oxidation-reduction potential
PAH	polycyclic aromatic hydrocarbon
PCL	preliminary cleanup level
POC	point of compliance
PRB	permeable reactive barrier
Premier	Premier Environmental Services, LLC
Property	two contiguous parcels located at 2717 and 2731 Federal Avenue, in Everett, Washington, owned by ExxonMobil and by ADC, respectively
PSI	Puget Sound Initiative
PTI	PTI Environmental Services
PVC	polyvinyl chloride
RAO	remedial action objective
RCW	Revised Code of Washington
RI	remedial investigation
RMP	risk management plan
RZA	Rittenhouse-Zeman & Associates, Inc.
SAP	sampling and analysis plan
SC	site characterization
SC/FFS	site characterization and focused feasibility study
SEPA	State Environmental Policy Act
Site	ExxonMobil and ADC Property and portions of neighboring parcels where releases of hydrocarbon contamination on the Property may have migrated
SPOC	standard point of compliance
Standard	Standard Oil Company of California
SVE	soil vapor extraction
SWCA	SWCA Environmental Consultants
Texaco	Texaco Refining and Marketing, Inc.
TPH	total petroleum hydrocarbons
TPH-D	total petroleum hydrocarbons as diesel
TPH-G	total petroleum hydrocarbons as gasoline
TPH-O	total petroleum hydrocarbons as oil
USC	United States Code
UST	underground storage tank
Vigor Marine	Vigor Marine LLC
VOC	volatile organic compound
WAC	Washington Administrative Code
Wood	Wood Environment & Infrastructure Solutions, Inc.
WRCC	Western Regional Climate Center

1.0 Introduction

Wood Environment & Infrastructure Solutions, Inc. (Wood), prepared this Site Characterization/Focused Feasibility Study (SC/FFS) Report on behalf of ExxonMobil Oil Corporation (ExxonMobil) and the American Distributing Company (ADC) for the ExxonMobil/ADC Property (the Property) located at 2717 and 2731 Federal Avenue in Everett, Washington, owned by ADC and ExxonMobil, respectively. Historical releases of petroleum products have been documented due to former operation of bulk petroleum storage, transfer, and distribution facilities on the Property and operations of other companies on nearby parcels. Consistent with Agreed Order (AO) No. DE 6184 (2010 Order), entered into between ExxonMobil, ADC, and Ecology in March 2010, the Site is defined as the Property owned by ExxonMobil and ADC, plus those portions of neighboring properties where releases of hazardous substances at the Site may have migrated or otherwise come to be located. The Site has a Washington State Department of Ecology (Ecology) Facility ID of 2728. The extent of soil and groundwater contamination resulting from the historic operations on the Property has been sufficiently identified for purposes of this SC/FFS and for development of remediation alternatives. This SC-FFS Report will identify the recommended cleanup alternative for the Site. The final cleanup remedy for the Site will be documented in the Draft Cleanup Action Plan (DCAP), which will be completed after the SC/FFS Report has been finalized and approved by Ecology.

1.1 Purpose of the SC/FFS report

This SC/FFS Report was prepared to meet the requirements of the 2010 Order and in accordance with Ecology's Model Toxics Control Act (MTCA) Cleanup Regulations (Washington Administrative Code [WAC] 173-340). This SC/FFS Report describes the nature and extent of Site soil and groundwater contamination, presents an evaluation of potentially applicable remediation alternatives to clean up Site contamination, and identifies a recommended final cleanup action to comprehensively address contamination in soil and groundwater at the Site. The recommended alternative will be developed more fully and described in detail in the DCAP. This SC/FFS will serve as the basis for preparing the DCAP to be developed for the Site, as specified by the 2010 Order.

The purposes of this SC/FFS are to:

- document the history of past Property ownership and operations conducted on the Property and surrounding properties;
- summarize past investigation and interim remedial activities conducted at the Site;
- identify constituents of concern (COCs) for the Site and present preliminary cleanup standards for the Site established pursuant to the MTCA regulations;
- document the nature and extent of Site contamination, based on investigations conducted to date at the Site;
- present a conceptual site model (CSM) describing the potential exposure pathways and potentially exposed receptors for Site contamination;
- establish remedial action objectives (RAOs) for the Site;
- identify preliminary cleanup levels (PCLs) for soil and groundwater;
- identify and evaluate alternative remedial actions to achieve the RAOs and PCLs at the Site in accordance with the MTCA regulations;

- select the recommended remedial action alternative; and
- provide information necessary to complete the DCAP.

1.2 Organization of the report

This SC/FFS Report is organized into the following sections:

- Section 1, Introduction: Presents the report purpose and outlines the organization of the SC/FFS Report.
- Section 2, Site description: Describes the physical setting and regulatory background for the Site.
- Section 3, Previous environmental characterization/sampling investigations: Presents a brief overview of previous environmental investigations conducted for the Site.
- Section 4, Summary of past remediation activities: Presents a brief overview of previous interim remedial measures implemented at the Site.
- Section 5, Constituents of concern and preliminary cleanup standards: Presents the COCs and discusses PCLs and the point of compliance (POC) for the Site.
- Section 6, Nature and extent of contamination: Summarizes locations and degree of contamination in soil and groundwater.
- Section 7, Aquifer and tidal studies: Presents an overview of studies conducted at the Site to evaluate groundwater conditions and tidal influence on groundwater flow patterns.
- Section 8, Conceptual site model: Presents the CSM for the Site and an evaluation of potential receptors and exposure pathways.
- Section 9, Remedial action objectives: Defines RAOs for the Site.
- Section 10, Remediation considerations: Outlines key considerations to be taken into account for the development and evaluation of remedial alternatives and for subsequent design of the preferred cleanup action.
- Section 11, Remediation technologies: Presents a focused evaluation of potential remedial technologies that may be appropriate for soil and groundwater at the Site.
- Section 12, Development of remediation alternatives: Describes the remedial alternatives considered for soil and groundwater remediation at the Site.
- Section 13, Evaluation of alternatives: Evaluates and compares the remedial alternatives described in Section 12.
- Section 14, Recommended remedial action alternative: Describes the recommended remedial alternative.
- Section 15, References: Provides a list of references cited in this report.

2.0 Site description

This section describes the historical, physical, and environmental setting of the Property and surrounding area, and presents the regulatory and compliance history relevant to the SC/FFS Report. As defined in the 2010 Order, the Site is defined as the property owned by ExxonMobil and ADC, plus those portions of neighboring properties where releases of hazardous substances due to ExxonMobil or ADC operations may have migrated or otherwise come to be located. In addition to historic operations by ExxonMobil and ADC, another source of contamination at the Site includes releases from former train car loading racks located east of the Property, under the current Terminal Avenue Overpass. The ExxonMobil–ADC Property occupies 0.86 acre of land and consists of two parcels (Figure 2-1). The northern parcel at 2717 Federal Avenue occupies approximately two-thirds of the Property (0.65 acre) and will be referred to as the ADC Parcel. The southern parcel at 2731 Federal Avenue occupies approximately one-third of the Property (0.21 acre) and will be referred to as the ExxonMobil Parcel. The extent of the site and the parcel boundaries are shown on Figure 2-2.

2.1 Description of property and vicinity

The Property is located east of Federal Avenue, west of the Terminal Avenue Overpass, and immediately south of the Kimberly-Clark Corporation (KC) property/former Everett Avenue in the northwest portion of Everett, Snohomish County, Washington (Figures 2-1 and 2-2).

2.1.1 Property ownership

The ADC parcel is owned by the Miller Trust (Cecilia Beverly Miller, beneficiary) and the ExxonMobil parcel is owned by ExxonMobil.

2.1.2 Current land use

The Property is an asphalt-paved empty parking lot. No structures are present on the Property. The Property and other parcels in the immediate vicinity are shown on Figure 2-2. In addition to the Property, the Site includes portions of the surrounding properties, including portions of former Everett Avenue, Federal Avenue, and the Port of Everett properties just west of Federal Avenue. It also includes portions of the City of Everett right-of-way east and south of the Property, the BNSF Railway Company (BNSF) parcel, the BNSF railway corridor right-of-way east of the Property, and the land under the Terminal Avenue overpass (Figure 2-2). Current land use for these properties is described in Section 2.1.3.

2.1.3 Surrounding properties

The Property is adjoined by the following properties (Figure 2-2):

- The KC property is located immediately north of the ADC Parcel, at 2600 Federal Avenue. The KC property was used for several decades for wood and paper products manufacturing. It housed former bulk petroleum storage tanks and currently includes a warehouse near the southern end adjacent to the ExxonMobil/ADC Property. Most of the former paper manufacturing facility was demolished in 2012. KC also owns a portion of the former Everett Avenue, north of the ADC Parcel.
- A City of Everett right-of-way is located immediately east of the Property. The City of Everett right-of-way is currently paved with asphalt and is otherwise unoccupied.
- Another City of Everett right-of-way is located immediately south of the Property. This right-of-way was formerly part of the ExxonMobil Parcel but was transferred to the City of Everett as part of the Terminal Avenue Overpass project. This right-of-way is currently paved with asphalt and is otherwise unoccupied.
- Federal Avenue is located immediately west of the Property. Federal Avenue is a public street and City of Everett utility corridor.

An active BNSF rail line and adjoining BNSF-owned parcels are located east and south of the Property, beyond the City of Everett rights-of-way. The Terminal Avenue Overpass crosses the BNSF railway corridor and the City of Everett right-of-way, and then joins Federal Avenue at grade near the southwest corner of the ExxonMobil Parcel. The properties to the west, beyond Federal Avenue, are owned by the Port of Everett, and several properties are occupied by various lessees, including Dunlap Towing. The shoreline of Port Gardner Bay is approximately 300 feet northwest of the Property.

2.2 Land use and operational history of the property and surrounding properties

This section briefly summarizes historical land use and operations at the Property and the surrounding area. Selected historical maps and other documentation for these parcels are provided in Appendix A. Additional historical documentation is available in the FFS Work Plan (AMEC Earth & Environmental, 2010a).

Native Americans were living along the shoreline of Port Gardner Bay as it existed at the time of initial European contact. Extensive development began in the late 19th century, when the shoreline was located in the general vicinity of the present-day Federal Avenue. The Property and surrounding properties were used for storage and transfer of petroleum and petroleum products beginning as early as 1920. Additional property development, including infilling of the bay west of the Property, continued until the present-day shoreline was established by 1976.

Figures 2-3 through 2-6 illustrate the recent history of the Property and its surroundings, as reconstructed using historical aerial photographs. Aerial photographs from 1947, 1967, and 1993 showing multiple aboveground storage tanks (ASTs) and extensive infrastructure are presented on Figures 2-3 through 2-5. Figure 2-6 shows the former features of the Property and neighboring parcels visible on historical maps and aerial photographs of the immediate vicinity, superimposed over a more recent aerial photograph from May 2013. This figure gives an indication of the types and locations of facilities that have been present on and near the Property. Additional historical maps and aerial photographs are presented in Appendix A.

2.2.1 ExxonMobil/ADC property

A search of records at the Washington State Department of Archaeology and Historic Preservation in Olympia and at the Everett Public Library's Northwest History Room failed to identify any evidence of previously recorded archaeological sites, historic buildings, or traditional cultural properties located on the Property.

Based on the 1902 Sanborn Fire Insurance map (Appendix A), the earliest known development of the Property consisted of wooden residential dwellings that lined the shoreline of Port Gardner Bay near present-day Federal Avenue. The map labels the Property as “marsh,” suggesting that these dwellings were likely constructed on native soils. The 1914 Sanborn map (Appendix A) indicates that the entire Property had become vacant. In 1915, the City of Everett passed Ordinance No. 1674 granting the Standard Oil Company of California (Standard), now known as Chevron Corporation (Chevron), permission to construct a tank farm consisting of three ASTs on Lot 1 of Block 619 (the northern portion of the ADC Parcel), with piping leading to Standard’s dock on the waterfront (Appendix A). However, it is not certain that the tank farm was actually built.

Historical documents show that a majority of the Property and surrounding properties were covered by a garbage dump in 1917 (Appendix A). A 1946 plot plan of the former ADC facility shows the toe-of-slope of the former garbage dump as of February 15, 1917, and references a City of Everett Engineering department drawing. Extensive background research failed to identify any further evidence that the dump was a formal sanitary landfill that accepted refuse from a City agency or wider geography.

Beginning as early as the 1920s, the Property was used for petroleum bulk storage, transfer, and distribution operations; marine offloading; truck loading; and rail loading and/or unloading of petroleum products that included fuel oils, stove oil, Bunker C fuel oil, diesel, and gasoline. Property use included handling a blend of synthetic and petroleum-based fluids (PS300) specially designed for compressor applications (AGRA 1996a); however, only small quantities (55-gallon drums or smaller) of PS300 were likely used and/or stored at the Property, as lubricating oils were not typically processed in bulk form at the Property.

In 1922, Gilmore Oil Co. Ltd. (predecessor to General Petroleum and later acquired by Mobil Oil Corporation [Mobil]) first leased the Property from the Great Northern Railway of Minnesota (a predecessor to BNSF) for bulk petroleum operations. In 1927, Gilmore Oil Co. Ltd. became an owner of the Property (AMEC Earth & Environmental, 2010a); General Petroleum and successors to the property, which included Mobil and ADC, continued bulk petroleum handling operations. An historical Great Northern Railway map dated 1930 (Appendix A) shows two large ASTs and several structures on the Property. By that time, the shoreline west of the Property had been extended farther into Port Gardner Bay, and several new developments were present on what is now the Port of Everett property across Federal Avenue.

In 1974, Mobil sold the northern two-thirds of the Property (the current ADC Parcel) to Mr. A.P. Miller for use by ADC. Mobil continued to operate a small bulk plant on the southern one-third of the Property (the ExxonMobil Parcel) until 1987. ADC operated a terminal on the ADC Parcel until 1990.

In 1985, recorded structures on the ADC Parcel consisted of two warehouse buildings, a pump house, and two diked fuel storage areas, each of which included two ASTs. In addition, fuel storage tanks were present in the northwest corner of the ExxonMobil Parcel. A 1985 environmental investigation conducted by Rittenhouse-Zeman & Associates, Inc. (RZA), identified evidence of surface spillage on the ExxonMobil Parcel at several locations, including the unloading racks, pump house, and near the outdoor drum storage area, and reported that a number of unintentional releases of petroleum products had occurred in the past due to tank leakage, tank overfills, and surface spills associated with the four ASTs (RZA, 1985). The tanks and other structures on the ExxonMobil Parcel were demolished in approximately 1987. The ExxonMobil Parcel appears to be covered with asphalt with no above-grade structures in the 1993 aerial photograph; several tanks and structures were present on the ADC Parcel in 1993 (Figure 2-5).

By 1990, four large ASTs and five small ASTs, surrounded by the concrete firewall, occupied the northern half of the ADC Parcel. An office building, a warehouse, a boiler room, an oil pump house, loading racks, and overhang canopies were located within the southern portion of the ADC Parcel. In addition, an AST, aboveground piping, and a concrete wall were located within the southern portion of the ADC Parcel. Locations of these former tanks are shown on Figure 2-6.

Peak operations at the bulk fuel tank farm on the Property occurred from the 1920s through early 1980s. ExxonMobil ceased operations in the mid-1980s, and ADC ceased operations in the early 1990s. Any releases of higher range petroleum hydrocarbons to the subsurface would be expected to have occurred during that time period. Thus, releases may have occurred as far back as 90 years ago, and at a minimum 25 years ago. Thus, contaminants that may be present in the subsurface and attributed to these business activities would consist of older, weathered petroleum products.

All structures on the ADC Parcel were demolished in 1998, and in 1999 the Property was capped with asphalt to meet the requirements of AO DE-98TCP-N223 (1998 Order) (Section 4.6). Since then, the Property has been used intermittently as a parking lot by neighboring businesses.

ExxonMobil was formed in 1999 by the merger of Exxon and Mobil. Ownership of the ExxonMobil Parcel passed to the newly formed corporation. Ownership of the southernmost portion of the historical ExxonMobil Parcel was transferred to the City of Everett as part of the Terminal Avenue Overpass project in the early 2000s.

2.2.2 History of surrounding properties

Several other facilities located north and northeast of the Property also had historical bulk petroleum operations. Additionally, beginning as early as the 1880s several wood and paper products manufacturing facilities lined the shoreline of Port Gardner Bay. Infrastructure at these properties included fuel pipelines, pumping facilities, storage facilities, railroad spurs, hog fuel burners, log and wood waste storage and disposal sites, and railroad and maritime loading facilities. In 1996, AGRA Earth and Environmental, Inc. (AGRA), identified various corporations in the vicinity with operations that could have resulted in releases of contaminants in the vicinity of the Property. These corporations included BNSF, Chevron, KC, Scott Paper Company, and Texaco Refining and Marketing, Inc. (Texaco). Historical features and operations of properties that surround the Property are shown on Figures 2-3 through 2-6. A brief summary of operations and activities at the properties is presented in Sections 2.2.2.1 through 2.2.2.4.

2.2.2.1 North, northeast, and northwest

The 1930 Great Northern Railway real estate map (Appendix A) shows that the southern portion of the current KC property was occupied by the Associated Oil Company (predecessor to Texaco) and Standard. Two railroad spurs located east of the Property and extending north are labeled “Associated Oil Co.” and “General Petroleum Corp” on the map. Three small oil ASTs were then located at the eastern boundary of the Standard property adjacent to a railroad spur labeled “Standard Oil Co.” (Figure 2-6).

In a 1947 aerial photograph, four small and two large ASTs are evident on the Associated Oil Company property approximately 400 feet north of the ADC Parcel, and three small ASTs remained next to the railroad spur on the Standard property (Figures 2-3 and 2-6). An industrial facility is evident on the photo farther north, beyond the Associated Oil Company property. This facility is the former paper mill, which operated originally as Puget Sound Pulp & Timber Company, later as Soundview Pulp Company, and eventually as Scott Paper Company in 1951.

Four small ASTs are evident half-way between the Associated Oil Company tank farm and the General Petroleum tank farm on a 1955 aerial photograph (Appendix A and Figure 2-6). Standard issued a quit claim for the Standard parcel to Scott Paper Company in 1958. In 1963, Standard sold its remaining property to Scott Paper Company.

Two additional large fuel oil ASTs are visible on the Associated Oil Company property in the 1967 aerial photograph (Figure 2-4), bringing the total number of ASTs on that property to eight. The four small fuel oil ASTs located just south of Associated Oil Company’s fuel farm are still present on the 1967 aerial photograph. By that time, KC’s warehouse had been built, and the footprint covered the location of the three former Standard ASTs (Figures 2-4 and 2-6).

Five ASTs on the Associated Oil Company fuel farm, and the KC building expanded to its current configuration, are shown in a 1976 aerial photograph (Appendix A). In addition, two large ASTs located northeast of the Associated Oil Company fuel farm and north of the KC warehouse appear on the 1976 aerial photograph. After purchasing the property from Chevron and successors to the Associated Oil Company, KC continued to use the former Associated Oil Company ASTs on the north side of the warehouse building to store bunker fuel for its boilers, and at least two of these tanks remained in place until 1997 (AECOM, 2011; Aspect, 2013a). According to the Polk City directories, “Scott Paper Co.” was listed as occupying the area to the north from 1958 to 1995. KC acquired Scott Paper Company in 1995, and KC has been listed as the owner of this property from 1995 until the present.

Two of the Associated Oil Company ASTs, the two ASTs associated with the KC mill, and the southern portion of the active mill are visible in the 1993 aerial photograph (Figure 2-5). The KC warehouse is also visible in the 1993 photograph. A reconnaissance of the Property and vicinity conducted in 1996 (AGRA, 1996a) indicated that one of the larger ASTs in the former Standard fuel farm was labeled as containing #3 Fuel Oil, and one of the smaller ASTs was labeled "caustic." One of the ASTs just north of the KC warehouse was reported to have contained diesel fuel or fuel oil (Ecology, 2013a). The other tank is labeled TREX on recent reports (Aspect, 2013a,b), but was not identified as a recognized or potential environmental concern in a Phase I Environmental Site Assessment prepared in 2011 (AECOM, 2011).

The former KC paper mill and the former ASTs visible in the historical aerial photographs were demolished in 2012–2013, although the warehouse building has been left intact (Aspect 2013a). Extensive contamination of soil and groundwater has been documented at the KC property, and KC is actively engaged in a cleanup process (Aspect, 2013a) (see Section 3.2.1).

2.2.2.2 South

In the late 1980s to early 1990s, Mr. Jack Johnston (part-owner of Johnston Petroleum) purchased the property immediately south of the current City of Everett right-of-way (just south of the ExxonMobil Parcel) from BNSF. At the time of the purchase, the Johnston parcel and ExxonMobil Parcel were adjoining. The Johnston property has been used for parking vehicles, storing packaged goods and oils, and receiving containers (e.g. 55-gallon drums) to be shipped to a recycling facility. Ownership of the former BNSF parcel passed to the Johnston Estate. In 2003, the southernmost portion of the ExxonMobil Parcel was severed and transferred to the City of Everett via a Consent Decree of Appropriation (No. 01-2-03480-2) as part of the Terminal Avenue Overpass project. Construction of the Terminal Avenue Overpass ramp was completed in 2003. The overpass crosses the Johnston Estate parcel and the southeast corner of the ExxonMobil Parcel.

2.2.2.3 West

As of 1915, the pre-development shoreline for Port Gardner Bay was located approximately along the present Federal Avenue (Appendix A). Over time, the shoreline was extended westward by filling the bay. A small warehouse is apparent across Federal Avenue from the Property and between 26th Street and California Street on the 1930 Great Northern Railway real estate map, and on aerial photographs through at least 1967 (Figures 2-3, 2-4, and 2-6; Appendix A). This warehouse was located directly on the waterfront of Port Gardner Bay as recently as 1967 (Figure 2-4). By 1947, the shoreline extended 100 to 200 feet west of the Property. A service garage for ADC was built along the 1947 shoreline, which was armored by a bulkhead, as seen in historical photographs. By 1967, additional dredge infilling had occurred immediately to the west of the KC property, where the eastern portion of the current Dunlop Towing parcel is located. Between 1967 and 1976, a much larger portion of Port Gardner Bay was filled in, resulting in the current sheet-pile bulkhead shoreline. The properties west of Federal Avenue belong to the Port of Everett and have been leased to various third parties, including ADC, for industrial use as the shoreline was extended westward over time.

According to Sanborn maps and a lease document, ADC leased the warehouse building from Great Northern Railway from 1937 until 1971. General Petroleum (predecessor of ExxonMobil) subleased the building from ADC between 1951 and 1971. General Petroleum and ADC stored oil, grease, and trucks in the warehouse and oil in steel drums adjacent to the warehouse. A wash rack and boiler room were located in the southern end of the building, as shown on the 1957 Sanborn map (Appendix A). Based on historical aerial photographs, the warehouse was removed sometime prior to 1976. In addition, a fuel pier extending westward into Port Gardner Bay was present adjacent to the warehouse from at least 1947 through 1967. The pier was leased by ADC and subleased to General Petroleum.

In 1973, the shoreline west of the Property was infilled to its current configuration by the Port of Everett. The 1976 aerial photograph shows the area used for log storage. The Port of Everett formerly leased the property west of Federal Avenue to Vigor Marine LLC (Vigor Marine). Vigor Marine used this property for ship repair and as a storage yard. Office trailers and a warehouse are also located on that property. The Port currently leases land northwest of the Property to Dunlap Towing, who operates a fleet of marine tugs and transports. Additional discussion of the progression of development and alteration of the shoreline adjacent to the Property is presented as part of the CSM in Section 8.

2.2.2.4 East

An alley belonging to the City of Everett as a right-of-way lies immediately to the east of the Property. This alley separates the Property from a larger parcel owned by BNSF and the active rail line farther to the east. Based on historic Sanborn maps and other historical maps and photographs, the rail line has existed at that location and appears to have been actively used since at least 1902 (Appendix A). According to the 1930 Great Northern Railway real estate map and Sanborn maps, the property directly east of the City of Everett right-of-way has belonged to BNSF since 1930.

Photographs and building plans showed a spur track to the east of the Property that appears to have been associated with a petroleum-loading rack that was used to pump oil into railroad tank cars. The 1930 Great Northern Railway map shows underground fuel lines running from the Property to the loading rack. Although no specific records were found documenting that these lines were decommissioned, the ADC Property owner believes all the piping was removed. The area appears to be unpaved with low-lying vegetation in the 1947 aerial photograph (Figure 2-3). The same area appears on historical aerial photographs to have been used predominantly as an open parking lot in 1947, 1955, 1967, 1985, and 1993 (Figures 2-3 through 2-5 and Appendix A). According to the City of Everett Tax Assessor records, the property to the east belongs to BNSF; this property was most recently used by KC as parking and storage prior to mill closure.

2.3 Anticipated future property use and site operations

The Property and the immediately surrounding properties are zoned M-2 Heavy Manufacturing land use by the City of Everett (2017a). The City's comprehensive plan shows the Property and the same surrounding properties as E.5.1 Heavy Industrial land use (City of Everett, 2017b). The current owners of the Property have no plans to sell or transfer the Property. The Property is currently used for industrial purposes and foreseeable future use is heavy industrial/or commercial.

The City of Everett has modified the M-2 zoning in Ordinance No. 3312-13 (effective January 25, 2013) by allowing some uses that could qualify as commercial uses in the Central Waterfront Planning Area, which includes the Property (City of Everett, 2013) and the nearby properties. In Table 5.2 of the ordinance, titled "Non Residential Uses," the M-2 zoning is modified to allow a mix of commercial and industrial uses. The allowed land uses specifically prohibit residential use and use for daycare facilities. Use of the area for parks is allowed. In addition, the owners of the Property anticipate that institutional controls will be put in place that will limit use of the Property to industrial/commercial purposes and potentially require implementation of passive or active vapor intrusion measures in the event that redevelopment in the future requires installation of utilities or new structures.

2.4 Environmental setting

This section presents a summary of general environmental conditions for the Property and the immediate vicinity. The Property is located in the southwest quarter of Section 19, Township 29 North, Range 5 East, Willamette Meridian. The nearest surface water is an inlet from Port Gardner Bay at Dunlap Towing, located approximately 300 feet northwest of the Property.

2.4.1 Topography

The topography of the Property and immediate vicinity is relatively flat, with an elevation of approximately 12 to 15 feet relative to the North American Vertical Datum of 1988 (NAVD88). The area slopes gently to the west toward Port Gardner Bay. Higher elevations, up to 150 feet, exist to the east of the Property. The surrounding area consists of roadways and industrial buildings surrounded by parking and storage areas.

2.4.2 Geology and hydrogeology

Extensive explorations have been conducted on the Property and in the nearby vicinity to characterize subsurface conditions. These explorations have included soil borings, monitoring wells, test pits, and limited subsurface excavations. Locations of these exploration points are presented on Figure 2-7. Lithologic logs collected from these explorations are compiled in Appendix B. These logs were used to construct representative stratigraphic cross sections of the Property and immediate vicinity. The locations of these cross sections (labeled A-A’ through E-E’) are illustrated on Figure 2-7, and the cross sections are presented on Figures 2-8 through 2-13.

Based on the 1914 Sanborn map, the Site consisted of low-lying mudflats shown as marshy areas, and the areas near these marshy areas were used by settlers for small residences and dwellings. The marshy areas were likely developed on top of the native near-surface geologic deposits. Settlers likely used the marsh for waste disposal. Near-surface geology in the area surrounding the Property is characterized by Vashon advance outwash deposits (Qva) and transitional beds (Qtb) (Minard, 1985). The outwash deposits are primarily granular and represent higher energy deposits that were deposited ahead of the Vashon glacier as the glacier melted. The transitional beds are composed of interbedded clayey, silty fine to medium sand, and the marsh was developed on top of these beds, so it is difficult to distinguish between fill and marsh deposits. The peat deposits noted in the cross sections likely represent the former marsh. The transitional beds are older than the advance outwash deposits and are the primary geologic unit mapped on the Property (Minard, 1985). The contact between the marsh deposits and the transitional beds occurs between 12 and 27 feet below ground surface (bgs).

Based on subsurface investigations conducted at the Property and surrounding vicinity, the near-surface soils at the Property consist of a heterogeneous mixture of fill materials. The fill materials consist of very loose to medium dense, brown, brownish gray, and gray silty sand and sand with areas of wood and brick debris extending to depths of approximately 5 to 10 feet bgs (corresponding to approximately 5 to 15 feet NAVD88).

The shoreline was gradually extended to the west as the Bay was infilled with sands and silty sands west of the Property and Federal Avenue. Among these typical shoreline silts and sands, significant quantities of organic substances are documented to be present, including wood waste and peat. The high organic content of native soil and fill materials present on the Property and in the immediate vicinity reduces mobility of the weathered petroleum hydrocarbons remaining in the subsurface from historic releases of diesel. Additional discussion concerning the fill history of the Site is presented in Sections 2.2.2 and 8.1.

Gray silty sand and silt and dark-brown to black peat mixed with wood debris are encountered beneath the shallow fill and extend up to 20 to 27 feet bgs. The transitional beds are dense, moist, brown, medium sand with various amounts of silt and discontinuous stiff, brown, organic-rich, clayey silt with some fine sand. The transitional beds were mapped at the land surface to the east of the Site.

Shallow unconfined groundwater occurs at the Site near the surface to 12 feet bgs, with shallower groundwater on the east side of the Site near the Terminal Avenue Overpass and deeper groundwater near the current shoreline. Groundwater is frequently observed to discharge from the base of the overpass and to the surface at the northeast corner of the Site on the KC property near the former Everett Avenue.

Contour maps based on groundwater elevations measured during semiannual monitoring events are shown on Figure 2-14 for February 2016 and on Figure 2-15 for August 2016. Groundwater levels vary seasonally by approximately 2–3 feet. The groundwater elevation contour maps show the 25-hour mean groundwater level calculated from continuous water levels recorded by transducers in February and August 2016. Based on the groundwater elevation data shown on Figures 2-14 and 2-15, groundwater beneath the Property flows generally toward the west and northwest. Groundwater wells located closer to the current shoreline show larger response to tidal variations. Wells MW-A1, MW-A2, and MW-A3 showed the greatest tidal response of 1.1 feet, compared to an 8- to 9-foot tidal range in surface water of Port Gardner Bay measured at the Everett Pier.

2.4.3 Surface water hydrology

Because the Property and surrounding area are paved, surface water drainage is controlled largely by surface topography and engineered drainage structures. Surface water runoff at the Property follows existing topography. Stormwater generally flows to the west and northwest, following the surface slope, toward catch basins located on the Property and on Federal Avenue directly west of the Property. Storm sewers serving the Property and vicinity discharge to Port Gardner Bay via the storm sewer discharge located near the northwest corner of the Port of Everett property leased by Dunlap Towing.

The locations of known storm drains and catch basins are shown on Figure 2-16, based on a survey conducted in 2010 by TrueNorth Land Surveying, Inc. (Appendix C). Four catch basins are located on the Property, approximately 70 feet east of the western Property boundary. These catch basins are located in a linear group oriented north-south. The catch basins on the Property are connected via underground conveyances (AMEC Earth & Environmental, 2007) and discharge via a lateral that extends toward Federal Avenue.

Additional catch basins are present along Federal Avenue farther west, but it is unknown if the storm drains are interconnected.

Some surface water may flow north from the Property toward the KC property and south from the Property to the City of Everett parcel. Surface water may also flow onto the Property from the BNSF property.

The combined stormwater and sanitary sewer line services the area. Sewage is pumped to and treated at the City of Everett sewage treatment plant except during periods of heavy rainfall, when overflow is routed directly to Port Gardner Bay.

2.4.4 Meteorology

Everett has a moderate climate usually classified as Marine West Coast, typified by wet, cool winters and relatively dry, warm summers. Temperature extremes are moderated by proximity to the adjacent Puget Sound and the greater Pacific Ocean. The region lies in a partial rain shadow, partially protected from Pacific storms by the Olympic Mountains, and from Arctic air by the Cascade Range.

The Western Regional Climate Center provides a summary of climatological statistics for Everett Junior College, located approximately 0.6 mile from the Property (WRCC, 2013). The average annual temperature measured at Everett Junior College is 50.6 degrees Fahrenheit (°F). Average monthly temperature varies from about 39°F in January to about 63°F in July and August. Winters are cool and wet with average lows around 35°F on winter nights. Colder weather can occur, but seldom lasts more than a few days. Summers are dry and warm, with average daytime high temperatures around 73°F in July and August. Hotter weather usually occurs only during a few summer days. The hottest official recorded temperature was 98°F on June 9, 1955; the coldest recorded temperature was 1°F on January 18, 1955 (WRCC, 2013).

Total annual precipitation is about 35.7 inches, with about two-thirds of the rainfall occurring during the wet season from October through March. Monthly average rainfall varies from a maximum of 4.96 inches in December to 1.04 inch in July. Most of the precipitation falls as drizzle or light rain, with only occasional downpours (WRCC, 2013). The 10-year and 100-year recurrence interval, 24-hour precipitation events are approximately 2.25 inches and 3.25 inches, respectively (Miller et al., 1973).

2.4.5 Ecological setting

The Property is located near the marine shoreline in the Snohomish River basin, in Washington Water Resources Inventory Area 7 (Ecology 2013b), in an area zoned for heavy industrial development (City of Everett, 2017a). The entire Property is paved, and no wetlands, streams, shorelines, floodplains, or functional wildlife habitat occur on the Property. Nearby environmentally sensitive areas include Port Gardner Bay and the Snohomish River.

Port Gardner Bay is located 300 feet west of the Property, immediately adjacent to the Port of Everett property, and contains the nearest wildlife area. Port Gardner Bay is classified as Dungeness crab (*Cancer magister*) habitat, according to the City of Everett Fish and Wildlife Habitat Conservation Areas Critical Areas Map (City of Everett, 2006). However, the shoreline near the Site consists largely of deepwater and limited subtidal and intertidal habitat that has been heavily modified by dredging, filling, and shoreline development (City of Everett, 2002).

Species listed under the Endangered Species Act (ESA) and Washington State Priority Species may be present in Port Gardner Bay and adjacent marine waters of Puget Sound. ESA-listed species present in Port Gardner Bay may include Chinook salmon (*Oncorhynchus tshawytscha*), bull trout (*Salvelinus confluentus*), coho salmon (*O. kisutch*), and steelhead (*O. mykiss*). Adult salmonid use of the area is limited to migration and possibly physiological transition. Juvenile use of the area is similar but may also include feeding/rearing and refuge from predation (City of Everett, 2002).

Common invertebrates present in Port Gardner Bay include snails (*Littorina* spp.), mussels (*Mytilus cf. edulis*), clams (*Macoma balthica, Macoma* spp., *Cryptomya* spp.), cockles (*Clinocardium* sp.), jingle shells (*Pododesmus macroschisma*), polychaetes (*Nereis* spp., *Notomastus* spp., *Nephtys* spp., *Glycera* spp.), barnacles (*Balanus glandula*), shore crabs (*Hemigrapsus* spp.), isopods (*Gnorimosphaeroma oregonesis*), ghost shrimp (*Callianassa* sp.), blue mud shrimp (*Upogebia pugettensis*), Dungeness crab (*Cancer magister*), red crab (*C. productus*), and anemones (*Mertridium senile*) (City of Everett, 2002).

Water quality in Port Gardner Bay meets Washington State water quality requirements for all parameters and is not listed on Ecology's 303d list of impaired waters (Ecology, 2014).

The Snohomish River is situated east and north of the Property, approximately 1.5 miles away. The East Waterway channel of the Snohomish River Estuary bends southward and empties into Port Gardner Bay adjacent to the Everett Naval Station. The East Waterway has been dredged and filled for development of deepwater port facilities. The Snohomish River and its estuary are separated from the Property by areas of industrial and other development, including the City of Everett's Central Business District, residential and commercial development, and areas of industrial and maritime services along the Snohomish River and East Waterway shoreline.

As noted previously, no wetlands, streams, shorelines, floodplains, or functional wildlife habitat occur on the Property or within the immediate vicinity (NWI, 2014; City of Everett, 2006 and 2012). Vegetation in the vicinity of the Property is sparse and generally limited to maintained landscaping, including ornamental shrubs and trees. The nearest stream habitat is Pigeon Creek #1 and its associated wetlands, located approximately 1 mile southwest of the Property.

2.4.6 Tidal influence

Studies to assess the influence of tidal cycles on groundwater flow were conducted at the Property by RZA AGRA in 1991 (as reported by Exponent, 1998) and by Wood in 2008 (AMEC Earth & Environmental, 2008), February 2011 (AMEC Earth & Environmental, 2011a), and 2014.

As reported by Exponent (1998), AGRA monitored water levels in selected monitoring wells for a 48-hour period to measure recovery after a 24-hour aquifer test and to assess potential tidal influences in shallow groundwater. During the 48-hour period, no clear evidence of tidal fluctuations was noted. Based on the results of the recovery monitoring, the observed hydraulic gradient at the Property, and the distance from Port Gardner Bay, it was concluded that tidal influences on shallow groundwater at the Property would be expected to be negligible (Exponent, 1998).

In 2014, a set of seven transducer/loggers were installed in seven wells both on and downgradient of the Property. Results of the 2014 tidal study were consistent with the results from the earlier tidal study conducted in 2011 (AMEC Earth & Environmental, 2011a). Figures 2-17 through 2-20 show hydrographs of water levels in these seven wells measured from late July 25, 2014, through September 29, 2014. Transducer readings for these wells have been corrected for barometric pressure readings, which were collected simultaneously, to yield water levels. The hydrographs show the actual water levels and the 25-hour moving average water level for each of the wells. The 25-hour moving average water level filters the daily tidal fluctuations to facilitate evaluation of mean groundwater levels and to evaluate groundwater flow directions (Serfes, 1991). The hourly precipitation records from Paine Field in Everett are also plotted on the hydrographs.

Groundwater levels at the Site are influenced by the tidal fluctuations in Port Gardner Bay. In areas where groundwater levels are influenced by tidal fluctuations, manual water level measurements can lead to under- or overestimates of the hydraulic gradients, with steeper gradients at low tides and flat or slightly reversed hydraulic gradients at high tide. In areas with tidally influenced groundwater, like the Site, the overall groundwater flow directions are determined by the mean hydraulic gradient (Serfes, 1991). The 25-hour average water level for each of the wells can be used to determine the mean or average groundwater flow direction and hydraulic gradient. The 25-hour average water level dampens or filters the tidal "signal" (Serfes, 1991). It should be noted that the amount of flow reversal during a given tidal cycle is minimal, since the peak high tides only last for approximately one hour before ebbing. Any mixing due to flow reversal would affect only the portion of the aquifer present near the shoreline.

There are two high and low tides in a day, and a complete tidal cycle takes 25 hours to complete. Of the two high tides in a cycle, one is generally higher than the other. In order to conservatively calculate the degree of mixing during the highest portion of the tidal cycle, Wood reviewed the tidal records for June 2016 (the highest and lowest tides of any year occur near the summer and winter solstices). The highest tide in June 2016 occurred on June 6, 2016, at 7:53 PM, with a height of 12.3 feet above mean lower low water (MLLW). Groundwater monitoring wells MW-A3, MW A4, and MW-A5 are all equipped with self-logging transducers that record water levels every 15 minutes. After correcting the measured water levels for barometric pressure, Wood calculated the tidal flux using the following steps:

- The mean water level for the 12.5-hour period prior to and after the highest high tide was determined using the vertical datum of NGVD88.
- The highest high tide water level of 12.3 feet MLLW was converted from MLLW to the NGVD88 datum by subtracting 1.8 feet, yielding a high-water elevation of 10.5 feet NGVD88.
- The groundwater seepage velocity equation $S_v = Ki/n_e$ (Fetter, 1994) was used to calculate tidal flux, where:

- S_v is the seepage velocity in inches/hour;
- K = the hydraulic conductivity of the aquifer materials expressed in inches/hour;
- i = the hydraulic gradient (dimensionless); and
- n_e = effective porosity

- The hydraulic conductivities used were determined by slug tests conducted in MW-A5 and MW-A6 (see Section 7.1).
- The hydraulic gradient was determined by dividing the difference between the highest high-water elevation and the 25-hour mean water level in MW-A3, MW-A4, and MW-A5 by the distance to Port Gardner Bay from each well.
- The effective porosity is the void space available for groundwater flow, and a value of 0.30 is typical for sands that comprise the aquifer material.

Assuming the highest high tide level was held constant for 6.25 hours, we calculated the distance the tidal flux would travel inland would range from approximately 0.17 to 0.56 feet. A copy of this calculation and the associated tidal graph and schematic cross-section are included in Appendix D. This estimate of the maximum tidal flux is very conservative and shows that the tidal exchange of surface water and groundwater is limited to the immediate vicinity of the shoreline.

Two of the seven wells (MW-40R and RW-2) are located on the Property and show a very minimal response (<0.05 foot) to tidal variations, but a strong response to infiltration of precipitation. The hydrographs for these two wells resemble one another, suggesting they are responding to the same influx of precipitation. After a spike in water levels caused by a rain event, groundwater levels gradually decrease until the next precipitation event.

Wells MW-A1, MW-A2, MW-A3, and MW-A5 respond in a limited way to infiltration of precipitation, with MW-A1 and MW-A5 showing the greatest precipitation response. Well MW-A3 shows very little response to precipitation. These same wells show tidal variations or “signals” ranging from 0.3 foot to 0.9 foot, with MW-A3 showing the strongest tidal signal, and MW-A1 the smallest tidal signal.

MW-A4 has a very minor response to the tides, and the mean water level in the well appears to vary in response to barometric pressure (Figure 2-21), with the general rise in water levels likely due to infiltration. Field observations indicate that MW-A4 has microbial growth on the surface of the water that coats the surface of the water level meter tape. The well log reports silty sands with wood noted at 15 and 20 feet bgs; at 20 feet bgs the sand becomes poorly graded with marine shells. It is not known why this well has a limited tidal response.

2.4.7 Historic and cultural resources

Records were researched at the State of Washington Department of Archaeology and Historic Preservation in Olympia and at the Everett Public Library's Northwest History Room to identify potential historic or cultural resources in the immediate vicinity of the Site. There are no previously documented historic properties (e.g., archaeological sites or isolated finds, historic buildings/structures/objects, and traditional cultural properties) either listed or eligible for listing in the National Register of Historic Places located on the Property. One pre-contact isolate find (45SN629) was recently recorded on the KC parcel located immediately north of the Property (Undem, 2013). The isolate was discovered during archaeological monitoring for the KC Upland Area Project (No. 110207-004-01). The archaeological monitoring was needed for the upland area project based on the findings presented in an Archaeological Resources Assessment that was completed in 2013 by SWCA Environmental Consultants (SWCA, 2013a).

The Archaeological Resources Assessment categorized the KC upland area based on sensitivity for unknown and significant archaeological materials. Upland areas classified with a high sensitivity for buried cultural resources were addressed in a monitoring and discovery plan for use during interim remedial measures ("opportunistic cleanup") to be implemented as part of demolition activities on the KC parcel (SWCA, 2013b). During implementation of the remedial action, one pre-contact lithic artifact, an edge-altered cobble (45SN629), was recorded (Undem, 2013; Aspect, 2015). The Archaeological Resources Assessment was based on geomorphological and historical analyses of the Port Gardner Bay nearshore environment. This analysis is relevant to the Property, as the feasibility study (FS) addressed in this report includes the same subtidal delta deposits (low sensitivity); marsh and foreshore environment (moderate sensitivity); and beach, backshore, and upland areas (high sensitivity) addressed in the KC report.

Three historic property inventory forms are on file with the Washington State Department of Archaeology and Historic Preservation for buildings located on the adjacent KC parcel. These buildings were formerly associated with the Puget Sound Pulp and Timber Mill that dates back to 1929 (Sharley, 2012; Artifacts, Inc., 2011; Ravetz, 2005). No historic buildings, structures, or objects that require historic property inventory documentation are present on the Property.

Although no specific traditional cultural properties have been identified within the project area, the Everett waterfront in general has a long history of tribal use. A brief summary of tribal use associated with the Everett waterfront along with tribal engagement activities that have taken place was provided by Ecology and is set forth below.

Ecology is working with landowners/stakeholders, including local Native American tribes, to clean up contaminated sites and sediments in the vicinity of Port Gardner Bay and the Snohomish River Estuary. Port Gardner Bay is identified as a high-priority, "early-action" cleanup area under the Puget Sound Initiative (PSI). The Site has been identified as a cleanup site under the PSI. Local tribes that have been actively engaged by Ecology under the PSI at Port Gardner include the Tulalip, Suquamish, Swinomish, and Lummi. Ecology has worked with a tribal liaison to assist in developing contacts and early engagement activities with cultural and natural resource sections within each of the aforementioned tribes. Engagement with the tribes has consisted of meetings to discuss PSI cleanup sites and cultural resources, providing the tribes with draft work products for comment, and a monthly update summarizing the current status of each PSI site, near-term work products to be submitted for tribal review, project schedules, and a summary of tribal engagement activities for the Port Gardner PSI Sites.

Based on information obtained from Ecology's discussions with the tribes and information provided in a 1973 Shoreline Historical Survey Report (Dilgard and Riddle, 1973), people have inhabited the Port Gardner Bay area for thousands of years. For centuries, the northwest point of the peninsula (i.e., Preston Point) was the location of Hebolb, the principal village of the Snohomish tribe. Its location near the mouth off the Snohomish River and next to Port Gardner Bay provided both abundant food and access to transportation routes. Native tribes used the Everett shoreline in part for subsistence activities, such as shellfish collection, hunting, plant gathering, and fishing. According to local tribes, native long houses were located up and down the Everett waterfront. Local tribes have communicated to Ecology that the Everett waterfront is a culturally sensitive area. Due to the cultural sensitivity of the project area and the potential to encounter cultural artifacts during cleanup activities, the cleanup action will include a monitoring and unanticipated cultural resources discovery plan outlining procedures to be used in the event cultural resources are encountered during remediation activities on the Property. The monitoring plan will address cleanup activities conducted in project areas that have a high sensitivity classification for cultural resources.

Historic maps and aerial photographs of the project area also were consulted. Sanborn Fire Insurance maps from the early part of the 20th century depict an emerging industrial area with a few wooden and temporary dwellings lining the historic shoreline of Port Gardner Bay. A 1946 plot plan of the former ADC facility shows the toe-of-slope of a former garbage dump on the property as of February 15, 1917 (Section 2.2.1). Extensive background research failed to identify any further evidence to suggest the Property was used as a formal dump/sanitary landfill accepting municipal refuse or trash from a wider geography. The BNSF excavation in 2011 encountered vintage bottles, old shoes, and lumber that were likely disposed in the old marsh area noted in the 1914 Sanborn map. Future cleanup planning will need to address cultural resources that may be encountered in this area. A building or artifact must generally be a minimum of 50 years old to be considered historically significant; however, not all objects more than 50 years old are considered significant cultural resources.

2.4.8 Utilities

Underground utilities in the vicinity of the Property are shown on Figure 2-16. Stormwater drainage lines are present beneath the Property. Underground stormwater, sanitary sewer, water, and telephone lines run beneath Federal Avenue and the adjoining KC property. The City of Everett's new 24-inch underground force main also runs beneath Federal Avenue and the KC property. An overhead power line runs along Federal Avenue and the KC property.

Any contractor conducting subsurface work at the Site must independently identify underground utilities prior to conducting the subsurface work.

2.5 Regulatory and compliance history

Petroleum contamination has been found in soil and groundwater beneath the Site, as described in detail in Section 3 of this report. This contamination is the result of historic releases from the bulk petroleum facilities that operated on the Property and adjacent properties to the west (Port of Everett), north (Everett Avenue right-of-way and adjacent to the KC warehouse), and east (BNSF property and in the vicinity of the former loading racks). Due to the presence of petroleum contamination, the Site is subject to cleanup under the terms of the MTCA regulations (WAC 173-340). Cleanup activities and Site investigations have been conducted at the Site since the mid-1980s, and include several AOs issued under MTCA that direct cleanup actions.

In 1996, Mobil and ADC entered into AO No. DE-95TC-N402 (1996 Order) with Ecology to take necessary steps to clean up, eliminate, and/or contain petroleum releases at and near the City of Everett combined sewer overflow (CSO) discharge line and/or diffuser into Port Gardner Bay. The 1996 Order also required pilot testing of petroleum recovery technologies; characterization of the nature of contamination in the vicinity of the CSO line; and repair of the CSO line. In response to the 1996 Order, interim remedial actions were undertaken, and studies performed at the Site demonstrated that the exposure pathway to Port Gardner Bay had been removed through repair and replacement of portions of the CSO line that also included slip-lining of the sewer. Approximately 23,000 gallons of petroleum was recovered within the vicinity of the CSO line by various interim remedial measures. Section 4 presents a more detailed discussion of interim remedial measures implemented at the Site.

In December 1996, Ecology issued notice of potential liability letters to KC, Texaco, BNSF, Scott Paper Company, and Chevron. The letters stated that credible evidence of releases of hazardous substances from the properties owned or operated by each of these companies existed.

In 1998, Mobil and ADC entered into a new AO (the 1998 Order) with Ecology to complete a remedial investigation (RI) and FFS. RAOs were developed and approved by Ecology using existing analytical data, agreed-upon exposure pathway analyses, and a screening-level risk assessment. The cleanup approach selected to achieve RAOs included a liquid-phase petroleum hydrocarbons (LPH) interceptor trench along the western and northern boundaries of the Property and a low-permeability cap over the Property. The interceptor trench and cap were installed in 1999 (Section 4.6).

Periodic groundwater monitoring began at the Site in the early 1990s. Regular quarterly groundwater monitoring and monthly LPH gauging and removal commenced in 2002, as a requirement under the 1998 Order and in accordance with a monitoring program that was prepared by Premier Environmental Services, LLC (Premier, 2002) and submitted to Ecology.

In 2007, the groundwater monitoring frequency for the Site was reduced from quarterly to semiannually. This change in monitoring frequency was verbally accepted by Ecology in February 2007, and acceptance was again confirmed in a meeting with Ecology on August 8, 2007.

In 2010, Ecology, ADC, and ExxonMobil entered into a third AO, the 2010 Order. The 2010 Order specifies that an FFS and DCAP be prepared to identify the nature and extent of Site soil and groundwater contamination in order to select a preferred final cleanup action to address contamination in soil and groundwater at the Site in compliance with requirements under MTCA.

A draft FFS Work Plan was prepared and submitted to Ecology in February 2010, which identified further investigations needed to complete the FFS (AMEC Earth & Environmental, 2010a) (Section 3.1.1). Additional field sampling and analysis were conducted in June 2010 through February 2011 to fill these data gaps, and the results were reported to Ecology in April 2011 (AMEC Earth & Environmental, 2011b) (Section 3.1.2).

ExxonMobil/ADC conducted several investigations and implemented interim measures in 2010–2011 to assist the City of Everett during the installation of a new 24-inch force main along Federal Avenue and former Everett Avenue. In June 2010, Wood decommissioned pipelines and removed areas of affected soil to the west of the Property to prepare for the force main installation (Section 4.9) (AMEC Earth & Environmental, 2011d). Wood also conducted two rounds of soil sampling at various depths to characterize soils that were to be excavated as part of the force main installation for disposal purposes (AMEC, 2014a) (Section 3.1.3).

In 2011, seeps of LPH were observed from a section of the roadway on former Everett Avenue, and an exploratory test pit advanced at the location of one of the seeps confirmed the presence of LPH below the asphalt. An interim action was conducted from December 2011 to April 2012 to excavate and dispose of surface asphalt, affected soil, and recovered LPH and groundwater from the ExxonMobil/ADC, BNSF, and KC properties that were contributing to these seeps (Section 4.10) (AMEC, 2012a). This interim action was undertaken independently by ExxonMobil/ADC and was not conducted under the 2010 Order. Ecology was notified in advance about the work and observed performance of the work on several occasions.

The information obtained while conducting the interim action indicated that the CSM presented in the 2011 Data Gaps Investigation Report (AMEC Earth & Environmental, 2011b) was incomplete. These observations indicated that further information was needed to refine the CSM and guide the development and evaluation of remedial measure alternatives in the SC/FFS report. Additional subsurface investigations were conducted at the Site during October–November 2013 and February 2014 to address remaining data gaps both on the Property and on separate properties adjacent to the Property. The investigations were conducted based on the final Data Investigation Work Plan (AMEC, 2013), and the results were reported to Ecology in April 2014 (AMEC, 2014a) (Section 3.1.7).

This SC/FFS report will serve as the basis for development of the DCAP, which will outline the final corrective measures for the Site, as specified in the 2010 Order.

3.0 Previous environmental characterization/sampling investigations

Extensive characterization and sampling activities have been conducted at the Site since 1985. These investigations included drilling soil borings, installation of monitoring wells, excavation of test pits, and collection and analytical testing of soil and groundwater samples. Table 3-1 provides a chronology and brief summary of previous investigations conducted at the Property and vicinity. The FFS Work Plan (AMEC Earth & Environmental, 2010a) presented a detailed description of previous investigations conducted through 2009, which are all included in Table 3-1.

This section presents a brief summary of characterization and sampling work conducted to date and identifies the basis for the discussion of the overall nature and extent of Site contamination presented in Section 6. Figure 2-7 shows the locations of historical explorations conducted to date, and the tables in Appendix E show the historical data used to identify Site COCs. Summaries of investigations conducted since preparation of the FFS Work Plan are presented below. A synthesis of these and earlier investigations in the context of exceedances, locations where residual TPH is present, and contamination depths is presented in Section 6.

3.1 Previous investigations for the ExxonMobil/ADC site

This section summarizes investigation work conducted on the Property since the FFS Work Plan was completed in 2010.

3.1.1 February 2010 focused feasibility study work plan

The FFS Work Plan presented a comprehensive summary of the history of past ownership and operations of the Property and its surroundings (the Site); summarized previous environmental investigations and interim remedial activities; presented a summary of known environmental conditions at the Site; presented a preliminary CSM; and identified remaining data gaps that needed to be filled in order to complete the FFS (AMEC Earth & Environmental, 2010a). The FFS Work Plan included a Sampling and Analysis Plan (SAP) outlining additional field investigations needed to fill those data gaps.

3.1.2 2011 Data gaps investigation

The FFS Work Plan (AMEC Earth & Environmental, 2010a) identified certain data gaps that needed to be filled in order to complete the FFS. Additional field sampling and analysis were conducted in June 2010 through February 2011 to fill these data gaps, and the results were reported to Ecology in April 2011 (AMEC Earth & Environmental, 2011b). The 2011 Data Gaps Investigation included the following scope of work to fill the gaps:

- sampling and analysis from seven deep borings (AB-1 through AB-7ab) located on- and off-Property to evaluate lithologic conditions, determine if a silt confining layer is present beneath the Site, and test soils at locations where field evidence indicated the presence of petroleum hydrocarbons;
- installation and monitoring of five new groundwater monitoring wells (MW-A3 through MW-A7) to define the limit of dissolved-phase petroleum hydrocarbon contamination;
- sampling and analysis of soil and groundwater samples from five shallow borings (AP-2 through AP-5 and AP-7) on the BNSF parcel to define the vertical and horizontal extent of soil contamination near the former loading racks;
- sampling and analysis of soil and groundwater from one shallow boring (AP-1) to identify potential contamination near the former ADC garage and shop building on the Port of Everett property;

- sampling and analysis of soil and groundwater samples from soil borings and monitoring wells to further define the nature and extent of petroleum impacts and to assess geochemical conditions;
- measurement of groundwater levels to assess the groundwater potentiometric surface, surface gradient, and direction of groundwater flow;
- aquifer testing to assess hydraulic conductivity of off-Property soils; and
- a study of groundwater elevations to assess tidal influence on the groundwater flow regime at the Site (Section 3.1.4).

Small amounts of light nonaqueous-phase liquid (LNAPL) were observed in wells W-10R, MW-27, W-1, and MW-15R, while larger amounts were recovered from wells W-2 and MW-29. No continuous silt layer was identified beneath the Property. A plume of groundwater affected by petroleum hydrocarbons was identified to the west and northwest of the Property. Groundwater downgradient from the Property was not affected by volatile organic compounds (VOCs), benzene, carcinogenic polycyclic aromatic hydrocarbons (cPAHs), lead, or total petroleum hydrocarbons (TPH) as gasoline (TPH-G). Monitoring well MW-A3, located southwest of the Property, had a concentration of TPH as diesel (TPH-D) greater than the preliminary screening level only in February 2011. Upgradient monitoring well MW-A7 did not have reportable concentrations of analytes. Spatial patterns in results for geochemical parameters at the Site were consistent with the development of an anaerobic environment in which petroleum biodegradation appears to be actively occurring. Additional details concerning the extent of hydrocarbons at the Site are discussed in Section 3.1.7 and Section 6.3.

As described in detail in the Section 6.5.2 of the Data Gaps Investigation report (AMEC Earth & Environmental, 2011b), the distribution of groundwater geochemical parameters (i.e., oxidation-reduction potential [ORP], dissolved oxygen [DO], dissolved iron and manganese, sulfate, methane, and alkalinity) across the Site supports natural biodegradation of hydrocarbons at the Site. Moving from upgradient well MW-11 (along the eastern border of the Property) downgradient toward Possession Sound, the ORP and DO decrease in concentration, indicating that biodegradation is utilizing oxygen and creating reducing conditions. Dissolved manganese and dissolved iron increase in concentration in the downgradient wells, which is consistent with biological use of these metals as electron acceptors. Sulfate concentrations decrease due to biological reduction to sulfide along the groundwater flow path. Biodegradation of hydrocarbons under anaerobic conditions contributes to the observed increases in methane concentrations along the groundwater flow path. Alkalinity is also observed to increase as groundwater migrates across the Site, due to dissolution of minerals caused by absorption of carbon dioxide generated from biodegradation (AMEC Earth & Environmental, 2011b).

3.1.3 February 2010 City of Everett force main sampling

Wood conducted soil sampling and analysis along the planned alignment of the City of Everett's new 24-inch force main to characterize soils along the alignment route for disposal requirements. The investigations were conducted based on (1) a SAP for borings CE-1 thorough CE-5 included as Appendix E to the FFS Work Plan (AMEC Earth & Environmental, 2010a), and (2) a second SAP for borings CE-6 through CE-8, which included decommissioning two monitoring wells on BNSF property and collecting a grab sample (CE-9) during the decommissioning. The analyses from those samples were sent to the City of Everett (AMEC Earth & Environmental, 2011c). Soil samples were collected at several depths from eight borings advanced on Federal Avenue and the former Everett Avenue in the alignment of the planned force main. Samples from selected borings and depths were analyzed for TPH fractions; benzene, toluene, ethylbenzene, and xylenes (BTEX); polycyclic aromatic hydrocarbons (PAHs); VOCs; and selected metals.

The analytical results were used by the City to classify soil to be excavated as part of the City's force main project for disposal purposes.

3.1.4 2011 Tidal study

Wood conducted a tidal influence study in February 2011 to determine whether fluctuations in groundwater levels were related to tidal fluctuations and, if so, to evaluate the extent of tidal influences. A stilling well equipped with a transducer was installed on the Everett Pier to automatically record tidal elevations, and pressure transducer/data loggers were installed in monitoring wells W-3, W-6, MW-11, MW-19, MW-28, MW-40R, and MW-A1 through MW-A7 to record groundwater levels every 6 minutes for a period of six days. In addition, a barometer was installed and programmed to collect barometric pressure readings throughout the tidal study period so that water level data collected in the monitoring wells and stilling well could be adjusted for barometric pressure.

Results showed that water levels in monitoring wells W-3, MW-11, MW-A1, MW-A2, MW-A3, MW-A5, and MW-A6 were tidally influenced, with tidal fluctuations ranging from 0.1 foot to 1.1 feet. MW-19, MW-28, MW-40R, and MW-A4 exhibited minimal tidal influence; water levels in these wells were most influenced by changes in barometric pressure. W-6 exhibited minimal response to tidal fluctuations, and water levels in monitoring well MW-A7 changed by less than 0.1 foot throughout the study period. These observations indicate that much of the Site groundwater is influenced by the tides in Port Gardner Bay, especially in areas filled after 1914. This finding indicates that tidal variation needs to be considered when establishing the groundwater gradient.

To evaluate tidal influence on the direction of groundwater flow, the mean groundwater elevation at each monitoring point was estimated using the method described by Serfes (1991). A potentiometric surface map derived from these mean groundwater elevations showed that the mean direction of groundwater flow at the Property on February 10, 2011, was toward the west (Figure 3-1) (AMEC Earth & Environmental, 2011a).

3.1.5 2011 Observations of seeps along former Everett Avenue

On several occasions in 2011, seeps of water with a visible sheen or the presence of LPH were reported along former Everett Avenue. Wood documented the presence of these seeps by recording photographs in the field (Figure 3-2) (AMEC Earth & Environmental, 2011d,e).

3.1.6 2012 Observations during City of Everett force main replacement

Wood was present on the Site in May 2012 when the City of Everett installed a new 24-inch sanitary sewer force main along Federal Avenue and the former Everett Avenue. Subsurface construction activities included excavation of trenches for the new sewer line and drilling of boreholes used for dewatering activities. Wood observed excavation and drilling activities and recorded notable subsurface features when relevant, including the presence of LPH if encountered. Wood documented the presence of LPH in borings and/or trenches along much of the alignment on former Everett Avenue, and at eight locations along Federal Avenue (AMEC, 2012b).

Dewatering for this project began May 15, 2012, and continued for a month. Dewatering progressed from east to west along former Everett Avenue, and then south along Federal Avenue. Dewatering for the project withdrew over 12 million gallons at an approximate rate of 300 gallons per minute. The dewatering lowered the water table along Federal Avenue to 12 feet bgs (a drop of 9–10 feet). The drawdown cone associated with the dewatering likely reached a diameter of 300 to 400 feet around dewatering points, which would have affected most of the Property.

During the 2012 force main replacement project, G-Logics reported material appearing to be LPH flowing into the trench from the northeast at Station 13+00; however, no samples were collected for analysis to confirm this observation. Material appearing to be LPH is often not recoverable and may be immobile due to high content of organic matter in subsurface soils at the Site. The presence of sheens in excavations can be attributed to residually saturated, immobile hydrocarbons in soil that are mobilized temporarily when the soil is disturbed.

3.1.7 2013/2014 Data gaps investigation report

Wood conducted field investigations in October–November 2013 and February 2014 to fill data gaps regarding the nature and extent of soil and groundwater contamination in areas of the Site potentially affected by former petroleum releases. The investigation was implemented based on the Data Investigation Work Plan (AMEC, 2013). During these investigations a total of 33 soil borings were drilled on the Property and surrounding properties (Federal Avenue and the BNSF, KC, Port of Everett, Dunlap Towing, and City of Everett properties). Soil samples were collected and analyzed to delineate areas of affected soil at the Site. Soil samples were analyzed for the following constituents:

- TPH-G;
- TPH-D and TPH as oil (TPH-O) (using silica gel cleanup procedure);
- BTEX and methyl tertiary-butyl ether (MTBE);
- 1,2-dichloroethane, 1,2-dibromoethane, and *n*-hexane (for selected samples based on field observations); and
- low-level PAHs.

In addition, analyses for extractable petroleum hydrocarbons and volatile petroleum hydrocarbons were conducted on selected soil samples with higher concentrations of petroleum hydrocarbons and benzene.

One of the borings was completed as a new monitoring well (MW-A8), and groundwater samples were collected from the well in November 2013. Groundwater samples were analyzed for TPH-G, TPH-D and TPH-O, BTEX, MTBE, 1,2-dichloroethane, *n*-hexane, 1,2-dibromoethane, low-level PAHs, and dissolved lead.

The results of the 2013/2014 data gaps investigation show that the area of soil affected by releases from the Property has been adequately characterized. Visible product and/or sheen were observed in borings conducted over much of the ADC and Exxon/Mobil Parcels, and in the vicinity of the former ADC garage on the Port of Everett property. In general, higher concentrations of COCs were found within the boundary of the Property and in the western portion of the former ADC garage. The boundary of contamination is defined to the east by borings on the BNSF property, where concentrations of COCs were either below the MTCA Method A cleanup level or were not detected. To the west, the boundary of highly contaminated soil is defined by borings PE-SB08 and PE-SB10, where lower concentrations of TPH were detected that were either below or just slightly above the MTCA Method A cleanup level. Contamination west of Federal Avenue is highest at the location of the former ADC garage, and exceedances were observed to the north, south, and west of the former garage footprint. To the north, soil contamination from the Property extends to former Everett Avenue. Soil samples from borings FA-SB06 exceeded the PCLs for TPH-G, TPH-D, total cPAHs and 1-methylnaphthalene. Petroleum contamination on KC property farther to the north of former Everett Avenue likely originated from sources that were located on the KC property.

3.1.8 Groundwater monitoring

Periodic groundwater monitoring began on the Property in the early 1990s. Regular quarterly groundwater monitoring and monthly LPH gauging and removal commenced in 2002 and continued through 2007, when the groundwater monitoring frequency for the Property was reduced from quarterly to semiannually. This change in monitoring frequency was verbally accepted by Ecology in February 2007, and the acceptance was confirmed in a meeting with Ecology on August 8, 2007.

The monitoring program at the Site currently consists of the following activities:

- monthly inspections of the Site;
- monthly measurements of LPH thickness and depth-to-water in LPH recovery wells (LPH-1, LPH-2, LPH-3, LPH-4, LPH-5, LPH-6, LPH-7, LPH-8, LPH-9, and RW-2), selected monitoring wells (W-1, W-2, W-3, W-6, MW-10, W-10R, MW-11, W-15R, W-17, MW-19, MW-40R, MW-A1, MW-A2), and Sumps 1 and 2;
- semiannual measurement of depth to water in monitoring wells MW-A3 through MW-A8; and
- sampling of designated monitoring wells and laboratory analysis of groundwater samples for TPH fractions, BTEX, MTBE, and selected PAHs.

In addition, LPH is removed from selected wells periodically (see Section 4.7).

The current groundwater monitoring network is shown on Figure 3-3. From 2002 to 2007, groundwater samples were collected from five monitoring wells: MW-11, MW-19, MW-40R, W-3, and W-6. Wells W-3 and W-6 have not been sampled since 2010. Eight additional off-Property monitoring wells (MW-A1 through MW-A8) have been installed since 2008 and are also included in the groundwater gauging and monitoring network.

Groundwater samples are collected using a peristaltic pump and dedicated disposable tubing. The purge water is monitored for field water quality parameters (temperature, pH, specific conductivity, turbidity, DO, and ORP) recorded at 5-minute intervals using a Horiba U-22 (or similar) water quality meter.

Regular groundwater monitoring has produced a comprehensive data set of groundwater elevations and groundwater quality dating back to as far as 1988 (Wood, 2018).

Groundwater samples were submitted to Test America Laboratories for chemical analysis until January 2015, when the laboratory was switched to Eurofins Calscience (Eurofins). All analytical data have been reviewed following requirements specified in U.S. Environmental Protection Agency (EPA) National Functional Guidelines for Superfund Organic Methods Data Review (EPA, 2008, 2017). Analytical data from all groundwater monitoring events are entered into the project database. Analytical results are discussed in detail in Section 6.2 for samples collected in January 2015 from a comprehensive set of groundwater monitoring wells.

3.2 Previous environmental investigations on nearby properties

This section presents a brief summary of information gleaned from environmental investigations conducted for other properties in the vicinity of the Site.

3.2.1 Kimberly-Clark

The KC property has a long history of industrial use dating back to 1892 (AECOM, 2011; Aspect, 2013a), and has been the subject of extensive environmental investigations over the past 20 years. Most recently, Aspect completed a Phase 2 Environmental Site Assessment, which included analysis of about 1,200 soil samples and 570 groundwater samples collected from 106 soil borings and 49 new monitoring wells (Aspect, 2013b). Results from the Phase 2 Environmental Site Assessment as well as results from earlier historical investigations were summarized in the RI/FS Work Plan for the KC property (Aspect, 2013a). The

RI/FS work plan documents widespread contamination on the KC property with areas of TPH, PAHs, arsenic, copper, and nickel in soil and groundwater, and lead in soil, above the applicable screening levels.

Figure 2-6 shows the locations of former Standard and Associated Oil bulk fuel storage and distribution infrastructure on the north side of the warehouse building at the southern end of the KC property. After purchasing the property from Chevron and successors to the Associated Oil Company, KC continued to use the former Associated Oil Company ASTs on the north side of the warehouse building to store bunker fuel for its boilers, and at least two of these tanks remained in place until 1997 (AECOM, 2011; Aspect, 2013a). ASTs just north of the northeast corner of the KC warehouse were used to store diesel fuel, and one of these tanks was also reported to have stored caustic soda (Aspect, 2013a).

The RI/FS Work Plan documents areas of soil affected by TPH and PAHs above the applicable screening levels on the north side of the existing warehouse building, which is at the southern end of the KC property, where the former Associated Oil Company ASTs were located (Aspect, 2013a). An area of surface soil was excavated and disposed of prior to removal of the tanks, and KC concluded, based on hydrocarbon fingerprinting analysis, *"that the petroleum in the AST area is likely not the same material present at the ExxonMobil ADC site south of K-C's warehouse"* (Aspect, 2013a).

Soil samples with petroleum and related constituents exceeding applicable screening levels also have been documented beneath the warehouse building in the vicinity of the former Standard ASTs and piping, but the extent and distribution of potential contamination from this historic source has not been fully characterized.

AECOM (2011) identified the former Associated Oil Company gasoline/bunker fuel AST farm as a recognized environmental condition in their Environmental Site Assessment report, based on the presence of TPH at concentrations exceeding MTCA Method A cleanup levels in the vicinity of the former ASTs and associated underground piping.

Aspect completed an interim removal action beginning in August 2013 to address petroleum-contaminated soil and groundwater on the north side of the KC warehouse. Petroleum-contaminated soil and groundwater were left in place beneath the warehouse and below inaccessible concrete footings. The soils were sampled and found to exceed cleanup levels for TPH. The residual petroleum found in the soils is associated with historical ASTs on the KC Property, according to the Interim Action Report (Aspect, 2015). Soils to the south of the warehouse on former Everett Avenue were not investigated as part of the interim action.

The RI Work Plan also called for soil vapor sampling to assess potential risk due to vapor intrusion in the event that KC intends to keep the warehouse building intact (Aspect, 2013a). Sampling was completed in March 2014, and results showed that indoor air concentrations were well below screening levels (Aspect, 2014).

A second interim removal action on the KC property is planned in preparation for redevelopment of the KC property. A draft final work plan for the second interim action was submitted to Ecology in July 2018 (Aspect, 2018).

3.2.2 Dunlap Towing

Dunlap Towing leases a portion of the Port of Everett property (Aspect, 2013a) and uses it for operation of maritime tugboat vessels. Dunlap Towing maintains and operates a fleet of marine tug vessels at the facility. Marine shipping terminals typically are equipped or have been equipped historically with underground storage tanks (USTs) for storage of diesel fuel or other fuels for maritime vessels.

Ecology advised Wood that the Dunlap Towing property has been recognized as a former UST site (Gritsch, 2014). A search of standard regulatory databases conducted by Environmental Data Resources, Inc., on behalf of AECOM (2011) identified the Dunlap Towing property on the UST, ICR, and ALLSITES standard statewide database listings, indicating that the property is of interest to regulatory agencies due to past environmental issues.

Ecology sent Wood copies of their files concerning USTs and spill history for the Dunlap Towing property. A leaking 5,000-gallon waste oil UST was located next to the Dunlap Towing shop building, and a 12,000-gallon diesel UST was located next to the current fuel storage area. Both tanks were removed on January 1, 1991, and soil confirmation samples were collected from the bottom and sidewalls of both excavations. A soil sample from the southwest corner of the waste oil tank excavation contained "petroleum oil" at a concentration of 10,000 milligrams per kilogram (mg/kg), which exceeded the PCL. The affected soil was assumed to extend under the building and under an underground electric conduit that runs into the building (Kaldveer Associates, 1991). No soil contamination exceeding PCLs was detected in the soil samples collected next to the former diesel UST excavation. There was a reported spill of an estimated 15 gallons of diesel fuel from a Dunlap Towing tugboat to Port Gardner Bay on October 12, 2008. Based on this information, soil and groundwater contaminated by a waste oil release appear to be present at the Dunlap Towing location.

3.2.3 California Street overcrossing project

Phase I and Phase II Environmental Site Assessments and geotechnical investigations were conducted as part of the California Street/Terminal Avenue Overcrossing (CSTO) Project in the early 2000s (URS, 2000a,b; 2001a,b). The CSTO alignment occupies portions of the neighboring BNSF and Johnston Petroleum properties, as well as public streets and rights-of-way. The southernmost portion of the Property was transferred to the City of Everett as part of the CSTO Project in the early 2000s.

Areas of soil containing concentrations of TPH-G, TPH-D, and/or TPH-O greater than the current MTCA Method A cleanup level were identified over an area of approximately 25,600 square feet within the CSTO Project footprint, mainly to the east and south of the Property (URS, 2000b). URS noted that these soils should be handled as a problem waste and be treated or removed and disposed of at an appropriate landfill as part of the CSTO Project (URS, 2000b, 2001a), but no documentation is readily available to confirm whether contaminated soils were excavated and disposed of, nor is any evidence available to show that record or confirmation samples were collected and analyzed as part of the CSTO Project. It is also expected that residual product is present in soils beneath the Terminal Avenue Overpass footprint.

The Phase I Environmental Site Assessment for the CSTO also identified various 55-gallon drums containing petroleum products on the neighboring Johnston Petroleum property, and minor staining of surface soils attributed to rail and track lubricants on the BNSF property, but these were not considered to be significant contamination sources (URS, 2000a).

3.2.4 Nearby City of Everett and Port of Everett projects

Other investigations that were undertaken in the Site vicinity included the following:

- In 1996, a CSO replacement project involved replacement of a collapsed section of CSO piping that ran north of the Property along the former Everett Avenue owned by KC. This project is more fully described in Section 4.4.
- In 2004, the Port of Everett was replacing fence posts along the western side of Federal Avenue directly west of the Property. According to a 2011 phone record (Ecology, 2011), a Port representative reported an observation of oil-affected soil in two to three of the fence postholes, which were reported to be 3 feet deep. The Port representative did not collect a sample but was reporting this observation seven years after the observation was made. Soil sampling data results for MW-33, which is the closest sample to the fence line, show a single PCL exceedance for TPH-G. This exceedance is

only slightly above the MTCA Method A cleanup level. Wood installed two borings in 2013 and 2014 (FA-SB05 and PE-SB-09, respectively) in the approximate area of the fence project, as shown in the phone record documentation. These borings did not encounter soils affected by TPH-O above the PCLs, suggesting that any TPH-O contamination is not widespread (Ecology, 2011). Soil sampling results are discussed in further detail in Section 6.1.

- In 2012, the City of Everett installed a force main from the City's pump station located northeast of the Property along former Everett Avenue, and then south along Federal Avenue. This work involved extensive dewatering and disposal of TPH-affected soil from the excavation. Additional details and relevant observations are discussed in Section 3.1.6.
- As part of the force main replacement project in 2012, the City of Everett's environmental consultant, G-Logics, collected soil samples for analysis at Stations 12+72 and 12+87, as well as two stockpile samples. Samples from the stockpile and 12+87 did not contain TPH-D or TPH-O above the reporting limit. Sample 12+72 contained TPH-O at 258 mg/kg, well below the respective PCL for TPH-O. Material appearing to be LPH was reportedly observed by G-Logics to be flowing into the trench from the northeast at Station 13+00; however, no samples were collected for analysis to confirm this observation. See Section 6.1 for additional discussion.

4.0 Summary of past remediation activities

Interim remedial actions conducted at and near the Property have included groundwater extraction and treatment, recovery trench installation, soil vapor extraction (SVE), excavation and disposal of affected soil on the Property and neighboring properties, manual LPH recovery, LPH vacuum recovery, excavation dewatering, interceptor trench installation, installation of a low permeability cap over the entire Property, and removal of abandoned piping.

Several attempts at LNAPL recovery have met with limited success. LNAPL has been observed in and recovered from wells, excavations, and recovery trenches installed specifically to recover free product. LNAPL has also been observed in monitoring wells after dewatering activities due to the induced flow of groundwater through the pore spaces. Recoverable quantities of LNAPL have been removed in the immediate vicinity of disturbed soils, but recovery rates typically decrease rapidly once the free product mobilized by soil disturbance has been recovered. High organic content in subsurface soils and the high viscosity and weathered nature of the petroleum hydrocarbons present result in low mobility of the petroleum hydrocarbons that are present. While the decreased mobility of hydrocarbons generally reduces the risk to the environment, recovery of LPH is greatly limited by this immobility.

This section provides a brief description of each of the interim remedial actions. Table 4-1 summarizes major interim actions implemented at the Property and lists the historical documents from which the information was taken. Figure 4-1 shows the general, approximate locations of the key interim remedial measures conducted at the Site.

4.1 1988 Recovery trench and infiltration gallery in vicinity of MW-14

LPH was observed at a depth of 1.29 feet during installation of monitoring well MW 14 in April 1988. At that time, RZA evaluated the feasibility of extracting LPH beneath the ExxonMobil Parcel by installing a recovery trench, vapor extraction system, and groundwater treatment system consisting of an oil/water separator coupled with an air stripper. In May 1988, an infiltration gallery was installed in the vicinity of MW 14. The infiltration gallery was T shaped and approximately 45 feet long. Construction activities consisted of trench excavation and installation of two modified 55-gallon drums as sumps. The trench was subsequently filled with 1.5–inch-diameter, washed gravel. On May 12, 1988, a vacuum truck pumped subsurface fluids from the sumps and 1,400 gallons of liquid was removed from the sumps, approximately 50 gallons of which was LPH. As a result of this interim remedial action, the LPH thickness in MW 14 decreased to 0.40 foot in August 1988. The recovery trench and infiltration gallery were decommissioned and removed in 1998 (Section 4.6).

4.2 1989 Groundwater extraction and treatment

In March 1989, an automated groundwater extraction and treatment system was installed by RZA in the location of the May 1988 infiltration gallery. The system consisted of a fluid extraction sump situated in RW 1 (formerly MW 14), an oil–water separator, an air stripper, and a re-infiltration gallery. The re-infiltration gallery, which was approximately 100 feet long, was constructed parallel to the north side of the ExxonMobil Parcel. It consisted of a perforated, 4-inch-diameter polyvinyl chloride (PVC) pipe surrounded by pea gravel within the excavated trench. The groundwater extraction and treatment system operated at a pumping rate of approximately 2 to 3 gallons per minute. However, no measurable quantities of LPH were removed, and no LPH was observed in recovery well RW 1. In August 1989, 0.68 and 0.73 foot of LPH was measured in MW 8 and MW 18, respectively (RZA, 1989). Approximately 7 gallons of free product and oily water were hand-bailed from both wells and disposed of in the oil–water separator of the groundwater treatment system at the Property. The groundwater extraction and treatment system was shut down in March 1990 because of flooding of the re infiltration gallery, and has not been restarted.

4.3 1993 Recovery trench installation in the vicinity of side sewer

In December 1993, an LPH recovery trench was installed on the southwest corner of the ExxonMobil Parcel. The trench was installed in a north-south orientation to a depth of approximately 4 feet bgs. Two recovery wells that consisted of 8-inch-diameter Schedule 40 PVC screens were placed to a depth of approximately 7 feet in the trench. The trench was backfilled with 7/8-inch-diameter rock to a depth of approximately 3 feet. The rock was overlain by a filter fabric and covered with compacted pit run soil, followed by approximately 6 inches of crushed rock over the pit run to bring the excavation to grade. Concrete vaults were then placed over the recovery wells. Underground PVC piping was extended from the vaults to the remediation equipment compound located on the ExxonMobil Parcel for future access to LPH recovery equipment. Soil excavated during construction was temporarily stockpiled on the Property, covered with visqueen, and later disposed of at an off-Property commercial disposal facility.

No LPH accumulated in the recovery trench, and no LPH was recovered from the trench following installation. The trench was inspected in August 1996, and no LPH accumulation was noted. Subsequent inspections since at least 2002 have not identified recoverable LPH in the trench.

4.4 1996 Combined sewer overflow line repair

In October 1995, discharge of petroleum product into Everett Harbor from a CSO line prompted an investigation by the U.S. Coast Guard Puget Sound Marine Safety Office and the City of Everett to assess the source of the hydrocarbons (AGRA 1996b). The outfall is located on the west side of the 2700 block of Federal Avenue, approximately 175 yards northwest of the ADC Parcel (Figure 2-6). Camera surveys of the sewer lines that flow to the outfall reportedly revealed LPH seepage into the section of the CSO line that runs approximately 40 feet north of the northern boundary of the ADC Parcel (AMEC Earth & Environmental, 2010a). The section of pipe in which the infiltration was observed during the camera survey was discovered to be made of clay tiles that had settled and cracked. In April 1996, Ecology entered into the 1996 Order with Mobil Oil Corporation, ADC, and A.P. Miller requiring cleanup and elimination and/or containment of petroleum releases at and near the City of Everett's CSO discharge line into Port Gardner Bay (Section 2.5). On April 16, 1996, a meeting was held at the City of Everett to discuss options for repairing the broken section of the CSO line. The repair option selected at the meeting consisted of replacement of the settled portion of the line and slip lining of the remaining portions.

In June 1996, AGRA began repair activities on the CSO line (AGRA, 1996b,c). The settled portion of the pipe, approximately 25 feet long, was excavated and replaced. Another section of pipe, which was approximately 20 feet long and made of metal, was found to be corroded and out of round. This section of pipe was also excavated and replaced. The excavation to repair the CSO line in this area was approximately 125 feet long. The remaining portions of the CSO line were slip-lined to eliminate the potential for leakage of LPH through the joints of the intact sections of the existing line. During the excavation activities, LPH was observed entering the excavation from a layer of wood waste where this layer intercepted both the north and south sidewalls.

Three 36-inch-diameter, 22-foot-deep dewatering wells (DW-1 through DW-3) were installed prior to excavation of the CSO line. Dewatering was performed throughout the excavation to allow for repair of the CSO line. Throughout construction, pumps operated alternately, both within the CSO line excavation and within the three dewatering wells. The recovered liquid was transferred to an 18,000-gallon baffled tank, then to two 21,000-gallon settling tanks, and finally to an 18,000-gallon baffled tank. Reportedly, 1,450,800 gallons of groundwater and 23,050 gallons of LPH were removed during CSO line excavation dewatering activities (AGRA, 1996b). During repair of the CSO line, daily LPH recovery volumes varied from 0 to 7,550 gallons. Approximately 80% of the total LPH recovered was removed in the first 6 days of CSO line excavation dewatering.

During CSO excavation and repair activities, oleophilic sorbent booms were installed to absorb and contain LPH discharging into Port Gardner Bay. Sorbent pads, oil sweeps and/or soil snares, sorbent booms, and a mechanical skimmer were used to contain and recover the floating petroleum to the extent practicable.

4.5 1996 LPH vacuum recovery pilot test

In May and June 1996, AGRA conducted a vacuum LPH recovery pilot test at the Property (AGRA, 1996a,d,e,f; PTI, 1997). The recovery system consisted of SVE and groundwater/LPH pumping systems installed on the newly installed 4-inch vacuum recovery well (VRW 1) located in the northeast corner of the ADC Parcel. The SVE exhaust discharged directly to the atmosphere, while the groundwater/LPH pumping system transferred the extracted liquid to a 500-gallon LPH separation tank, then to a 6,900-gallon groundwater storage tank. The test was performed for 14 days, and LPH thickness and water levels varied significantly throughout the 14 days of testing.

LPH was also removed from a test pit (TP 6 96) with a vacuum truck in May 1996. LPH did not recharge into test pit TP 6 96 during a 2-week period, and no additional LPH was removed.

A 1997 technical memorandum by PTI Environmental Services (PTI, 1997) stated the following conclusions following a review of various LPH recovery efforts:

> *"Active (LPH and groundwater) recovery performed to date indicates that it is effective in short durations but recovery structures do not continue to recover LPH for extended periods of time when active recovery is performed.*
>
> *In summary, the complexity of the hydrogeology underlying the area and variable viscosity of the LPH will make future recovery of the LPH from the site difficult. Since there does not appear to be any evidence indicating that migration of the LPH is a threat to human health or the environment and since the site is located in a controlled industrial area, active LPH control does not appear to be warranted. … It is clear that if subsurface recovery structures (e.g., well, trench) penetrate the wood waste and debris layer, and the LPH has a lower viscosity, a passive LPH recovery program could be effective."*

It should be noted that, in nearly 20 years of LPH recovery operations, LPH has not been mobile and passive recovery has not been effective under static conditions (no dewatering). (See Section 6.3 for additional details.)

4.6 1998–2000 interim remedial actions

Remedial actions implemented at the Property from the end of 1998 through 1999 included demolition of structures and the aboveground portion of the AST firewall on the ADC Parcel, asbestos abatement, monitoring well abandonment, clearing and grubbing of the ExxonMobil Parcel, construction of an interceptor trench, abandonment of underground utilities, installation of a downgradient liner and LPH collection piping, installation of a low-permeability cap, and installation of a storm drain system (Exponent, 2000). Documented details of the interim remedial measures, based on the Exponent report, are summarized below.

Demolition activities at the Property were completed in January 1999. Prior to demolition activities, Kleinfelder, Inc., performed an asbestos survey. Asbestos was found to be present in buildings on the Property, and asbestos abatement was conducted by Performance Abatement Services between November 12 and 17, 1998.

Structures on the ADC Parcel that were demolished included four buildings (an office building, oil pump house building, a warehouse, and boiler room), aboveground piping, loading racks, the firewall surrounding the former ADC ASTs (including 40 feet of foundation of the wall in the northeast corner of the Property), and the AST pads. In addition, the trench that was installed in 1988 in the vicinity of MW-14/RW-1 was demolished. The two modified 55-gallon drums that had been used as sumps were filled with concrete and left in place. In addition, 22 groundwater monitoring wells were abandoned. Approximately 162 tons of contaminated shallow soil and vegetation were removed from within the ADC firewall area on the northern portion of the ADC Parcel. The soil was disposed of at TPS Technologies in Lakewood, Washington. Approximately 3.5 tons of Class 3 petroleum-affected soil was taken to CRS Associated located in Everett, Washington. Marine Services, Inc., removed 110 gallons of purge water for recycling at a commercial disposal facility.

A water management and treatment system was constructed at the Property in 1998 to manage fluids collected from the interceptor trench and generated during interim measure construction. The treatment system consisted of an oil–water separator, a settling tank, and a carbon polishing unit. Between December 1998 and September 1999, the system treated approximately 2.5 million gallons of water. The treated water was discharged via the storm sewer system to the Everett Water Pollution Control Facility, in accordance with project-specific City of Everett Industrial Waste Discharge Permit No. 154. Approximately 19,900 gallons of oily water and 450 gallons of sludge were collected at the Property between December 1998 and September 1999. Sources of oily water included product recovered from underground pipes prior to removal; water from tank washing prior to removal; water skimmed from excavated areas during interceptor trench construction; and water skimmed from the water treatment system product overflow and flow equalization tanks.

In January 1999, the interceptor trench was constructed along the western and northern Property boundaries. The trench was installed to a depth of 4 to 5 feet below the water table along the northern and western Property boundaries. The trench penetrated the existing wood waste and debris layer. An impermeable liner placed over the downgradient side of the trench, contiguous with an existing footing, was used on the downgradient side of the trench to enhance LPH recovery. The trench was backfilled with uniform washed gravel and was constructed to the current grade. Lateral piping and vaults were also installed during construction of the Property cap construction activities in September 1999. Nine 4-inch-diameter LPH recovery wells (LPH 1 through LPH 9) were installed in the trench.

The LPH recovery trench was explicitly designed to capture LPH passively (PTI, 1997), with the trench installed into the wood waste and debris layer (Exponent, 2000). Only minimal amounts of LPH have ever been recovered from the LPH trench since installation was completed, and although the trench is still present at the Site, no LPH has been recovered by the trench since 2010.

From August to September 1999, cap construction activities were performed, including complete grading of the Property, installation of stormwater catch basins, installation of two layers of geotextile fabric along the entire trench, installation of asphalt-treated base material and paving fabric, installation of the asphalt cap, and abandonment of monitoring wells. Additional minor grading and asphalt paving were completed in December 1999.

4.7 2002–Present LPH bailing and groundwater monitoring

Manual bailing of LPH from wells that contain a measurable amount of LPH has been performed on a daily, weekly, and eventually on a monthly basis beginning in December 1991. LPH recovery activities currently conducted at the Property are based on the groundwater monitoring program included in the 1998 Order.

The current monthly LPH gauging program consists of the following activities:

- monthly measurement of LPH thickness and depth-to-water in 10 LPH recovery wells (LPH 1 through LPH 9 and RW-2), 13 monitoring wells (W 1, W 2, W 3, W 6, MW 10, W 10R, MW 11, W 15R, W 17, MW 19, MW 40R, MW-A1, and MW-A2), and Sumps 1 and 2;
- removal of LPH from monitoring wells in which more than 0.05 foot of LPH is detected; and
- placement/replacement of oleophilic socks as needed in wells with measurable accumulations of LPH.

From August 2014 through March 2018, LPH was observed in the following locations:

- Monitoring wells W-1, W-2, W-10R, W-15R, and MW-A1; and
- Sump 2.

4.8 2008 Puget Sound outfall 5 overflow structure project

In July 2008, on behalf of the City of Everett Utilities Department, Floyd|Snider collected soil and water samples from an excavation at the CSO Puget Sound Outfall 5 Overflow Structure. The overflow structure was built to control overflows from the CSO into Puget Sound. The project was located north-northeast of the Property. Water samples were analyzed during excavation dewatering to verify that water discharged to the City sewer system met the requirements of the City's industrial pretreatment requirements. Soil samples were collected to characterize soils for disposal. Soil samples were screened in the field. Soil samples that exhibited signs of contamination were not sampled, but instead disposed of under a Class III soil profile. Apparently clean soil samples were sampled per disposal specifications and disposed of as Class II soils. The locations and depths of contaminated soil were not identified by Floyd|Snider or the City of Everett, and no report has been available documenting this work.

4.9 2010 Removal of abandoned pipes and affected soil

In 2010, Wood decommissioned several pipelines beneath Federal Avenue to the west of the Property to prepare for upgrades to the storm sewer line planned by the City of Everett. Former underground fuel lines crossing Federal Avenue were excavated and removed, along with surrounding soil (AMEC Earth & Environmental, 2011d). A short segment of piping that extended onto the Port of Everett property also was removed (Figure 4-1).

Wood oversaw pipe removal, off-Site shipment of excavated soil and other materials, and Site restoration performed by Clearcreek Contractors of Everett, Washington, and their subcontractors. Work was performed from June through November 2010. Pipes were evacuated under vacuum prior to removal, and the removed liquids were captured and disposed of along with excavated soil and removed piping material. Samples of excavated soil were analyzed, and results showed that all excavated soil and recovered water could be managed as non-hazardous waste. A total of 76.55 tons of construction debris, 243 tons of soil, 487 linear feet of piping, 65,669 gallons of non-regulated liquid, four 55-gallon product/water drums, and four 55-gallon solid waste drums were removed in general accordance with the Underground Pipeline Decommissioning Work Plan dated May 17, 2010 (AMEC Earth & Environmental, 2010b).

Two soil samples were collected from the base of the excavation and analyzed to characterize the soils left in place. B-POE was collected on the Port of Everett property, and B-WROW was collected on the west side of Federal Avenue. Results from these samples were uploaded to Ecology's Environmental Information Management database and are included in the discussion in Section 6.1. Both samples contained concentrations of TPH-G and undifferentiated TPH greater than the MTCA Method A unrestricted cleanup level; the sample from the Federal Avenue right-of-way also contained concentrations of total cPAHs and TPH-O greater than the MTCA Method A cleanup level (AMEC Earth & Environmental, 2011d).

4.10 2011–2012 Excavation

An interim action was conducted from December 2011 to April 2012 to mitigate seeps of free hydrocarbon product observed along former Everett Avenue (see Section 3.1.5). Work was conducted based on the Excavation Work Plan (AMEC Earth & Environmental, 2011e). The interim action consisted of excavation and off-site disposal of surface asphalt, affected soil, and recovered LPH, and treatment of the recovered groundwater from the secondary source areas on the BNSF and KC properties (AMEC, 2012a).

The extent of the excavation is shown on Figure 4-1. Excavation work was sequenced beginning on the BNSF property. Approximately 3,060 tons of material was excavated from the BNSF property and disposed of at a permitted landfill, and approximately 2,530 gallons of LPH was removed using a vactor truck. Monitoring wells MW-27 through MW-30 were abandoned as part of the excavation work. Figure 4-2 presents photographs of the excavation on the BNSF property.

The excavation on the BNSF property was extended to the limit of available access, as shown on Figure 4-1. The vertical limit of excavation was extended until a visually clean bottom was exposed, which in most areas was between 8 and 10 feet bgs. LPH and petroleum hydrocarbon contamination was encountered at 3 to 4 feet bgs and extended to 8 to 10 feet bgs. Underlying the upper 2.5 to 3.5 feet of soil cover on the BNSF property was a layer 5 to 7 feet thick (extending to a total excavation depth of 8 to 10 feet bgs) of refuse and debris, consisting primarily of wood, soil, rocks, bottles, and other debris. This fill layer was impacted with petroleum hydrocarbons, including LPH. Figure 4-3 presents photographs of the soil and debris that were removed during the excavation.

Affected material was evident at all sidewall areas of the completed excavation on the BNSF property, and therefore no side wall samples were collected. A low-permeability barrier wall constructed of controlled density fill approximately 3 feet wide by 4 feet deep was placed in an east/west-trending strip running the approximate length of the excavation along the BNSF property boundary, as shown on Figure 4-1. This barrier wall was installed to limit further product migration from the BNSF property. Figure 4-4 presents photographs of the barrier wall installation.

The depths of the excavation on the KC property were limited by utilities and varied from 3 to 5 feet bgs. The extent of the excavation was limited on the north side in order to maintain a free corridor of 12 feet between the excavation and the KC building. Approximately 725 tons of soil and debris were excavated from the KC property (on the former Everett Avenue) and disposed of at a permitted off-Site landfill. Affected sidewalls were encountered to the north and east on KC property and left in place. Only LPH-affected soils were removed from the KC property. Photographs from the excavation on the KC property around the utility corridor are presented on Figure 4-5.

A total of 1,489,246 gallons of petroleum-affected groundwater was removed from the BNSF property. The affected groundwater was treated at the Site and discharged to the Everett publicly owned treatment works. Approximately 12,500 square feet of asphalt was removed from the KC and BNSF properties and disposed of off Site.

The excavation on BNSF property was backfilled using quarry spalls, gravel borrow, and crushed rock. The excavation on KC property was backfilled using gravel borrow and crushed rock. The excavations were backfilled in lifts when placing the gravel borrow and crushed rock. Removed asphalt was replaced with asphalt in accordance with local roads standards. Photographs during backfill activities are presented on Figure 4-6.

The KC excavation was not intended to restore Site soil or groundwater to levels consistent with MTCA Method A cleanup levels, but rather to eliminate seeps of LPH on Everett Avenue to the extent practicable (Section 3.1.5). During this interim action (excavation on the BNSF and KC properties), LPH was encountered over a greater area and at greater depths than had been anticipated based on previous investigations at the Site.

The excavation extended to the maximum limits that would maintain structural integrity of the neighboring buildings and infrastructure. The excavation was effective in removing COC mass within the accessible portions of the excavation area at the northern and eastern extent of the site, and no LPH seeps have been observed since the excavation was completed. LPH has since returned to a portion of the excavation from adjacent areas, including the inaccessible area, as evidenced by the presence of LPH at Sump 2.

5.0 Constituents of concern and preliminary cleanup standards

As described in Section 3, multiple investigations have been conducted to characterize Site soil and groundwater contamination. Analyses conducted include VOCs; semivolatile organic compounds; TPH-G, TPH-D, and TPH-O; and select metals. The Site has been delineated based on the results of these investigations—the Site includes the Property and extends onto adjacent areas owned by the City of Everett, BNSF, KC, and the Port of Everett. The delineation of the Site and the Property boundaries are shown on Figure 2-2. This section identifies the Site COCs in groundwater and soil and presents the preliminary cleanup levels (PCLs) that will be used in the FFS.

5.1 Constituents of concern

This section defines the COCs for groundwater and soil at the Site.

5.1.1 Constituents of concern for groundwater

Groundwater monitoring data have been collected at the Site since 1988. Quarterly monitoring of several wells was conducted from 2002 through mid-2007. The monitoring wells have been sampled semiannually since 2007, with the most recent sampling event completed in August 2018 (and latest available validated results from February 2018). These data provide a substantial basis for assessing the nature of Site groundwater contamination and identifying COCs to be addressed in the FFS. A copy of a map showing the analytical results from the four semiannual groundwater sampling events conducted from August 2016 through February 2018 for the 11 wells monitored during each event can be found in Appendix F.

The groundwater COCs to be addressed for the Site are:

- benzene;
- ethylbenzene;
- xylenes,
- 1-methylnaphthalene;
- TPH-G;
- TPH-D;
- TPH-O; and
- cPAHs.

These COCs will be addressed in this SC/FFS. Toluene was not present above the PCL.

5.1.2 Constituents of concern for soil

Analytical data for Site soil are available from 1988 through February 2014. The COCs in soil are:

- benzene;
- ethylbenzene;
- total xylenes;
- 1-methylnaphthalene;
- TPH-G;
- TPH-D and undifferentiated TPH;
- TPH-O; and

- total cPAHs.

These soil COCs will be addressed by the alternatives evaluated in this SC/FFS.

5.2 Preliminary cleanup standards

This section outlines the proposed preliminary cleanup standards to be used for the Site FFS. The preliminary cleanup standards must be established for affected media and must be appropriate for the anticipated land uses, groundwater uses, and relevant potential exposure pathways identified in the CSM. The affected media identified through previous Site investigations are soil and groundwater.

MTCA regulations require evaluation of remedial action alternatives that are capable of achieving cleanup standards. MTCA regulations establish three components for cleanup standards:

- cleanup levels for COCs that are protective of human health and the environment,
- the point of compliance (POC) where these cleanup levels must be met, and
- other regulatory requirements that apply.

Cleanup levels specified in MTCA can be established using Methods A, B, and/or C; these cleanup levels are required by the Revised Code of Washington (RCW) 70.105D.030 (2)(d) to be *"at least as stringent as all applicable state and federal laws."* These requirements are similar to the applicable, relevant, and appropriate requirements (ARARs) approach of the federal Superfund law and are described in WAC 173-340-710. The immediate Site area is expected to remain under industrial and commercial use for the foreseeable future. Therefore, the remedial alternatives evaluated in the FFS will include institutional controls requiring the Site to remain under industrial and commercial use. As noted in Section 2.3, residential use of the area is not allowed under the current zoning.

Site-specific PCLs developed in accordance with the MTCA regulatory requirements for cleanup levels are proposed for the FFS. The PCLs must be protective of the relevant potential exposure pathways identified in the CSM, which include the following:

- groundwater—the groundwater-to-surface water pathway (the groundwater discharges to Port Gardner Bay), consumption of marine organisms, direct contact with contaminated shallow groundwater by utility or construction workers, and protection of indoor air quality due to volatilization;
- soil—direct human exposure pathways (ingestion, inhalation of volatile constituents, dermal absorption); and
- soil—groundwater pathway (soil must be protective of groundwater that may be in contact with the soil).

PCLs used in the FFS must be established for the soil and groundwater COCs identified in Section 5.1. Development of the PCLs is discussed in Section 5.2.2.

5.2.1 Point of compliance

To develop and evaluate a reasonable range of cleanup alternatives in the FS, a POC must be defined for contaminated sites. As defined in the MTCA regulations, the POC is the point or points at which cleanup levels must be attained. As stated previously, the POC, cleanup levels, and other applicable standards, taken together, define the cleanup standard. Sites that achieve the cleanup standards at the POC and comply with applicable state and federal laws, as approved by Ecology, are presumed to be protective of human health and the environment. A POC or multiple POCs will be used in the FFS to design and evaluate potential remedial alternatives. The basis for selecting the POC(s) for the FFS is described in Sections 5.2.1.1 and 5.2.1.2. The final POC(s) to be used for implementing the cleanup action will be determined after Ecology approves the DCAP and after completing the requirements specified in the MTCA regulations for approval by other agencies, other property owners, and the public. The final POCs will be approved by Ecology as part of the DCAP approval.

5.2.1.1 Point of compliance for soil

The regulatory requirements for the soil POC are presented in the MTCA regulations [WAC 173-340-740(6)]. The requirements for the soil POC depend on the relevant exposure pathways. Therefore, MTCA may require different soil POCs for different COCs. The requirements specified by MTCA are as follows.

- For soil COCs whose cleanup level is based on protection of groundwater, the soil POC shall be established in the soils throughout the Site.
- For soil COCs whose cleanup level is based on human exposure, the POC must include the soils throughout the Site from the ground surface to a depth of 15 feet bgs.

Not all of the remedies considered in the FFS assume that cleanup levels will be attained at a standard POC. The remedies considered will comply with WAC 173-340-740(6)(f), which states that the cleanup action may be determined to comply with the cleanup standards, provided that:

- The selected remedy is permanent to the maximum extent practicable using the procedures in WAC 173-340-360.
- The cleanup action is protective of human health.
- The cleanup action is demonstrated to be protective of terrestrial ecological receptors.
- Institutional controls are put in place.
- Compliance monitoring and periodic reviews are designed to ensure the long-term integrity of the containment system.
- The types, levels, and amount of hazardous substances remaining on the Site and the measures that will be used to prevent migration and contact with those substances are specified in the DCAP.

The remedial alternatives developed and evaluated in the FFS have been designed to achieve these requirements. The preferred remediation alternative is presented in Section 14.

5.2.1.2 Conditional point of compliance for groundwater

MTCA regulations favor a permanent solution that achieves groundwater cleanup at the standard point of compliance (SPOC), which is essentially the volume of groundwater extending beneath a site from the water table to an appropriate depth, as determined by Ecology. If a permanent cleanup action (e.g., a cleanup action capable of attaining groundwater cleanup levels at the SPOC) is not selected for a site or is infeasible, MTCA rules specify additional requirements for a conditional POC (CPOC), as described in WAC 173-340-360(2)(c)(ii).

The groundwater SPOC, as described in WAC 173-340-720(8)(b), would include all groundwater within the saturated zone beneath the Site. Under WAC 173-340-720(8)(c), Ecology may approve use of a CPOC if the responsible person demonstrates that it is not practicable to attain the SPOC within a reasonable restoration time frame and that all practicable methods of treatment have been used. A CPOC is essentially a vertical surface extending downward from the water table and laterally so that it spans the vertical area affected by the release (e.g., the affected groundwater extending beyond the boundary of the Property, across Federal Avenue to the west onto the Port of Everett property). Groundwater cleanup levels would apply everywhere at and downgradient of the CPOC; groundwater cleanup levels could be exceeded upgradient of the CPOC.

MTCA rules specify that a groundwater CPOC may be located either within the boundary of the source property or beyond the source property boundary. The requirements for establishing a groundwater CPOC beyond the property boundary for facilities that are near, but not abutting, surface water are set forth in WAC 173-340-720(8)(d)(ii) and include:

- The CPOC must be located as close as practicable to the source of the release.
- The CPOC must not be located beyond the point or points where groundwater flows into surface water.
- The conditions specified in WAC 173-340-720(8)(d)(i) must be met.
- All affected property owners between the source of contamination and the CPOC agree in writing to the CPOC location.

It is anticipated that a CPOC located on the Port of Everett property, downgradient of the Property, will be established for groundwater. Historically ADC conducted operations on the Port of Everett property, resulting in releases of petroleum products. The specific regulatory requirements (WAC 173-340-720[8][c]) that will apply for establishing a groundwater CPOC for the Site are:

- demonstration that it is not practicable to attain the cleanup standard at the SPOC within a reasonable restoration time frame;
- demonstration that the CPOC is as close as practicable to the source of the release; and
- demonstration that treatment or removal of highly mobile LNAPL source areas are used to the extent practicable in the Site cleanup.

The remedial alternatives developed and evaluated in the FFS will be designed to achieve these requirements.

5.2.2 Preliminary cleanup levels

This section describes the PCLs for groundwater and soil.

5.2.2.1 Beneficial use of groundwater

Because of the industrial and commercial zoning classification for the Site properties, Site groundwater is not currently recovered for potable use. Site groundwater will not likely be suitable for potable use in the future, even if the zoning changes, due to the proximity of the Site to marine water in Port Gardner Bay. Site groundwater meets the provisions of WAC 173-340-720(2)(a) through (c) to be defined as non-potable. This means that:

- Groundwater does not serve as a current source of drinking water.
- The groundwater is not a potential future source of drinking water because of the Site's proximity to marine waters in Port Gardner Bay.
- Groundwater is sufficiently connected to the surface water body to render the groundwater not practicable for use as drinking water.

In addition, a portion of the Site was historically used for disposal of refuse prior to 1917. The presence of refuse in the subsurface precludes use of the aquifer as a source of potable water.

The relevant complete potential exposure pathways for groundwater are discharge to the marine surface waters of Port Gardner Bay, contact with contaminated shallow groundwater by utility or construction workers, and exposure to workers within buildings via the inhalation pathway. Currently, there are no buildings over or in the vicinity of the affected soil and groundwater; however, the vapor intrusion pathway is a pathway of concern because it is possible that buildings could be constructed in the future.

5.2.2.2 Preliminary cleanup levels for groundwater

Under the MTCA regulations, groundwater cleanup levels are established based on the current complete potential pathways for exposure to groundwater, which at this Site is discharge to surface water, potential human exposure through consumption of marine organisms, contact with contaminated shallow groundwater by utility or construction workers, and inhalation of indoor air in industrial buildings. Though the groundwater-to-vapor pathway is not currently a complete pathway, this pathway could potentially be complete in the future if buildings are constructed within the Site. The PCLs will be established to be protective of these current and potential future exposure pathways.

PCLs for groundwater are presented in Table 5-1 and were selected by choosing the minimum of the following, in accordance with WAC 173-340-720:

- **MTCA Groundwater Table Values (from Cleanup Levels and Risk Calculation [CLARC] website)**
  - MTCA Method A: The MTCA Method A values were only used for TPH compounds because there is not an applicable federal standard for these compounds. MTCA Method A values for Site COCs other than TPH are based on the minimum screening levels based on protection of surface water and protection of indoor air.
- **Surface Water ARARs**
  - Water Quality Standards for Surface Waters of the State of Washington (WAC 173-201A): Acute and Chronic effects, Aquatic Life, Marine Water and Human Health Criteria for Consumption of Organisms only.
  - National Recommended Water Quality Criteria (Clean Water Act §304): Marine Water, Acute and Chronic effects; aquatic life; and Protection of Human Health, Consumption of Organisms Only.
  - Federally Promulgated Water Quality Standards (Code of Federal Regulations [CFR] Title 40, Part 131.45): Revision of certain Federal water quality criteria applicable to Washington; Human Health Criteria, Marine Water.
- **Protection of Indoor Air**
  - MTCA Method B groundwater to vapor inhalation screening levels, obtained from a revised Vapor Intrusion Screening table issued by Ecology in April 2015 (Ecology, 2015).

Numerical values for the criteria described above are presented in Table 5-1. The PCLs shown in Table 5-1 for each groundwater COC were selected as the minimum criterion value from the surface water or indoor air ARARs. If no applicable ARAR was available, the MTCA Method A cleanup levels were selected as the PCL. For cPAHs, the lowest criterion was the surface water ARAR for Human Health (0.0021 microgram per liter [µg/L]). The PCL for cPAHs was revised in accordance with the MTCA regulations (WAC 173-340-705[6]) so that the PCL was not lower than the practical quantitation limit for the project laboratory. The

PCL for cPAHs was set equal to the practical quantitation limit, which is also numerically equal to the MTCA Method A cleanup level.

The MTCA Method A cleanup levels for TPH-G, TPH-D, and TPH-O are based on noncarcinogenic health effects for drinking water use; these values were used as the PCLs for these constituents. Therefore, the groundwater PCLs presented in Table 5-1 are protective of the current and potential future uses of the Site.

5.2.2.3 Preliminary cleanup levels for soil

The Site is located in an area zoned for heavy industrial and commercial use; therefore, MTCA Method A Unrestricted or Method B standard soil cleanup levels are appropriate for use at the Site. Additionally, soil cleanup levels must be protective of groundwater, as specified in WAC 173-340-745(5)(A). Using the groundwater PCLs of Table 5-1 and Method A groundwater cleanup levels for ethylbenzene and total xylenes, soil cleanup levels protective of groundwater were calculated in accordance with WAC 173-340-747(4), and the resulting calculated soil cleanup levels are presented in Table 5-2. The calculations are summarized in Table 5-3; the calculated soil cleanup levels protective of groundwater were considered when selecting the soil PCLs shown in Table 5-2.

PCLs for soil were selected by choosing the minimum of the following MTCA cleanup levels:

- MTCA Method A Soil Cleanup Levels for unrestricted use (MTCA Table 740-1). For Site COCs other than TPH, the Method A cleanup levels are based on potable groundwater use and are not applicable to the Site.
- MTCA Method B cleanup level based on direct contact/ingestion for workers obtained from the CLARC website.
- Soil cleanup levels protective of groundwater resulting from the calculations shown in Table 5-3.

The soil PCLs for non-TPH COCs are based on protection of groundwater and the TPH PCLs are based on MTCA Method A cleanup levels for unrestricted land use (Table 5-2). The PCLs for benzene and 1-methylnaphthalene were revised in accordance with the MTCA regulations (WAC 173-340-705[6]) so that the PCL was not lower than the practical quantitation limit for the project laboratory (Table 5-3). As a conservative measure, the PCLs for saturated soils will generally be applied for site characterization, since shallow groundwater is present throughout the Site and the PCLs for saturated soil are lower (more conservative) than the PCLs for unsaturated soils.

5.3 Terrestrial ecological evaluation

Soil concentrations considered protective of terrestrial receptors (plants and animals) were assessed using a simplified terrestrial ecological evaluation following the procedures outlined in WAC 173-340-7492. A copy of the evaluation is presented in Appendix G. The Site qualifies for an exclusion from performing a terrestrial ecological evaluation, based on meeting the requirements of WAC 173-340-7492.

6.0 Nature and extent of contamination

This section discusses the nature and extent of COCs in soil and groundwater at the Site. Many soil and groundwater samples have been collected at the Site since field investigations began in 1991. These investigations are discussed in Section 3. Site soil characterization results are shown on Figures 6-1 through 6-8. The soil sample data shown in these figures represent the highest concentration at a given sample location; these figures do not include data for soil that has been excavated for off-Site disposal. Groundwater characterization for the Site is presented on Figures 6-9 through 6-14. Figures 6-9 through 6-14 are based on groundwater sampling data for samples collected in January 2015. The data used to prepare Figures 6-1 through 6-14 are presented in Appendix E. The extent of affected groundwater defines the boundaries of the Site, as defined in the MTCA regulations at WAC 173-340-200. The Site extent is shown on Figures 6-1 through 6-14. The Site boundary is based on the areal extent of soil and groundwater samples that exceeded the PCLs. As shown on these figures, the Site boundary extends onto the KC property. However, other known sources of Site COCs are present on the KC property that are being addressed as part of KC's environmental response under the MTCA program.

6.1 Soil

The nature and extent of soil contamination at the Site is defined for the following Site COCs:

- benzene;
- ethylbenzene;
- total xylenes;
- 1-methylnaphthalene;
- TPH-G;
- TPH-D and undifferentiated TPH;
- TPH-O; and
- total cPAHs, expressed as benzo(a)pyrene toxicity equivalents.

Undifferentiated TPH results generally represent older samples analyzed using EPA Method 8015M, in which the hydrocarbon classification was not determined. For the purposes of this discussion, undifferentiated TPH is combined with TPH-D. The discussion focuses on those areas of the Site where soil samples exceeded the PCLs discussed in Section 5.2.2.3 for each respective COC. As a conservative measure, analytical results for soil are compared to the PCLs for saturated soils, since shallow groundwater is present throughout the Site and the PCLs for saturated soil are lower (more conservative) than the PCLs for unsaturated soils.

In general, the source areas for the Site COCs are associated with past petroleum product storage and handling areas, including the Property, the former loading racks and underground fuel lines under and near the railroad tracks east of the Property, and the former ADC garage. Secondary soil source areas under the former Everett Avenue and BNSF parcels, the Terminal Avenue Overpass, and Federal Avenue were created through migration of LNAPL from the primary source areas, especially under the influence of dewatering.

The benzene distribution in soil is shown on Figure 6-1; soil samples with benzene concentrations exceeding the PCL of 0.005 mg/kg are scattered along the east side of the ADC Parcel and throughout the ExxonMobil Parcel, with isolated occurrences in samples collected on the KC property to the north and Federal Avenue just east of the former ADC garage location. Figures 6-2 and 6-3 show the soil samples with ethylbenzene and total xylenes, respectively, that exceed the applicable PCLs. These two COCs are generally found in the same general area as the benzene exceedances.

The locations where 1-methylnaphthalene concentrations in soil exceed the PCL of 0.5 mg/kg are shown on Figure 6-4. The distribution extends east, north, and west of the properties formerly used by ADC, including the former ADC garage property west of Federal Avenue.

The TPH-G distribution in soil is shown on Figure 6-5; soil samples with TPH-G exceeding the PCL of 30 mg/kg were located across the Site, with samples collected from locations under the Terminal Avenue Overpass, extending west through the Property, and north and west of the Property onto the location of the former ADC garage. (The more conservative standard of 30 mg/kg was selected as the PCL for TPH-G since benzene was commonly detected in the same samples as TPH-G.)

The TPH-D and undifferentiated TPH distribution in soil is shown on Figure 6-6. Points on Figure 6-6 are treated as an exceedance if the sum of the TPH-D plus TPH-O concentrations is greater than the PCL of 2,000 mg/kg. Soil samples with TPH-D concentrations exceeding the PCL of 2,000 mg/kg extend from under the Terminal Avenue Overpass through the center of the Property and to the west onto the location of the former ADC garage. Exceedances also occur to the north of the Property on the former Everett Avenue.

Borings CE-6 and FA-SB06 were installed south and west of the remaining KC building, respectively (Figures 6-1 through 6-8). Both were installed after completion of the CSO replacement project in 1996, where extensive dewatering was required during repair and replacement of the CSO line. During completion of the CSO repairs, nearly 1.5 million gallons of groundwater was recovered, along with approximately 23,000 gallons of LNAPL. (See Section 6.3 for details.)

Both borings contained 5 to 6 feet of silty sand over well-graded sand with silt. Samples for analysis were collected from both the upper finer soil layer and the lower coarser layer in both borings. The samples from the lower layer contained TPH-D at concentrations of 5,390 mg/kg in CE-06 and 3,130 mg/kg in FA-SB06. A minor exceedance for TPH-G in CE-06 (381 mg/kg) was also noted. None of the shallower soil samples for these two borings contained COCs above the PCLs. This pattern suggests that dewatering for construction may have caused lateral movement of COCs and LNAPL through the higher permeability fill materials, likely from the north and northwest of these two locations rather than from the Property. The dewatering proceeded from east to west then south; if surface spills or releases had been responsible for the observed soil contamination then the shallow soils should also have been contaminated.

The TPH-O distribution in soil is shown on Figure 6-7. Points on Figure 6-7 are treated as an exceedance if the sum of the TPH-D plus TPH-O concentrations is greater than the PCL of 2,000 mg/kg. Soil samples with TPH-O concentrations exceeding the Method A soil cleanup level PCL are more scattered in distribution than TPH-G or TPH-D, with isolated occurrences near the location of the former ADC garage. While TPH-O was detected in a discrete soil sample collected from the Everett Force Main project in 2012, the sample collected from Station 12+72 only contained TPH-O at 258 mg/kg, well below the MTCA Method A TPH-O PCL of 2,000 mg/kg (G-Logics, 2012). This sample was reportedly collected from an area where G-Logics reported a sheen; however, the analytical result does not reflect the concentration expected where free product is observed.

The cPAH distribution in soil is shown on Figure 6-8. The cPAH concentrations are expressed as the toxicity equivalents of benzo(a)pyrene, and concentrations of cPAHs exceeding the toxicity equivalent PCL of 0.1 mg/kg can be found from the northeast portion of the Site to the west, scattered across the property, and on the former ADC lease area on the west side of Federal Avenue. Two isolated exceedances located to the south are attributed to the presence of cPAHs along a former BNSF Spur line and the associated creosote-tainted railroad ties.

As shown on the geologic cross-sections (Figures 2-8 to 2-13), the vertical distribution of benzene, other aromatic hydrocarbons, and TPH (all hydrocarbon classes) generally occurs in the upper 10 feet of soil. These COCs are also found below the water table, where smear zones and rising groundwater levels have trapped the COCs in the soil. As discussed in Section 6.3, some of the TPH analytical results are high enough in concentration to suggest that the hydrocarbons are present in residual saturation or as LNAPL. Hydrocarbons in residual saturation can be mobilized if the soils are dewatered. Under current conditions, however, most hydrocarbons are immobile and are likely trapped in residual saturation below the water table.

6.2 Groundwater

The nature and extent of groundwater contamination at the Site is defined for following Site COCs:

- benzene;
- ethylbenzene;
- xylenes
- TPH-G;
- TPH-D;
- TPH-O;
- cPAHs, expressed as benzo(a)pyrene toxicity equivalents; and
- 1-methylnaphthalene.

The areas with the highest concentrations of COCs are associated with the primary and secondary source areas discussed in Section 6.1.

Table 6-1 presents the results of semiannual groundwater sampling from an expanded network of wells in 2015. Only the January 2015 groundwater monitoring data are used to discuss the nature and extent of affected groundwater, as this data set included samples from several wells that are not routinely sampled and is, therefore, more comprehensive than the other semiannual data sets. Based on a review of 17 years of semiannual groundwater data, the Site exhibits only a limited seasonal variation in groundwater quality. The January 2015 groundwater data were reviewed in accordance with the project-specific data validation standards for the Site requirements, and the data review memorandum and laboratory reports are included in Appendix E.

As discussed in detail in the letter report in Appendix H, and as shown in Tables 4 and 5 of that report, it appears that the Test America laboratory's silica gel cleanup methodology for the TPH-D and TPH-O groundwater samples was insufficient to remove polar compounds, which silica gel cleanup is intended to accomplish. The corresponding Eurofins split-sample analytical data are much lower in reported TPH-D and TPH-O concentrations than the corresponding Test America samples. Comparisons of TPH-G, benzene, and cPAH analytical results are comparable between the two laboratories. The primary difference between the Test America and Eurofins split-sample analytical data is the effectiveness of the silica gel cleanup of the TPH-D and TPH-O samples. The most recent Eurofins laboratory TPH-D and TPH-O analytical results will be used when discussing the nature and extent of TPH-D and TPH-O in groundwater samples.

The benzene distribution in groundwater is shown on Figure 6-9; there were two exceedances of the groundwater benzene PCL of 1.6 µg/L during the January 2015 sampling event in a sample collected from LPH-1, located at the southern end of the LPH recovery trench, and W-15R, located in the southeast quadrant of the ADC parcel. Since 2014, additional exceedances of the benzene PCL for groundwater samples have been observed for samples collected at LPH-1, MW-15R, and MW-40R. It should be noted that wells MW-15R and MW-40R also contain LPH.

The TPH-G distribution in groundwater is shown on Figure 6-10; TPH-G exceeded the PCL of 800 µg/L in groundwater from two monitoring wells located east of the Property—monitoring well W-17 and Sump 2. Both of these locations border the former BNSF excavation. TPH-G was also detected above the PCL in two groundwater samples collected from W-2 and W-15R, both located on the Property. It should be noted that both of these well often contain LPH, which might have influenced these analytical results. TPH-G was not detected above the PCL in any of the other groundwater samples collected from the Property or the Port of Everett property, and was not detected in the groundwater from wells installed on Federal Avenue.

The TPH-D distribution in groundwater samples is shown on Figure 6-11. Groundwater samples with TPH-D concentrations exceeding the PCL of 500 µg/L occur throughout the Property and extend west into and beyond Federal Avenue, and also occur in samples previously collected on the KC property, the former BNSF property, and underneath the Terminal Avenue Overpass. The most recent TPH-D analytical results from Eurofins show that the groundwater samples collected from MW-A5 and MW-A6 on Dunlap Towing property were below the Method A groundwater cleanup level for TPH-D (Appendix F). A single exceedance was recorded in February 2016 at MW-A5 with an estimated concentration of 540 µg/L (denoted by a "J" quality assurance flag). Dunlap Towing is known to use diesel fuel in its business operations. All TPH-D results for MW-A5 since August 2016 have been below the PCL (Appendix F).

The TPH-O distribution in groundwater is shown on Figure 6-12. TPH-O concentrations in groundwater exceeding the PCL of 500 µg/L occurred in samples collected from LPH-4 on the Property and from Sump 2, located east of the ExxonMobil Parcel on the BNSF property.

The cPAH distribution in groundwater samples is shown on Figure 6-13. Concentrations of cPAHs, expressed as benzo(a)pyrene toxicity equivalents, exceeded the PCL of 0.1 µg/L in groundwater samples from only two locations. One location, monitoring well W-1, is located on the ExxonMobil Parcel, and the other location, Sump 2, is located east of the ExxonMobil Parcel on the BNSF property.

1-Methylnaphthalene exceeded the PCL of 1.5 µg/L in multiple wells located on or near the ADC and ExxonMobil parcels, but not west of Federal Avenue (Figure 6-14).

Concentrations of ethylbenzene and total xylenes were both below detection limits for all wells sampled in January 2015.

6.3 Liquid-phase petroleum hydrocarbons

LPH has been observed in wells, trenches, sumps, and excavations at the Site since environmental investigations began. The LPH varies in nature from TPH-G to TPH-D to heavier TPH-O fractions, and all of the LPH is generally characterized as "weathered" in various laboratory reports.

The viscosity and weathering of the LPH limit mobility of LPH at the Site. The original releases occurred between 25 and 90 years ago. Weathering, including volatilization of lighter hydrocarbons and microbial degradation, works to increase the viscosity of the LPH and limit the ability of the LPH to flow and accumulate in the subsurface. This increased viscosity contributes to the limited effectiveness of the LPH recovery trench. The weathered LPH preferentially adsorbs to peat, wood waste, and other organic constituents present in the subsurface, further limiting the mobility of LPH.

LPH has been observed on the BNSF parcel, on the Property, seeping through damaged asphalt along former Everett Avenue during periods of elevated groundwater, and across Federal Avenue in groundwater monitoring well MW-A1. Many of the observations describe the LPH as being viscous.

Comingling of the various types of products that have been handled on the Properties—diesel fuel, stove oil, heavy fuel oil, Bunker C, and gasoline, among others (AGRA 1996a)—can change the viscosity of the LPH. Viscosity can also increase due to weathering in the subsurface, which typically results in degradation of the light hydrocarbons, making the overall LPH thicker and more difficult to recover. Since 2010, limited amounts of LPH (< 40 gallons) have been recovered from five monitoring wells and/or sumps at the Site.

Table 6-2 outlines the various attempts at recovering LPH from wells, excavations, sumps, recovery wells, and the LPH trench. LPH has been recovered from the Site using active methods (groundwater pumping and vacuum-induced skimming) as well as passive methods (oleophilic absorbents and LPH pumping). However, as shown in Table 6-2, passive LPH recovery yields very small volumes of hydrocarbon over time: over the past six years of LPH monitoring and recovery, no LPH was recovered from the LPH recovery trench despite it being designed for that purpose (Exponent, 2000). Approximately 34 gallons of LPH has been captured from recovery and groundwater monitoring wells (W-1, W-2, W-10R, W-15R, and MW-A1) using passive recovery techniques, bailing, peristaltic pumps, and/or oleophilic socks since March 2010. Oleophilic socks are the preferred recovery method since the field sampling personnel can quickly extract and contain the socks while minimizing chances for contamination.

The largest quantities of LPH have been recovered as a by-product of dewatering, such as the dewatering events that occurred during the 1996 CSO replacement project and the 2011–2012 BNSF excavation. While the volume of LPH recovered during dewatering is not insignificant, the volume of water requiring handling, disposal, and treatment as a result of these dewatering events is many times greater than the LPH volume. During the CSO replacement project in 1996, LPH accounted for only 1.6% of the recovered water volume; during the BNSF excavation, LPH accounted for only 0.4% of the recovered groundwater volume.

The behavior of LPH under both active and passive recovery techniques suggests that most of the LPH is in residual saturation and can be mobilized only under the extreme hydraulic gradients induced by dewatering. Soil with concentrations of TPH-G, TPH-D, TPH-O, or undifferentiated TPH potentially high enough to indicate the presence of immobile, residual LNAPL or floating, potentially mobile LNAPL is found both on and upgradient of the Property, on the recently cleaned up BNSF property, underneath Federal Avenue and the former Everett Avenue, and on the former ADC garage area on property owned by the Port of Everett (Figure 6-15). *Residual saturation* is defined as fluid distributed within a porous medium and held in place by capillary action. Under these conditions, the fluid is not connected between pores; therefore, it does not flow. The quantity of LNAPL in a soil under residual saturation conditions depends on the fluid properties of the LNAPL, the specific soil properties, and the percentage of water saturation. The fluid properties of LNAPL can vary widely, depending on the composition and viscosity of the liquid.

The distinction between residual LNAPL and potentially mobile LNAPL is based on research into how much LNAPL is expected to be retained by saturated soils of various textures for different LNAPL viscosities. In general, LNAPL with higher viscosity has a correspondingly higher residual saturation. Table 747-5 in the MTCA regulations (WAC 173-340-900) presents a generic screening level for residual saturation of 2,000 mg/kg for TPH-D; however, the actual residual saturation concentration for a given soil type depends on the soil grain size and the specific properties of the LNAPL.

In preparing Figure 6-15, potential residual saturation levels for TPH fractions were selected based on the sand and silty sand soils typically present at the Site and TPH concentrations observed historically in soil samples collected at the Site. Residual saturation levels for TPH-D, TPH-G, and TPH-O were determined for site-specific data using guidance from *Non-Aqueous Phase Liquid (NAPL) Mobility Limits in Soil* (Brost and DeVaull, 2000). Residual saturation levels for TPH-G in soils at the Site range from 2,470 to 3,410 mg/kg. Residual saturation levels for TPH-D in soils at the Site range from 4,800 to 8,840 mg/kg.

Similarly, residual saturation of TPH-O is based on residual saturation concentrations for fuel oil in soils similar to Site soils, yielding concentrations ranging from 5,810 to 11,000 mg/kg. LNAPL was assumed to be present when concentrations exceeded the upper limit of the residual saturation concentrations. The residual saturation levels for TPH-G were used for historical undifferentiated TPH analyses, as those concentrations were most conservative. Therefore, LNAPL present at the locations shown on Figure 6-15 was identified as representing potentially mobile LNAPL, based on field observation of LNAPL in the wells, or residual saturation, based on soil analytical results and these residual saturation concentrations.

Starting in January 2012 and extending through June 2014, Wood conducted a study to assess LPH behavior in five Site monitoring wells: W-1, W-2, W-10R, W-15R, and MW A1. For this study, the oleophilic (or sorbent) socks normally deployed in these wells were removed because the sorbent socks preclude LPH accumulation in the well. Figures 6-16 through 6-20 show groundwater elevations graphed against measured LPH thicknesses in the five wells that contained greater than 0.2 foot of LPH during the study period. The primary observations that can be drawn from the plotted data are:

- For four out of five wells, rising groundwater elevation causes a greater amount of LPH to gather in the wells.
- For MW-A1, no LPH was present until May 2013, approximately one year after the completion of the City of Everett Force Main Installation Project. MW-A1 has contained LPH since May 2013, and the amount of LPH measured in the well does not correlate to groundwater elevation.

The increase in LPH thickness with rising groundwater elevation indicates that LPH is being released from finer grained sediments and accumulating in coarser fill materials under the influence of buoyancy. The coarser grained sediments have a lower residual saturation concentration, so the LPH can accumulate in the more permeable filter pack around the well screen. As the groundwater elevation falls, the LPH in both the coarser fill and filter pack is re-absorbed into the finer grained fill materials that have a higher residual saturation, and the LPH is immobilized.

MW-A1 was installed before the force main installation. The excavation for the force main, which proceeded along the former Everett Avenue from the east to Federal Avenue, and then south along Federal Avenue to the intersection with Terminal Avenue, appears to have extended to within a few feet of the well. It would appear that the path of dewatering and the amount of dewatering was sufficient to mobilize LPH, and as the dewatering moved past MW-A1 to the south, the LPH was left in the more permeable excavation backfill. Data indicates that this LPH eventually seeped into the coarser sand pack surrounding well MW-A1. Because of the uniformity of the excavation backfill compared to the native silty sands, wood waste, and debris, the residual saturation of the sand pack and pipe bedding material is very similar. Therefore, there should be less correlation of LPH thickness with changes in groundwater elevation in MW-A1.

In the absence of future dewatering events, the LPH in the vicinity of MW-A1 is unlikely to migrate farther west of MW-A1 due to the finer grained and lower permeability sediments of the fill material.

6.4 Evidence for biodegradation

Figure 6-21 shows trend charts of total BTEX concentrations over time for selected wells based on ongoing groundwater monitoring. These wells represent locations upgradient, within the source areas, and downgradient of the Property. We chose total BTEX as representative of the decrease in dissolved-phase contamination over time, as BTEX compounds are more easily dissolved and transported with groundwater flow.

Wells shown on Figure 6-21 (MW-11, MW-19, MW-40R, W-3, and W-6) have the most extensive long-term groundwater monitoring history. Wells that were only sampled early in the monitoring program, and which have since been abandoned, and wells with limited detections of cumulative BTEX did not contain sufficient data to plot. All of these wells exhibit a decrease in total BTEX concentrations over time, supporting the idea that hydrocarbons in groundwater are being biodegraded either aerobically on anaerobically.

Figure 6-22 shows sulfate concentrations and ORP results for samples collected during the 2011 Data Gaps Investigation (AMEC Earth & Environmental, 2010a). The figure shows that both sulfate concentrations and ORP decrease downgradient of the source area, which suggests that sulfate reduction of contaminants is occurring as groundwater passes through the source area. These data further support the idea that hydrocarbons in groundwater are undergoing natural biodegradation under current conditions.

7.0 Aquifer and tidal studies

A number of aquifer and tidal studies have been performed at the Site. This section summarizes the results of these studies. Tidal studies focus on assessing fluctuations in groundwater level induced by adjacent marine waters. Aquifer studies are focused on characterizing the hydrogeologic properties of the saturated zone. Two types of tests have been performed within groundwater wells at the Site to characterize the shallow groundwater zone: aquifer (or pump) tests and slug tests. In an aquifer test, a given well is pumped at a constant rate or a series of rates and the aquifer drawdown is measured in nearby observation well(s). Aquifer tests are expensive and time-consuming to perform but generally provide data that are more accurate than slug test data. A slug test involves rapidly introducing or removing a solid plug from a well, which creates a rapid rise or decrease in the water level in the well. The resulting change in water level within the test well is then measured as it returns to the initial water level. Slug tests are easily performed, but the data are generally considered to be lower in quality due to limitations on the size of the slug and the amount of water displaced during the test.

7.1 Aquifer studies

AGRA performed an aquifer pump test on three wells located on the Property (MW-10, MW-18, and RW-1) during the 1990s (Exponent, 1998). During the test, groundwater was extracted from RW-1 and the drawdown or response was measured in MW-10 and MW-18 along with the pumping well. Table 7-1 presents the hydraulic parameters calculated from different responses to pumping or recovery at these three wells. Hydraulic conductivity is a measurement of how the aquifer matrix transmits water in response to pumping from the test well (RW-1). As shown in Table 7-1, hydraulic conductivities measured during these tests ranged from approximately 1.4 x 10^{-3} centimeters per second (cm/sec) to 3.4 x 10^{-3} cm/sec, with an average of 2.1 x 10^{-3} cm/sec. This range of hydraulic conductivities is consistent with the silty to poorly graded sands that have been observed in the saturated zone located beneath the Property.

Slug tests were performed in three monitoring wells located on the Port of Everett property, which lies west and northwest of the Property. Typically, data from the "rising head" portion of the slug test, when the slug is suddenly removed from the well, is more accurate than the "falling head" portion. Three monitoring wells, MW-A1 (west of the Property) and MW-A5 and MW-A6 (northwest of the Property at Dunlop Towing) were tested five times each. The geometric mean of the five test results for each of the three wells are presented in Table 7-1. The mean hydraulic conductivities from these slug tests ranged from approximately 6.4 x 10^{-3} to 2.7 x 10^{-2} cm/sec (AMEC Earth & Environmental, 2010a). These measured hydraulic conductivities are consistent with values expected for the cleaner and slightly coarser fill materials that have been observed in the filled area west and northwest of the Property. The results shown in Table 7-1 indicate that the native soils underlying the Property have slightly lower hydraulic conductivities than the filled area west of Federal Avenue.

7.2 2011 tidal study

The most extensive and complete tidal study was performed at the Site over a two-week period in February 2011. The purpose of the tidal study was to determine the extent of tidal influence and the mean groundwater level at the Site. Data were collected from 13 groundwater monitoring wells installed across the Site. Non-vented, self-logging transducers were installed in each of the groundwater monitoring wells and in a stilling well installed on the Everett Pier. Water levels were recorded at 6-minute intervals at the same time by each transducer. A separate barometric pressure-logging transducer was also used to record the barometric pressure at the Site.

Tidal influence was observed to be strongest in monitoring wells W-3, MW-11, MW-A1, MW-A2, MW-A3, MW-A5, and MW-A6, which indicates that water levels in these wells are influenced by tidal fluctuations in the adjacent Port Gardner Bay. The tidal fluctuations measured in wells ranged from 0.1 foot to 1.1 feet. It should be noted that the tidal fluctuations measured in the stilling well in Port Gardner Bay had a magnitude of approximately 9 feet, while the data recorded in the monitoring wells showed a significantly dampened response in even the most strongly influenced well (AMEC Earth & Environmental, 2011a). The most strongly influenced wells are located west of the Property, closer to Port Gardner Bay. Well MW-11, located on the east side of the Property, had a strong tidal response; this is likely due to a preferential flow conduit (probably a former stream channel) that transmits the tidal signal inland to MW-11. With the exception of MW-11, wells located on and east of the Property had minimal response to tidal fluctuations, and mainly responded to changes in barometric pressure (AMEC Earth & Environmental, 2011a).

7.3 2014 tidal study

Since the 2011 tidal study, completed over a limited two-week period in February 2011, showed a significant tidal impact on groundwater levels, logging transducers were placed in several wells in July 2014 to collect groundwater level data to support the FFS and to better characterize Site groundwater flow. A total of seven self-logging, non-vented transducers were installed in RW-2, MW-40R, MW-A1, MW-A2, MW-A3, MW-A4, and MW-A5. In addition, a logging barometric transducer was placed on the Property. Water levels in each of the wells were logged simultaneously with barometric pressure every 15 minutes during this period. The data recorded by each well transducer and the barometric transducer are periodically downloaded and analyzed to assess groundwater elevations in these wells. Groundwater elevation data collected prior to October 2014, including hydrographs for the wells, are discussed in Section 2.4.6.

Figure 2-15 is a groundwater contour map based on the mean groundwater elevations measured in August 2016 using the transducers. The mean groundwater elevations were calculated using a 25-hour average of the recorded water levels to filter short-term tidal influence and show mean groundwater flow conditions (Serfes, 1991). Mean groundwater flow direction is generally to the west, with seasonal fluctuations. The hydraulic gradient is much steeper across the Property (at 0.037) compared to the area west of Federal Avenue, where the gradient decreases to 0.006. This change in gradient likely reflects changes in permeability, with the more permeable sands west of Federal Avenue allowing groundwater levels to equilibrate compared to the lower permeability, silty sands on the Property.

As discussed in Section 2.4.6, there is limited mixing of Site groundwater with surface water because the tidal response of the groundwater is limited and because groundwater flows in response to the mean or average hydraulic gradient in the groundwater. Mixing during any one tidal cycle is limited to the area immediately adjacent to the Port Gardner seawall, within the distance groundwater can travel during the "flood" portion of the twice-daily high tides.

8.0 Conceptual site model

This section presents the CSM based on the geology, hydrogeology, and history of the Site and the nature and extent of soil and groundwater contamination. The purpose of the CSM is to document Site characteristics that affect the fate and transport of COCs and the relevant potential exposure pathways for the Site.

Section 8.1 summarizes Site geology and hydrogeology as determined through Site investigation data, data from interim remedial actions, tidal studies, and observations during historic dewatering activities conducted as part of interim remedial actions and construction activities. Section 8.2 presents the various potential exposure pathways for potential receptors. Section 8.3 summarizes the CSM and identifies data gaps and/or uncertainties that remain, if any.

8.1 Geology and hydrogeology

Figure 8-1 shows a plan view of the CSM, and Figure 8-2 shows a generalized cross-section adapted to show the features of the CSM. Figure 8-1 also shows the Site boundary based on the extent of soil and groundwater exceeding PCLs, as detailed in Section 6.0.

The Property was developed over former nearshore marsh and mudflats that have generally been infilled to prepare the area for development. Aerial photographs show the pre-development shoreline near the west side of the present Federal Avenue. The surface soils (uppermost 5 to 10 feet) at the Site are characterized by heterogeneous mixtures of fill generally consisting of very loose to medium dense silty sand and sand with areas of peat. Occasional debris, such as wood, glass, lumber, and brick pieces, have been observed mixed into the peat. This debris likely originated from past residences that occupied the marshy grounds prior to regrading and filling, and some may possibly have been present in the material used to fill the site. The surface fill overlies native glacial advance outwash deposits and transitional beds (Section 2.4.2). The historical shoreline west of Federal Avenue was gradually extended to the west beginning sometime after 1917. By 1976, the shoreline had been extended to its current location, approximately 500 to 600 feet west of the 1917 shoreline. The source of the fill materials used to extend the shoreline to the west is unknown.

The hydrogeology at the Site has been significantly affected by the changes in topography and shoreline. The area near the Property was occupied by small residences in 1902, surrounding what was labeled "marsh" on an historical fire insurance map (Appendix A) The former marsh is likely represented by peat deposits that underlie much of the current land surface. The 1902 groundwater surface beneath the Property likely corresponded roughly to the surface water elevation in the former marsh. Over time, the groundwater table would have risen as the discharge area (i.e., the shoreline) was extended to the west. After the shifting of the shoreline, groundwater within the native fill deposits beneath the Property rose until the depth-to-groundwater along the eastern portion of the Property reached 2 to 3 feet. Surface seeps of groundwater have been observed at the base of the Terminal Avenue Overpass just east of the BNSF parcel and along the BNSF tracks and the City of Everett lift station. Shallow groundwater was also observed during the 2011–2012 excavation on the BNSF parcel. These observations suggest that the vadose zone on the east side of the Property is not very thick. The 2014 tidal study (Section 7.3) showed that the groundwater hydraulic gradient beneath the Property is six times steeper than the hydraulic gradient west of Federal Avenue. This steeper hydraulic gradient is an indication that native sediments are more restrictive to groundwater flow (lower permeability) than the sandy fill materials west of the Property, as also indicated by aquifer test results (Section 7.1).

Residual LNAPL is present in some areas of the Site, observed as either a floating layer in a well or sump or observed in soil based on measured concentrations at or above the expected residual saturation concentration (Section 6.3). The Property had been used as a petroleum product storage depot for approximately 50 years prior to the infilling that moved the shoreline to its current location. Historical releases of petroleum products would have pooled on the lower water table/capillary fringe elevation that existed at that time. As the groundwater surface beneath the Property rose after the shoreline was extended, the rising groundwater would have submerged and trapped petroleum product within the depth interval between the historic and new water table elevations. As shown by the LPH responses to rising groundwater elevations discussed in Section 6.3, LPH in some areas accumulates in the well casing. Most of the five wells that occasionally contain LPH are also adjacent to or upgradient of the LPH trench, yet LPH is not recovered from the trench. This observation suggests that the LPH is discontinuous and immobile, and does not flow into the LPH trench recovery sumps.

Under normal groundwater conditions (i.e., in the absence of construction dewatering), LNAPL at the Site is immobile, and historic attempts to recover LNAPL from the subsurface using standard hydrocarbon recovery techniques have not been successful. However, changes in the water saturation of soils can remobilize residually saturated LNAPL when relationships between LNAPL, water, the porous media, and air change. Such a change can occur when dewatering for construction or excavation lowers groundwater levels across a large area for an extended period of time, allowing the vadose zone to expand and the hydraulic gradient to steepen. These conditions appear to have mobilized LNAPL during excavation activities associated with the 2011-2012 interim action (Section 4.10) and the City of Everett force main project in 2012 (Section 3.1.6). Wood began measuring LNAPL in Sump 2, which was installed in the former BNSF excavation in the quarry spall backfill, starting in mid-October 2013. Since then, LNAPL has continued to accumulate in Sump 2. LNAPL was also observed in MW-A1, located on Federal Avenue, in July 2013 after the City of Everett force main project. The dewatering cone of depression associated with the force main excavation would have pulled groundwater from the north as dewatering proceeded to the south. Therefore, the LNAPL observed in MW-A1 could potentially be attributable to either the Property or an off-Site source.

The LNAPL present at the Site originates from releases that occurred 30 to potentially 100 years ago. As such, the LNAPL is highly weathered, and has been generally depleted of the more soluble and mobile hydrocarbon components. Weathering of the releases has increased LNAPL viscosity and further decreased the mobility of the petroleum hydrocarbons remaining at the Site. The fine-grained sediments and organic matter identified beneath the Site (wood waste and peat) also limit migration and recovery of LNAPL, resulting in higher residual saturation concentrations for hydrocarbons in fine-grained soils and high levels of adsorption to organic materials. The limited downgradient extent of groundwater affected by dissolved COCs further demonstrates that migration of LNAPL constituents from the source areas is minimal.

8.2 Exposure pathways

This section summarizes potential exposure pathways relevant to the Site.

8.2.1 Soil

There are four potential exposure pathways for soil contamination at the Site: direct exposure, volatilization to subsurface vapor, dissolution into groundwater, and contact with COC-affected soil in stormwater, surface water, and sediment.

Direct exposure to soil contamination through dermal contact or incidental ingestion could potentially expose temporary construction workers during subsurface construction. Subsurface construction could be performed as part of remediation, as part of underground utility repair/replacement within the Site, or for property redevelopment. Direct exposure to soil COCs is a complete pathway. Existing surface cover limits the potential for direct exposure to other potential receptors.

Volatilization of constituents from soil within the source areas directly to subsurface vapor may allow contaminants to be transported to ambient air above ground. There are no buildings presently located on the Property, so vapor intrusion is not currently a complete exposure pathway on the Property. For the off-Property portions of the Site, the nearest structures are either above-grade modular offices or open structures. Therefore, volatilization from soil contamination and vapor intrusion in buildings is not presently a complete exposure pathway. However, future development in areas with elevated concentrations of volatile COCs could make this pathway complete. See Section 8.3.3 for additional discussion regarding the vapor inhalation pathway.

Dissolution of soil contamination may occur due to rain water infiltration and dissolution into migrating groundwater. Since the Site is paved and surface water drains to stormwater catch basins and sewers, minimal infiltration occurs at the Site. However, groundwater originating off site that passes through affected soil can dissolve COCs that can then migrate with groundwater. Therefore, the soil to groundwater pathway is complete for the Site, and potential exposure pathways for groundwater are discussed in Section 8.3.2.

Surface water runoff can potentially transport COC-affected soil to stormwater, surface water, and sediment. Since the Site is paved and surface water drains to stormwater catch basins and sewers, these pathways are currently incomplete for the Site. While these represent potential exposure pathways should the on-Property cap or off-Property paving be damaged or removed, they are not considered likely under current or expected future Site conditions.

8.2.2 Groundwater

Three potential mechanisms exist for transport of COCs from groundwater—volatilization from affected groundwater to subsurface vapors, transport of dissolved COCs in groundwater, and direct contact with or incidental ingestion of affected groundwater.

While volatilization is a possibility, especially in those areas with volatile aromatic hydrocarbons (such as the former ADC garage west of Federal Avenue), the only structures in these areas are above-grade modular offices or open structures. Benzene exceeds the groundwater screening level protective of indoor air of 2.4 µg/L at LPH-1. Therefore, volatilization of COCs from groundwater is a potentially complete Site pathway. See Section 8.3.3 for additional discussion.

As noted above, COCs can dissolve in groundwater and potentially migrate to Port Gardner Bay. In 1996, groundwater infiltrated the CSO line and flowed to Port Gardner Bay. Extensive repairs were made to the CSO line in 1996, so further direct infiltration into the CSO line is unlikely. The proposed CPOC is located downgradient of the source areas, between the source areas and the Port Gardner Bay shoreline. Therefore, although Site groundwater is discharging to marine surface water, the cleanup standard would be attained prior to discharge, thereby reducing potential risks to surface water and/or sediments to acceptable levels. Therefore, this is an incomplete pathway.

A third potential exposure pathway for affected groundwater is direct contact or incidental ingestion by construction workers. During subsurface excavations in areas of affected groundwater, workers may contact groundwater, resulting in the potential for dermal absorption or incidental ingestion. Temporary worker exposure to affected groundwater is a complete exposure pathway. Potential direct exposure to affected groundwater produced from wells is considered to be unlikely, as groundwater is neither potable nor suited for industrial or commercial use, due to the proximity of the Site to Port Gardner Bay. As discussed in Section 5.2.2.1, the highest beneficial use of groundwater at the Site is discharge to marine surface waters.

8.2.3 Vapor

Subsurface vapors could potentially transport volatile COCs from LPH, soil, or groundwater to indoor air, ambient air, excavations, or utility line backfill. Groundwater contamination by volatile Site COCs (with the exception of benzene) is below PCLs that are protective of indoor air; soil contamination in the highly affected areas may be a source of indoor air contamination. Potential vapor exposure through inhalation can affect temporary construction workers during subgrade utility work. Subsurface vapors also can accumulate inside slab-on-grade or subgrade structures or utility corridors. Currently, all Site structures are temporary, modular, above-grade offices or open-air maintenance buildings where the potential accumulation of vapors is unlikely. Based on these considerations, only inhalation by construction workers during subsurface construction work is currently considered a complete and significant potential exposure pathway.

As noted above, there are currently no slab-on-grade or subgrade buildings present over or in the vicinity of affected Site soil. However, the vapor intrusion pathway is a pathway of concern because it is possible that buildings could be constructed in the future. As noted in Section 5, the groundwater PCLs were established to be protective of indoor air, and no volatile Site COCs except benzene (in samples collected at LPH-1 and W-15R) have been detected in groundwater at concentrations exceeding PCLs based on protection of indoor air. Soil contamination in the source areas may pose a potential risk to indoor air. To address this potential future pathway, institutional controls requiring the indoor air pathway to be evaluated and addressed as part of redevelopment will be established for those parcels that contain elevated soil concentrations.

8.2.4 Light nonaqueous-phase liquids

Since completion of the BNSF excavation in 2011 and dewatering activities associated with the City of Everett utility construction activities in 2011 and 2012, LNAPL has been accumulating in sumps and wells located on and upgradient of the Property. As shown on Figure 8-2, LNAPL is present at or above residual saturation levels in several locations. Temporary construction workers could be exposed to LNAPL through ingestion or direct dermal contact when soils are removed during subsurface excavations, other excavation in affected areas, or repair or replacement of utilities or remedial activities. For these reasons, exposure to LNAPL by construction workers through direct exposure is a complete potential exposure pathway.

8.2.5 Stormwater

The surface of the Property is capped, and the surface of the remaining portions of the Site is paved. Stormwater flows to the catch basins located on the Property and in other portions of the Site. The cap and surface pavement effectively prevent stormwater from contacting affected soil or groundwater. Management of stormwater in subsurface sewer lines significantly reduces the potential for human or ecological contact with stormwater runoff. For these reasons, there is no complete potential exposure pathway related to Site stormwater runoff.

8.2.6 Surface water

The only potentially complete exposure pathway to surface water is groundwater discharging to Port Gardner Bay. However, discharge of groundwater to surface water and/or associated impacts have not been observed. While there is likely discharge of groundwater to marine surface water, dissolved COCs may naturally attenuate prior to reaching surface water. Any COCs present in groundwater discharging to surface water may result in exposure to ecological receptors via direct contact or ingestion and to human receptors via direct contact (dermal absorption or incidental ingestion) or by ingestion of aquatic organisms. Since Site COCs are attenuating prior to groundwater discharge to surface water, this pathway is incomplete.

8.3 Conceptual site model summary

The CSM is presented on Figure 8-1 and includes the site boundary based on the extent of soil or groundwater exceeding preliminary cleanup levels. This section summarizes the information provided in the preceding sections to show how the Site geology, fill history, hydrogeology, and nature and extent of contamination in soil and groundwater will determine the design of remedial alternatives.

- The shallow saturated zone on the Property east of Federal Avenue generally consists of fine-grained soils and is characterized by silty sands, silts, peat, and minor amounts of coarser sand at depth. This portion of the Site was originally a marshy, low-lying area prior to development, accounting for the presence of subsurface peat.
- The area west of Federal Avenue consists primarily of filled materials; the fill materials emplaced to extend the shoreline to the west generally consist of silty sands and well-graded to poorly graded sands.
- Groundwater within the finer grained sediments east of Federal Avenue has a steeper hydraulic gradient than groundwater in the more permeable fill materials west of Federal Avenue.
- Groundwater flows from the east to the west across the Site. The groundwater surface approaches the land surface east and northeast of the Property, as shown by the presence of seeps along the base of the Terminal Avenue Overpass and near the railroad right-of-way. This surface discharge is partially due to the finer grained, lower permeability soils in this area that restrict groundwater flow and cause groundwater levels to rise until it starts discharging to the surface.
- The gradual filling and extension of the shoreline to the west of Federal Avenue has lengthened the groundwater flow path before it eventually discharges to Port Gardner Bay. The longer flow path has caused groundwater levels to rise in areas upgradient of the pre-development shoreline, which was located just west of Federal Avenue.
- TPH-D and TPH-O or oil hydrocarbons in soil dominate COCs on the Property and the area to the east, under the Terminal Avenue Overpass. These hydrocarbons are found at concentrations suggesting that they are present in the soil at residual saturation or as limited areas of LPH. This contamination beneath the Terminal Avenue Overpass may be an ongoing source for releases to groundwater and/or soil, and this area cannot be excavated or otherwise remediated due to the presence of the overpass structure and foundation.
- TPH-G in soil is primarily found near the former ADC garage area west of Federal Avenue.
- Residual concentrations of COCs in soil are also located beneath Former Everett Avenue and Federal Avenue.
- Hydrocarbons released to subsurface soils prior to extension of the predevelopment shoreline to its current location would have flowed downward through the soil to pool on the water table as it existed historically. As the water table rose due to extending the shoreline, at least a portion of these hydrocarbons would have been trapped below the rising water table in residual saturation.
- Groundwater flowing through the hydrocarbon-affected soils can dissolve the more soluble portions of the trapped hydrocarbons, causing these dissolved constituents to migrate downgradient, and resulting in increased average molecular weight of the hydrocarbons left behind.
- Dewatering for construction is meant to lower the water table to stabilize soils in an excavation. Lowering the water table can allow hydrocarbons trapped in the soil at concentrations exceeding residual saturation levels to pool and begin moving in the direction of the induced gradient toward

the area being dewatered. This phenomenon was observed in the engineered fill in the former BNSF excavation, where LPH was observed a few months after dewatering by the City of Everett in 2012.

- The complete potential exposure pathways are:
  - **Soil:** direct exposure, volatilization to subsurface vapor, dissolution into groundwater, and contact with COC-affected soil in stormwater, surface water, and sediment;
  - **Groundwater:** volatilization from affected groundwater to subsurface vapors, transport of dissolved COCs in groundwater, and direct contact with or incidental ingestion of affected groundwater;
  - **Vapor**: inhalation by construction workers during subsurface construction work and potentially vapor intrusion into future buildings that may be constructed at the Site; and
  - **LNAPL:** ingestion or dermal contact.

Volatilization into soil vapor and then vapor intrusion into an occupied building is a potential route of exposure that may be applicable in the future. However, all existing buildings at the Site are above-grade buildings that are open or have well-ventilated crawlspaces, so at present there are no complete volatilization exposure routes. If new buildings are constructed within Site source areas, the possibility of future vapor intrusion would need to be considered and addressed.

Lastly, any remedial alternative that lowers the permeability of soil (through use of a barrier or low-permeability material such as controlled density fill) should account for the possibility of groundwater mounding on the upgradient side. This mounding could cause groundwater to flow onto the surface and may potentially cause LPH to seep to the surface, along with groundwater.

9.0 Remedial action objectives

The RAOs are Site-specific goals established to protect human health and the environment and must be achieved by remedial alternatives considered for evaluation in the FFS. The RAOs provide a general framework, along with other requirements specified in the MTCA regulations, for developing and evaluating remedial action technologies and alternatives. The preliminary RAOs that have been identified for the FFS are:

- Prevent COCs from migrating off Site from source areas.
- Prevent contaminated soil containing concentrations of COCs above soil cleanup levels from becoming airborne or waterborne and impacting surface water or sediment in the East Waterway (via dust migration, leaching into soil, or stormwater runoff).
- Reduce the potential for COCs to leach from Site soil to groundwater.
- Remove LPH to the maximum extent practicable.
- Prevent future migration of residual LPH (after removal to the extent practicable) at the Site.
- Reduce the potential for the dissolved-phase groundwater plume to expand downgradient toward the East Waterway via diffuse groundwater flow or through utility corridors and discharge to surface water and sediment in the East Waterway.
- Prevent vapor intrusion into current or future buildings on the Site above indoor air cleanup levels from volatile COCs in soil and groundwater.
- Prevent direct human contact (dermal and incidental ingestion) and inhalation exposure to contaminated soil and groundwater above the cleanup levels.
- Attain cleanup standards in soil and groundwater by achieving cleanup levels at the applicable POCs within a reasonable restoration time frame and in accordance with MTCA regulations.

It is expected that cleanup levels for groundwater will be attained at an off-Property CPOC.

10.0 Remediation considerations

The remediation alternatives considered in the FFS must be designed to address applicable or relevant regulations and requirements as specified in the MTCA regulations. Additionally, there are several Site-specific factors that constrain and/or otherwise affect Site remediation. These considerations are described below.

10.1 Applicable or relevant and appropriate requirements

Several regulations will apply to Site remediation. The alternatives considered in the FFS must address these requirements. The applicable regulatory requirements are summarized in Sections 10.1.1 through 10.1.8.

10.1.1 MTCA requirements

The MTCA cleanup regulations provide that a cleanup action must comply with cleanup levels for identified COCs, POCs, and applicable or regulatory requirements, based on federal and state laws (WAC 173-340-710).

10.1.2 State Environmental Policy Act

The Washington State Environmental Policy Act (SEPA) (RCW 43.21C), State implementing rules (WAC 197-11), and City of Everett regulations may apply to cleanup actions that may affect the environment. SEPA applies to cleanup actions that may affect the environment, and MTCA cleanup actions are not exempt from SEPA procedures. Ecology is required to complete a SEPA checklist to determine if a proposed cleanup action will or will not have a significant adverse impact on the environment. If Ecology determines that there is no significant impact, Ecology issues a Determination of Non-significance or a mitigated Determination of Non-significance with conditions.

10.1.3 Construction stormwater general permit

A stormwater, grading, and drainage permit will be required prior to any earthwork that will result in excavation that is deeper than 3 feet and/or disturbs more than 100 cubic yards (CY) of soil. This permit will specify the excavation protection (shoring) methods and temporary erosion and sedimentation controls to be used during remedial actions.

10.1.4 Other potentially applicable regulatory requirements

Other regulatory requirements must be considered in the selection and implementation of the cleanup action. MTCA requires the cleanup standards to be "at least as stringent as all applicable state and federal laws" (WAC 173-340-700[6][a]). Besides establishing minimum requirements for cleanup standards, applicable federal, state, and local laws and ordinances also may impose certain technical and procedural requirements for performing cleanup actions. These requirements are described in WAC 173-340-710.

10.1.4.1 National Recommended Water Quality Criteria

The National Recommended Water Quality Criteria (NRWQC) are federally promulgated water quality criteria. These standards are referenced in the MTCA regulations (WAC 173-340-730 [3][b]) as applicable federal standards and are based on human health. Of the Site COCs, NRWQC are listed only for benzene and total cPAHs. The NRWQC for these two COCs were considered for establishing the PCLs for groundwater at this Site. Other ARARs applicable to protection of surface water were identified in Section 5.2.2.2.

10.1.4.2 Native American Graves Protection and Repatriation Act

The Native American Graves Protection and Repatriation Act is codified at 25 United States Code (USC) 3001 through 3113 (43 CFR 10) and Washington's Indian Graves and Records Law (RCW 27.44). These statutes, or local variations, prohibit the destruction or removal of Native American cultural items and require written notification of inadvertent discovery to the appropriate agencies and Native American tribes. Because the general waterfront area has been occupied, or otherwise used, by Native American tribes, remediation activities could uncover artifacts. Requirements for these laws and regulations must be addressed as part of design and implementation of the selected Site remedy.

10.1.4.3 Archaeological Resources Protection Act

The Archaeological Resources Protection Act (16 USC 470aa et seq.) and the federal regulations issued pursuant to this law (43 CFR 7) are potentially applicable requirements. This federal program, and any similar state and/or local programs, set forth requirements that are triggered when archaeological resources are discovered. These requirements will apply only if archaeological items are discovered during implementation of the selected remedy.

10.1.4.4 Washington Dangerous Waste Regulations

The dangerous waste requirements (WAC 173-303) potentially apply to the identification, generation, accumulation, and transport of hazardous/dangerous wastes at the Site during remediation and monitoring. These standards are applicable to any soil or monitoring wastes that are taken off Site for disposal that have concentrations of COCs that exceed Washington Dangerous Waste criteria.

10.1.4.5 Washington Solid Waste Handling Standards

The solid waste management regulations (WAC 173-350) establish minimum standards for handling and disposal of solid waste. They are applicable for Site activities, including remediation and monitoring, that generate solid waste, the definition of which includes affected soils, affected groundwater, investigation-derived waste, construction and demolition wastes, and garbage. The standards require that solid waste be handled in a manner that does not pose a threat to human health or the environment, and that complies with local solid waste management rules and applicable water and air pollution controls.

10.1.5 Washington Industrial Safety and Health Act regulations

Cleanup activities will be performed in accordance with the requirements of the Washington Industrial Safety and Health Act (RCW 49.17), the federal Occupational Safety and Health Act (29 CFR 1910 and 1926), the Hazardous Waste Operations and Emergency Response (HAZWOPER) regulations (29 CFR 1901.120), and Washington General Occupational Health Standards (WAC 296-62). These applicable regulations include requirements for worker protection from physical hazards (such as improper shoring, confined space entry, and equipment hazards), and protection from exposure to hazardous substances or other deleterious materials.

10.1.6 Monitoring well construction, maintenance, and decommissioning

Ecology enforces rules for the construction, maintenance, and abandonment of monitoring and other types of wells in Washington (WAC 173-160), excluding injection wells. To conduct soil remediation, several existing monitoring wells will be abandoned, and several new monitoring wells will be installed to monitor the groundwater contamination levels after completion of the Site cleanup action.

10.1.7 Air quality

For Site grading or excavation work that could generate dust, controls would need to be in place during construction (e.g., wetting or covering exposed soils and stockpiles), as necessary, to meet the substantive restrictions for off-Site transport of airborne particulates by the local agency (the Puget Sound Clean Air Agency).

10.1.8 Shoreline management

The Washington State Shoreline Management Act and the federal Coastal Zone Management Act are implemented through the City of Everett's Shoreline Master Program. These acts establish requirements for substantial development occurring within the waters of the State of Washington or within 200 feet of a shoreline. These requirements may be relevant to Site remediation, although most work would be performed more than 200 feet from the Port Gardner Bay shoreline. The cleanup action will be designed to comply with any applicable and substantive requirements under the City of Everett's Shoreline Master Program.

10.2 Site-specific constraints

Remediation alternatives for the Site were developed while considering the following Site-specific remediation constraints:

- **Terminal Avenue Overpass:** This overpass is within a City of Everett right-of-way and provides access to the Port of Everett, KC, and BNSF properties. The project is limited by the overpass because contamination beneath and immediately adjacent to the structural features associated with the overpass (e.g., pilings/supports) cannot be safely accessed for removal by excavation, as there is significant potential for damage to the overpass structural footings and this area cannot be practicably remediated by other means.
- **City of Everett Lift Station #3:** The lift station is located at the east end of former Everett Avenue and northeast of the ADC Parcel. This lift station provides combined sanitary and stormwater sewer capacity; however, during large storms overflow from the lift station flows directly into Port Gardner Bay. The City of Everett requires access to this lift station for inspection of equipment, such as telemetry monitors, levels, and pumps, and for maintenance on a daily basis. For this reason, potential for removal of contamination below the access road is limited.
- **Aboveground and underground utilities:** Numerous critical utilities are located along Federal Avenue and the former Everett Avenue alignments, located both above and below the area of concern. These utilities include a 24-inch force main, two sanitary sewer lines, storm drain line, underground telephone line, and overhead electrical lines (Figure 2-16). Remediation activities within these areas are substantially limited because these services are required to keep local businesses operable.
- **KC Maintenance Building:** This building is located on KC property adjacent to the former Everett Avenue. Remediation in areas adjacent to the building are limited by this structure because contamination beneath the structure is not safely accessible for removal by excavation, as there is potential for damage to the slab/footings and for building settlement.
- **Surrounding property access:** Ongoing operations are occurring at several properties within or adjacent to the Site. Ongoing access is currently required for the Port of Everett, Dunlap Towing, and KC properties. Maintaining access to local businesses for daily industrial activities will limit remediation efforts in some areas. Depending on the extent of contamination, excavation or construction areas will be limited to areas where access by construction equipment and personnel can be maintained while avoiding significant disturbance of business operations. Also, the project is limited to areas that are legally permissible to access.
- **Site conditions:** Existing Site conditions, such as the known high groundwater table or groundwater seepage from upgradient areas, may affect the maximum feasible depth of excavation. The high groundwater table or excessive seepage can affect the stability of excavation sidewalls and limit the safe depth of excavation. The high water table limited the safe depth of excavation and increased the

volume of petroleum-impacted groundwater collected during the 2011–2012 excavation conducted in the area to the east of the Property.

- **Non-potable groundwater:** As noted in Section 5.2.2.1, groundwater present beneath the Site is not suitable for use as a source of potable water due to the proximity to Port Gardner Bay and the hydraulic connection between the groundwater and marine surface waters. The historic use of the area for disposal of refuse and very high potential to capture marine water from Port Gardner Bay preclude use of Site groundwater as a potable water source.
- **Off-property constituents:** The Site consists of the Property owned by ExxonMobil and ADC as well as several properties owned by other parties. The processing area that was leased by ADC is located west of Federal Avenue on property owned by the Port of Everett. Since Site constituents are present in the inaccessible areas beyond the boundary of the properties owned by ExxonMobil and ADC, an off-property CPOC is necessary for the Site because it is not practicable to meet cleanup levels throughout the entire Site within a reasonable restoration time frame.

11.0 Remediation technologies

A reasonable number and type of potentially applicable remediation technologies were evaluated in a feasibility study for this Site, which was completed in 1998 (Exponent, 1998). Based on the previous work, potentially applicable technologies were considered and presented in the FFS Work Plan (AMEC, 2013). A limited number of additional remediation technologies have been considered for this FFS. Based on the technology evaluations completed to date and discussion with Ecology, this FFS will not repeat technology screening. Instead, this FFS will proceed directly to development and evaluation of feasible remediation alternatives. Consistent with discussions and meetings with Ecology, the FFS will focus on evaluating a select number of remediation alternatives that are considered potentially feasible to address petroleum hydrocarbon impacts in soil and groundwater at the Site. This section provides a general description of the remediation technologies that have been included in the remediation alternatives that are developed and evaluated in Sections 12 and 13.

11.1 Institutional controls

Institutional controls limit access or use of the Site to reduce the potential for applicable receptors to be exposed to Site COCs. Institutional controls applicable to the Site include requirements to provide basic information/notification and/or measures to inform the public and those performing work within the Site about potential risks from Site COCs. Institutional controls, such as restrictive covenants and/or security systems, will be incorporated into the remediation alternatives as appropriate to preclude Site uses or activities with the potential to expose receptors to Site COCs, to restrict inadvertent access by the general public, and to mitigate any potential for vapor intrusion into potential future buildings. The technologies considered for institutional controls include perimeter fencing, signage on the fence, and restrictive covenants.

11.2 Excavation and off-site disposal

This remediation technology includes excavation of contaminated soil, characterization for waste disposal, transportation, and off-Site disposal within a permitted landfill or other appropriate disposal or treatment facility. Excavated soil would be replaced by importing and placing clean fill or utilizing treated soil generated by in situ soil stabilization. Confirmation samples are typically collected from excavations to verify removal of affected soil. This technology can be implemented to remove all affected soil or to remove areas of LNAPL-impacted soils or the known source area. This remediation method is widely used and results in permanent removal of affected soil from the Site. Contaminated soil is typically placed within an engineered landfill; contaminants are not permanently destroyed by this remediation technology.

11.3 LNAPL recovery

LNAPL recovery is a technology that removes mobile, free-phase petroleum hydrocarbons that float on the groundwater surface. Recovery typically utilizes a hydraulic recovery system (such as pumping) or a skimming system to remove the mobile LNAPL. LNAPL recovery systems can be implemented using wells or using recovery trenches. For both such systems, LNAPL must be removed either continuously or periodically, with either treatment or disposal of recovered fluids, which normally include water and petroleum hydrocarbons.

LNAPL recovery is not considered an applicable technology for this Site. As noted in Section 8, LNAPL present at the Site is immobile under existing conditions. The oil-recovery trench previously constructed has not been effective in recovering LNAPL. An aggressive dewatering program conducted by the City of Everett for repair of the combined sewer overflow line did recover some LNAPL, but the volume of LNAPL recovered was only 1.6% of the total volume of groundwater recovered, indicating that dewatering was a highly inefficient means to remove LNAPL. Aggressive dewatering was also performed by the City of

Everett for installation of the sewer force main in 2012. Recovered groundwater did not require pretreatment prior to discharge to the publicly owned treatment works, indicating that LNAPL recovery was minimal. Our previous experience in the vicinity of the Site indicates that LNAPL recovery has been ineffective and inefficient; therefore, LNAPL recovery will not be included in the remediation alternatives considered in this FFS.

11.4 Natural attenuation

Natural attenuation is a remediation technology that relies on natural processes—including biodegradation by indigenous organisms—to degrade contaminants that have been released to soil and groundwater. Monitored natural attenuation (MNA) has been proven at many petroleum hydrocarbon sites as an effective technology to retard, disperse, and/or degrade groundwater plume contaminants in combination with appropriate monitoring to verify its effectiveness (Ecology, 2005). Natural attenuation by indigenous organisms has also been found to be effective in remediating petroleum hydrocarbon source areas (ITRC, 2018). Ecology allows the use of natural attenuation when source removal or source control has been implemented to the extent practicable, contaminants left on Site do not pose an unacceptable threat to human health or the environment, there is evidence of natural or chemical biodegradation, and appropriate monitoring is conducted [WAC 173-340-370(7)]. Natural attenuation is considered an appropriate technology for potential implementation at the Site to address groundwater and source area remediation.

11.4.1 Monitored natural attenuation

This technology is especially appropriate for petroleum hydrocarbon plumes. The depositional history of the shallow subsurface in the vicinity of the Property has resulted in a substantial level of natural organic materials in the subsurface. The high organic content of Site soils increases retardation of groundwater contaminants. The natural soil conditions at the Site are expected to provide a favorable environment for effective natural attenuation of organic constituents present in affected Site groundwater. The limited extent of the downgradient dissolved-phase plume indicates that natural attenuation is active at the Site. The Site will remain capped or covered following source area removal to limit infiltration and potential human or environmental exposures.

A groundwater monitoring well network and monitoring program are typically associated with MNA to ensure that COPC degradation is effective and that cleanup levels are attained. Ecology guidance provides technical recommendations regarding the types of monitoring parameters and analyses useful for evaluating the effectiveness of MNA (Ecology, 2005). These recommendations will be incorporated into remediation alternatives that incorporate MNA as a technology.

11.4.2 Monitored natural source zone attenuation

Natural source zone attenuation is a relatively new remediation approach which relies upon naturally occurring processes, such as dissolution, biodegradation, and degradation by-product volatilization, to reduce the mass of LNAPL and Site COCs in subsurface source areas (ITRC, 2009, 2018). Recently developed techniques have been applied to LNAPL source areas to confirm attenuation and to assess attenuation rates. Historically, the rate of LNAPL attenuation within source zones was thought to be controlled solely by electron-acceptor-mediated biodegradation, with a degradation rate less than 50 gallons of hydrocarbon per acre per year. However, recent measurements of attenuation of source area LNAPL suggest that source area depletion also occurs by anaerobic biodegradation and vapor transport processes. Reported depletion rates for petroleum hydrocarbons range from 300 to 7,700 gallons per acre per year (Garg et al., 2017). It has also been found that the presence of groundwater in conjunction with LNAPL has a substantial role in natural attenuation processes (ITRC, 2009).

Depletion rates for source zone attenuation can be used to compare estimated remediation time frames for this technology. The depletion rate is generally determined by estimating the LNAPL flux associated with the following three mechanisms (Mackay et al., 2018):

1. *Dissolution*: Estimate the mass flux of dissolved hydrocarbon to groundwater downgradient of the source area.
2. *Biodegradation*: Estimate the LNAPL depletion associated with both aerobic (i.e., electron-acceptor-mediated) and anaerobic (i.e., electron-donor-mediated) biodegradation using appropriate characterization data, stoichiometry, and local groundwater chemistry data.
3. *Vapor transport*: Estimate LNAPL depletion due to volatilization by monitoring the release of gaseous biodegradation by-products (e.g. carbon dioxide and methane) within or above the source zone and estimating various properties of the media to estimate the volatilization rate for the entire source zone.

Regulatory policies regarding source zone attenuation have been changing in many states. Natural source zone attenuation has been used as an acceptable remedial approach at sites in several states, such as the Guadalupe Oil Field in California (ITRC, 2009), the Bemidji site in Minnesota (Essaid et al., 2011), and the BNSF Midland Market Railyard in Oregon (Oregon DEQ, 2014).

Natural source zone attenuation is considered an appropriate remedial technology for the Site for several reasons. As discussed previously, much of the LNAPL and affected soil within the Site source areas is below the water table, a condition that supports natural source zone attenuation. The potential rate of LNAPL removal associated with natural source zone attenuation reported in previous studies (up to thousands of gallons per acre per year) exceeds the volume of LNAPL recovered historically from remediation activities conducted at the Site, as noted in Table 6-2. Higher removal rates were only achieved during the CSO dewatering work conducted in 1996. Site TPH and LNAPL have been highly weathered, likely due to natural attenuation processes that are active at the site (Section 6.4). Additionally, a substantial portion of the Site LNAPL source area is inaccessible and cannot be addressed by other remediation technologies. Natural source zone attenuation is a newly recognized remediation technology that may be effective for remediation of Site contaminants from impacted areas, including the inaccessible areas. A monitoring program is typically associated with natural source zone attenuation to verify that natural source zone remediation is effective. This technology is considered an essential tool for Site remediation and will be incorporated into remediation alternatives as appropriate.

11.5 Subsurface barrier wall

Low-permeability barrier walls can be used to completely or partially contain source areas or areas with high levels of contamination. These barriers have been proven to be highly effective for isolating and containing both contaminated soil and contaminated groundwater. Shallow barrier walls, which would most likely be applicable to the Site, are typically constructed of a soil-bentonite mixture using the slurry wall technique. The slurry wall technique involves excavation of a trench and filling the trench with bentonite and water slurry to maintain an open excavation. The excavated soil is stockpiled alongside the trench, where it is mixed with bentonite to achieve the desired permeability. The amended backfill is then placed back into the trench as backfill, displacing the bentonite slurry and forming the barrier wall. Conventional soil-bentonite slurry walls can be readily completed to depths of about 50 feet bgs and are capable of achieving a hydraulic conductivity on the order of 10^{-7} cm/sec, which is approximately two orders of magnitude lower than the hydraulic conductivity of Site soils. Barrier walls may be keyed into a lower confining soil layer or they may be constructed as a "hanging" wall when no lower confining unit is present. Both types of barrier walls can be effective for containing contaminated soil and/or groundwater.

11.6 Permeable reactive barrier

Permeable reactive barriers (PRBs) are used to remediate dissolved groundwater contaminants as groundwater flows through the reactive medium. They are typically constructed using reactive media that interact with groundwater contaminants that flow through the barrier wall, with the PRB medium selected to address the specific contaminants present at a given site. For TPH, an activated carbon or amended organoclay medium may be used, as these materials will adsorb dissolved TPH. The PRB medium must have a permeability higher than the surrounding saturated soils. A PRB may be used in conjunction with a low-permeability barrier wall in a "funnel-and-gate" arrangement to direct groundwater flow through the PRB. Funnel-and-gate designs require proper design to control excessive mounding on the upgradient side. PRBs are designed to provide a minimum contact time and adsorption capacity for the contaminants being addressed. Depending on the design of the PRB and the mass flux of the contaminants into the PRB, the medium may need to be replaced to address all of the dissolved-phase contamination. The medium in the PRB could also support biological activity, which would degrade adsorbed TPH over time.

11.7 In situ soil stabilization

In situ soil stabilization (ISS) is accomplished by mixing a stabilization additive (typically Portland cement) to stabilize the soil and bind contaminants. Portland cement, and/or other pozzolanic materials, tightly bind to most inorganic contaminants and effectively immobilize them, thereby eliminating migration and direct exposure risks. The stabilized soil is usually friable after stabilization but has good bearing capacity and reduced permeability. For organic contaminants, such as TPH or creosote, this technology can be effective in reducing mobility if an additive, such as bentonite or organophilic clay, is added. Mixing the additives with the soil results in a volume increase (which may be in the range of 20–30%); the excess soil is typically removed from the Site to maintain the existing grade. If this technology is combined with excavation of affected soil, the stabilized soil may be used to backfill portions of the Site that have been excavated.

Soil mixing can be accomplished in situ by several methods, including use of modified augers, proprietary soil mixing heads, or conventional excavator buckets. Augers and mixing heads provide more thorough mixing than can be accomplished using a conventional excavator bucket. Thorough mixing also homogenizes the treated soil column, distributing COCs throughout the treated volume. Treatability testing is required to determine the appropriate amendment ratios. Stabilized materials are usually covered with clean soil or pavement to limit infiltration and erosion. This technology has been demonstrated to be effective for hydrocarbon sites. If treated soil is removed in the future to support development after remediation is complete, the excavated soil would not require management or disposal as dangerous waste but would require management and disposal as solid waste.

Advantages of ISS include decreased mobility of COCs due to binding of stabilized soils, decreased concentrations of COCs in treated soil due to mixing into the soil column, and slightly reduced permeability of treated soils, thus reducing the potential for migration. Additionally, site-specific admixtures can be developed and evaluated to achieve desired results. For example, increasing bentonite along the perimeter could further reduce permeability, resulting in decreased groundwater flow through the treated area. The mixing and stabilization of affected soils would also make it unlikely that vapor intrusion barriers would be necessary for future development over treated soils.

Disadvantages of ISS include the potential for excessive reduction in the permeability of treated soils (increasing the likelihood of surface seepage under some conditions) and the presence of residual COCs that remain in place after treatment. In addition, the stabilized soils would be considered solid waste by Ecology if they are excavated in the future, such as for utility or redevelopment work, requiring additional costs for handling and disposal. ISS would also hinder or inhibit the natural biodegradation of Site contaminants within the stabilized areas that is occurring under current site conditions (ITRC, 2011). This inhibition of natural biodegradation would reduce the degradation rate of COCs at the Site and extend the restoration time frame. Another disadvantage is that implementation of ISS requires a second mobilization for construction activities using specialized equipment to perform the work.

12.0 Development of remediation alternatives

The objective of the FFS is to provide sufficient information to identify a preferred, comprehensive Site remediation alternative that adequately addresses Site soil and groundwater contamination and the relevant exposure pathways identified in Section 8.3. The alternatives developed for the FFS have been designed such that they can be implemented within a reasonable time frame and within the existing Site constraints, including the presence of affected media in inaccessible areas beneath and adjacent to the Terminal Avenue Overpass and along the utility rights-of-way (Section 10.2). Two groups of remediation alternatives have been developed and evaluated.

The first group of alternatives has been designed to address affected soil and groundwater within the source areas (Figure 12-1). *Source areas* are defined as those areas where soils affected by the operations conducted by ExxonMobil and ADC significantly exceed PCLs. Within the source areas are more limited areas defined by the presence of LNAPL-affected soil, where LNAPL has been observed or where concentrations of petroleum hydrocarbons are high enough to suggest that the hydrocarbons are present in residual saturation ("LNAPL Areas"). The LNAPL Areas occur in two portions of the Site: one includes the majority of the Property, and the other is located west of Federal Avenue on property owned by the Port of Everett in the vicinity of the former ADC garage (Figure 12-1). The *inaccessible source areas* (or inaccessible areas) are areas where soils affected by the operations conducted by ExxonMobil and ADC may exceed PCLs, but where access is not practicable for remediation construction activities. These areas include the areas beneath and adjacent to the Terminal Avenue Overpass, adjacent to the neighboring KC building, and along the utility rights of way on Federal Avenue and former Everett Avenue (Figure 12-1).

The second group of alternatives has been designed to address the areas of affected groundwater extending downgradient from the source areas, with dissolved-phase COC concentrations that are significantly lower than the COC concentrations found within the source areas. As noted in Section 6, concentrations of most of the COCs in groundwater west of Federal Avenue are lower than the PCLs. Both groups of remediation alternatives were developed and evaluated separately to provide the information necessary to identify the preferred alternative from each of the two groups (source area and affected groundwater).

The final, comprehensive Site alternative will combine the preferred alternative from each of the two groups so that both the source areas and affected groundwater are addressed effectively. All alternatives being evaluated meet both the MTCA requirements and ARARs. The recommended Site remediation alternative is presented in Section 14.

Using the remediation technologies identified in Section 11, three remediation alternatives were developed to address affected soil and groundwater within the source areas, and two alternatives were developed to address dissolved-phase COCs in downgradient groundwater.

The FFS will evaluate the following three source area remediation alternatives:

- **Source Area Alternative 1: LNAPL Area Excavation and Natural Source Zone Attenuation.** Excavation of accessible source area soils impacted by LNAPL and/or residual LNAPL saturation would occur to the maximum extent practicable under this alternative. Remaining source area soil exceeding PCLs and impacted portions of the inaccessible areas would be addressed by natural source zone attenuation.
- **Source Area Alternative 2: LNAPL Area Excavation and Source Area Stabilization.** This alternative would combine excavation of accessible source area soils impacted by LNAPL and/or residual LNAPL saturation to the maximum extent practicable, as described for Source Area Alternative 1, with in situ soil stabilization of affected soils exceeding PCLs within the source areas. Affected soils within the

source areas would be treated using an admixture of Portland cement and bentonite to immobilize remaining COCs and limit potential migration risks. Impacted areas within inaccessible areas would be addressed by natural source zone attenuation.

- **Source Area Alternative 3: Source Area Excavation**. This alternative consists of comprehensive excavation of accessible affected soils exceeding PCLs in the source areas to the maximum extent practicable. As noted for Alternatives 1 and 2, impacted portions of the inaccessible areas would be addressed by natural source zone attenuation.

The three remediation alternatives for the source areas all include institutional controls as appropriate to achieve remediation objectives, particularly for the inaccessible areas. In these areas, it is impracticable to treat or remove affected soil and groundwater, which would remain in place for some time. In addition, isolated exceedances of certain COCs outside the source areas and inaccessible areas do not pose unreasonable risk as they are only slightly above the PCLs and are already contained beneath existing pavement. The source area remediation alternatives are described in more detail in Section 12.1.

The FFS evaluated two remediation alternatives that focus on remediation of the dissolved groundwater plume downgradient of the source areas:

- **Groundwater Alternative 1: Monitored Natural Attenuation.** Groundwater remediation based on monitoring attenuation of groundwater COCs by intrinsic, natural processes.
- **Groundwater Alternative 2: Funnel and Gate.** Groundwater remediation using a PRB and monitoring the attenuation of groundwater COCs.

The two groundwater alternatives would address dissolved COCs and would include institutional controls and a groundwater monitoring program to fully achieve remediation objectives. The two groundwater alternatives are described in more detail in Section 12.2.

12.1 Source Area remediation alternatives

The three remediation alternatives developed for the source areas at the Site are described in Sections 12.1.1 through 12.1.3. The two defined source areas for the Site described above are generally located (1) on the Property and (2) in the vicinity of the former ADC garage on Port of Everett property immediately west of Federal Avenue. The two source areas include areas where free LNAPL or LNAPL at concentrations at or above residual saturation is present. These areas are referred to as *LNAPL areas* and are shown on Figure 12-1. Figure 12-1 also shows the soil sampling locations where each of the Site COCs has exceeded the PCLs and demonstrates that the source areas and the LNAPL areas effectively cover the areas impacted by these constituents. Figures 12-2 through 12-4 show schematic drawings of the three source area alternatives. The areas to be addressed by each of the source area remedial alternatives effectively cover the areas with soils affected by petroleum hydrocarbons.

The two defined source areas can be practicably remediated and include most of the areas with the highest concentrations of COCs and/or LNAPL. The inaccessible areas cannot be feasibly remediated by active measures, as any remediation would significantly impact existing infrastructure and vehicular traffic while creating undue health and safety risks for workers involved in the remediation effort, as well as the general public. In addition, serious and expansive structural concerns would have to be addressed prior to performing work adjacent to structures in these areas.

For conceptual design of the source area alternatives, it was assumed that any excavation must be set back from the base of the Terminal Avenue overpass a sufficient distance to achieve a one-to-one horizontal-to-vertical (1H:1V) ratio to minimize the potential for adverse impacts to the overpass. For example, if the excavation on the southeast side of the property adjacent to the overpass is expected to be 10 feet deep, the edge of the excavation would be set back 10 feet from the overpass. The southeast edge of the excavation would also be protected using piling. Installation of protective measures such as shoring may allow for excavation closer to the overpass; however, further geotechnical investigation and testing would be necessary to determine an adequate approach to safely conduct the excavation. The contamination present beneath the utility corridors (former Everett Avenue and Federal Avenue) cannot be directly addressed due to the presence of utilities (both underground and overhead) and because it is the sole source of access for several active businesses. For all three alternatives, contamination remaining in these inaccessible areas would be remediated by natural source zone attenuation processes.

12.1.1 Source Area Alternative 1: LNAPL Area excavation and natural source zone attenuation

This alternative entails removal of accessible soils contaminated with LNAPL or residual LNAPL saturation within the two defined source areas. Remaining COCs exceeding PCLs within source areas and inaccessible areas would be remediated by natural source zone attenuation. In this alternative, the most highly affected portions of the accessible source areas would be excavated for off-site disposal. The excavation areas shown on Figure 12-2 are based on currently available analytical data. Based on Site investigation data, five different excavation areas have been defined with different excavation depths. The excavation depths are based on Site investigation boring logs, which are included in Appendix B. Additional site characterization data may be collected for final design if this alternative is selected for implementation. The areas beneath the Terminal Avenue Overpass and areas within a 1H:1V setback from the overpass are not included for excavation under this remedial alternative due to potential structural issues for the overpass. The excavation areas shown on Figure 12-2 may change during final design, based on additional design data collected and/or provisions to protect the structural integrity of the overpass and adjacent roadways.

For conceptual design of this alternative, it was assumed that remedial activities would be conducted in the following sequence:

1. Excavate soils containing LNAPL and/or residual LNAPL saturation.
2. Backfill the excavation.
3. Pave/cap and restore the final surface.
4. Implement natural source zone attenuation monitoring for the remaining source area soils and the inaccessible areas.

For the FFS, it was assumed that the excavated soil would be disposed of off Site as impacted soil.

It was assumed that the LNAPL area excavation would be conducted as open excavations in the areas shown on Figure 12-2. To the maximum extent practicable, excavation would be performed without groundwater removal. Temporary shoring using sheet piling was assumed to allow excavation to the depths shown on Figure 12-2 and is necessary to protect the City of Everett Force Main sewer to the north, the Overpass to the east, and Federal Avenue to the west (i.e., the inaccessible areas). The temporary shoring would be removed upon completion to allow normal groundwater flow. For excavation areas not along public rights-of-way, the perimeter of the excavation would be sloped at an angle determined by a competent person based on results of soil testing and analysis. For conceptual design of this alternative, it was assumed that the side slopes would be sloped at a 1:1 ratio. Figure 12-2 shows the approximate limits of the side-slope excavations used for conceptual design and cost estimates. For this alternative, it was assumed that approximately 520 linear feet of shoring along public rights-of-way would be needed to the approximate depth of 30 feet, representing approximately 15,700 vertical square feet of sheet pile shoring. The temporary shoring would be removed upon completion to allow normal groundwater flow. Side-slope soils excavated along boundaries that are not expected to exceed PCLs were assumed to be reused as backfill. Side-slope soils excavated along boundaries expected to exceed PCLs were assumed to be disposed with LNAPL-impacted soil.

Excavation will be performed as dredging, with minimal groundwater removal. Groundwater will be removed if necessary to achieve the following objectives: (1) prevent groundwater from overtopping the excavation, and (2) remove LNAPL from groundwater within the excavation. LNAPL may be removed from the surface of the groundwater within the excavation as it is performed using methods such as skimming from the water surface using a vacuum truck or using absorbent booms/pads. Due to the depth to groundwater in the excavation areas (generally 2-5 feet bgs), groundwater recovery to prevent groundwater from overtopping the excavation will likely not be necessary. LNAPL will be removed from the surface of groundwater within the excavation prior to placement of backfill. Recovered groundwater will either be treated on site and discharged to the City of Everett publicly owned treatment works or temporarily stored in on-site tanks for off-site disposal.

The LNAPL Area excavation is expected to generate approximately 16,800 tons of impacted soil, which would be transported to an off-site landfill for disposal. Due to the potential for mobilization of LNAPL from inaccessible areas during excavation, provisions would be needed for LNAPL recovery and disposal during the excavation work. Based on past experience during the interim action to the east of the Property, it was assumed that approximately 800 gallons of LNAPL may be recovered during this excavation. It was assumed that the recovered LNAPL would be transported to a commercial facility for disposal.

It was assumed that the excavations would be left open and undisturbed for two to three days after completing excavation work to allow LNAPL that might have been mobilized due to excavation activities to collect and be recovered prior to commencing backfill. The conceptual design for this alternative assumes that the excavations would be backfilled with crushed rock. The backfill material placed below the water table was assumed to be similar to City of Seattle Standard Specifications for Road, Bridge, and Municipal Construction ("Seattle Standard"; City of Seattle, 2017) Mineral Aggregate Type 13, and the backfill material placed above the water table to within 10 inches from the finish grade was assumed to be a finer crushed rock, such as Seattle Standard Mineral Aggregate Type 17. Although low concentrations of dissolved-phase COCs will remain in groundwater within the excavation areas, recent groundwater sampling of source area wells indicates that these low COC concentrations will not cause any significant contamination of backfill material. It was assumed that a 6-inch-thick layer of pavement subgrade would be placed above the crushed rock backfill, followed by 4 inches of asphalt pavement. The paved surface would be graded to restore current drainage patterns. The paved surface would also serve as a protective cap.

Under this alternative, impacted soils would remain in the inaccessible areas and in the source areas beyond where soils with LNAPL and/or residual LNAPL saturation were removed. The weathered LPH currently present at the Site preferentially adsorbs to peat, wood waste, and other organic constituents present in the subsurface, which limits the mobility of LPH during natural source zone attenuation. Therefore, the restoration time for this alternative is expected to be the time required for LNAPL within these areas to become sufficiently weathered so it is permanently immobile (i.e., so that LNAPL cannot be mobilized due to excavation or induced changes in the water table).

The inaccessible source areas would be remediated by natural source zone attenuation. The COC degradation rate would be determined by measuring the gaseous release of carbon dioxide, methane, and other biodegradation by-products from the vadose zone. The natural source zone attenuation rate would be monitored at four different locations (plus one duplicate at one location) to produce an average value for the entire site. It was assumed that the natural source zone attenuation rate would be monitored annually for the first 5 years after active remediation, and then biannually for the following 20 years. The natural source zone attenuation rate would be used to estimate the quantity of LNAPL remaining in inaccessible areas, and the restoration time for the site. Natural source zone attenuation monitoring methods would not involve significant ground disturbance, therefore would be feasible in most inaccessible areas.

Institutional controls would supplement active remediation performed under Source Area Alternative 1 so that the alternative is protective of human health and the environment. Environmental covenants would establish requirements for soil management, groundwater recovery or use, and building construction conducted over the source areas within the Site. The environmental covenants would address the Property and the portions of the Site located on the Port of Everett and KC properties where soil or groundwater exceeding PCLs would remain. Landowners for these properties will be consulted to obtain their consent to proposed environmental covenants on their properties as part of the DCAP. The City of Everett will also be consulted to ensure proposed environmental covenants are consistent with current and future land-use plans.

Additionally, risk management planning has been included in this alternative to mitigate potential future safety risks that Site COCs may present to workers (either public works or private contractors) conducting subsurface work within or adjacent to the inaccessible areas (Federal Avenue, former Everett Avenue, and the overpass) where COCs may remain in place. Work conducted within these areas also may result in recovery of impacted soil, impacted groundwater, or LNAPL. ExxonMobil/ADC would prepare and implement a Risk Management Plan (RMP) that would establish procedures and plans to maintain worker safety and establish protocols for proper management and disposal of media affected by LNAPL and other Site COCs in these areas. The RMP would establish a general framework for third parties performing work to mitigate risks in a manner appropriate for the specific work to be performed.

Institutional controls would be implemented to achieve the following objectives:

- Limit future use of the Property to industrial or commercial uses.
- Prohibit recovery and use of groundwater from the Site unless it is adequately treated.
- Require appropriate management of soils and groundwater recovered from the areas within the two defined Site source areas that were not excavated under this alternative. Excavated soils and groundwater from possible future subsurface construction work must be managed as waste and require treatment or disposal in accordance with solid and dangerous waste regulations.
- Require appropriate health and safety plans for any subsurface work and require appropriate training for construction workers conducting subsurface work within the two defined source areas and portions of the plume where cleanup levels are exceeded.
- Require permanent buildings constructed within the source areas to incorporate vapor barriers to limit potential migration of affected soil vapor into buildings.
- Require that soil vapor discharges not cause violations of applicable ambient air quality standards for Site COCs.

Institutional controls would also include access agreements with neighboring landowners as appropriate to allow access to and maintenance of monitoring wells included in the long-term monitoring program.

The restoration time frame for this alternative is expected to be determined by the COC degradation rate in the inaccessible areas resulting from natural source zone attenuation. The restoration time frame is estimated to be either the time required for inaccessible areas to be degraded to PCLs or the time required for residual COCs within inaccessible areas to become sufficiently degraded so that remaining Site constituents are permanently immobile (i.e., so that COCs cannot be mobilized due to induced changes in the water table or excavation at or near the impacted location). It is difficult to estimate how much time would be required to achieve this level of weathering or degradation. For this FFS, it has been assumed that it would occur within 50 years, considering that storage and transfer of petroleum and petroleum products began as early as 1920, and LNAPL is largely immobile under existing conditions.

12.1.2 Source Area Alternative 2: LNAPL Area excavation and Source Area stabilization

This alternative includes removal of soils impacted by LNAPL and/or residual LNAPL saturation within the LNAPL Areas combined with ISS for remaining accessible source area soils that exceed PCLs. The COCs remaining within the inaccessible areas would be remediated by natural source zone attenuation. The soil excavation areas in this alternative are identical to those for Alternative 1. The most highly affected portions of the source areas would be excavated, and COCs in remaining source area soils would be treated using ISS to reduce mobility under this alternative. As described for Alternative 1, there are five excavation areas with different excavation depths. The excavation depths are based on the boring logs from Site characterization, which are included in Appendix B. The excavation assumptions described for Alternative 1 in Section 12.1.1 were used for excavation design for this alternative. The remaining impacted soil within the two defined source areas would be remediated using ISS.

The areas shown on Figure 12-3 were used for conceptual design of this alternative. Additional characterization data may be collected for final design if this alternative is selected for implementation. The areas beneath and within a 1H:1V setback from the Terminal Avenue Overpass were not included for excavation under this remedial alternative due to potential structural issues for the overpass, as described in Section 12.1.1.

For conceptual design of this alternative, it was assumed that remediation activities would be conducted in the following sequence:

1 excavation of LNAPL Areas;
2. ISS of impacted soil in the source area;
3. backfilling the excavation;
4. placement of surface pavement;
5. final work area restoration; and,
6. monitoring inaccessible areas for natural source zone attenuation.

For the FFS, it was assumed that LNAPL area soil would be excavated in open excavations. Figure 12-3 shows the approximate limits of the side slope excavations used for the conceptual design and cost estimate. The conceptual design for excavation, soil disposal, groundwater management, and LNAPL recovery under this alternative is the same as described in Section 12.1.1 for Source Area Alternative 1.

During the two- to three-day period when the excavation would be open and left undisturbed, ISS of soil outside the source area excavations would occur. For conceptual design of ISS for this alternative, it was assumed that stabilization would extend to a depth of 10 feet bgs and that a stabilization recipe of 10% dry weight Portland cement and 1% dry weight bentonite mixed with the Site soils would be used. The total amount of bentonite to be added is estimated at 92 tons, and the quantity of Portland cement is estimated to be 920 tons for conceptual design of this alternative. For final design, treatability testing would be performed to determine the appropriate stabilization recipe to achieve effective stabilization and immobilization of COCs, the appropriate swell volume for Site soils, and the curing curve (for quality control purposes). It was also assumed that a specially designed, proprietary mixing head and admixture feed equipment would be used to inject and mix the amendments in situ.

Stabilization of the impacted source area soil is expected to cause soil expansion. For conceptual design, it was assumed that the stabilized soil volume would expand vertically by 3 feet, which corresponds to 1,600 CY of stabilized soil. It was assumed that any stabilized soil in excess of what is required to maintain the existing grade would be placed within the excavated LNAPL Areas, thereby reducing backfill requirements.

Following implementation and curing of soil stabilization, the excavations would be backfilled using the excess volume of stabilized soil and crushed rock. It was assumed that all of the 1,600 CY of the excess stabilized soil would be used as backfill, and 13,300 tons of imported crushed rock would be required to backfill the remaining excavation areas. Excavation backfill material, subgrade placement, and asphalt surface would be the same as described in Section 12.1.1 for Alternative 1. Areas remediated by ISS would be graded and paved as described for the excavation areas. The paved surface would also serve as a protective cap.

Inaccessible source areas would be remediated by natural source zone attenuation, as described in Section 12.1.1 for Alternative 1.

Institutional controls would supplement the active remediation performed under Source Area Alternative 2 so that the alternative is protective of human health and the environment. Environmental covenants would be used to establish requirements for soil management, groundwater recovery or use, and building construction conducted over the source areas within the Site. The environmental covenants would address the Property and the portions of the Site located on the Port of Everett and KC properties where soil or groundwater exceeding PCLs would remain, as described for Source Area Alternative 1 in Section 12.1.1. The RMP described in Section 12.1.1 for Alternative 1 would also be included in this alternative to ensure the alternative is protective of workers conducting subsurface work on the adjacent areas.

Institutional controls would be implemented to achieve the following objectives:

- Limit future use of the Property to industrial or commercial uses.
- Prohibit recovery and use of groundwater from the Site without adequate treatment.
- Require that soils and groundwater recovered from the two defined Site source areas during possible future subsurface construction would be managed as waste and require treatment or disposal in accordance with solid and dangerous waste regulations.
- Require appropriate health and safety plans for any subsurface work and require appropriate training for construction workers conducting subsurface work within the two defined source areas and portions of the plume where cleanup levels are exceeded.
- Require permanent buildings constructed within the source areas to incorporate vapor barriers to limit potential migration of affected soil vapor into buildings.
- Require soil vapor discharges not cause violations of applicable ambient air quality standards for Site COCs.

Institutional controls would also include access agreements with neighboring landowners as appropriate to allow access to and maintenance of monitoring wells included in the long-term monitoring program.

The restoration time frame for this alternative is expected to be determined by the COC degradation rate in the inaccessible areas under natural source zone attenuation. The restoration time frame is estimated to be either the time required for COCs in inaccessible areas and source areas to be degraded to PCLs or the time required for residual COCs within inaccessible areas to become sufficiently degraded so that remaining Site constituents are permanently immobile (i.e., so that COCs cannot be mobilized due to induced changes in the water table or excavation at or near the impacted location). It is expected that ISS of source area soil would inhibit and slow the natural degradation of Site COCs, potentially increasing restoration time. It is difficult to estimate how much time would be required to achieve this level of weathering or degradation. For this FFS, it has been assumed that it would occur within 50 years, considering that storage and transfer of petroleum and petroleum products began as early as 1920, and LNAPL is largely immobile under existing conditions. However, because of the uncertainty about the degree to which ISS could impede natural attenuation of stabilized COCs, a 15% contingency has been added to the operations and maintenance cost estimate for Alternative 2 versus a 10% contingency for Alternative 1.

12.1.3 Source Area Alternative 3: Source Area excavation

This alternative is similar to Alternative 1, except that soils exceeding PCLs (including LNAPL Areas) within both source areas would be excavated for off Site disposal (Figure 12-4). The depths of the excavation vary across the site and are shown on Figure 12-4. The excavation depths are based on the boring logs from Site characterization, which are presented in Appendix B. Additional characterization data may be collected for final design if this alternative is selected for implementation. The inaccessible areas are not included for excavation under this remedial alternative due to potential structural issues for existing infrastructure and access issues on public streets, as described in Section 12.1.1 for Alternative 1. Remaining COCs within inaccessible areas would be remediated by natural source zone attenuation.

For conceptual design of this alternative, it was assumed that the sequence of activities would be: excavation of the source area, backfilling the excavation, placement of surface pavement, final work area restoration, and natural source zone attenuation monitoring for inaccessible areas. It was assumed that the excavated soil would be disposed of off Site as impacted soil.

It was assumed that the excavations would be conducted as open excavations in the areas shown on Figure 12-4. To the maximum extent practicable, excavation would be performed without groundwater removal. Temporary shoring using sheet piling was assumed to allow excavation to the depths shown on Figure 12-4 and is necessary to protect the City of Everett Force Main sewer to the north, the Overpass to the east, and Federal Avenue to the west (i.e., the inaccessible areas). For excavation areas not along public rights-of-way, the perimeter of the excavation would be sloped to stabilize the side walls of the excavation. For conceptual design of this alternative, it was assumed that unshored sidewalls would be sloped at a ratio of 1:1 and that all soils excavated for side slopes would be reused as backfill. Figure 12-4 shows the approximate limits of the side-slope excavations used for conceptual design and cost estimates. For the configuration shown in Figure 12-4, it was assumed that an estimated 800 linear feet of shoring would be needed to the approximate depth of 30 feet, or approximately 24,000 vertical square feet of shoring. The temporary shoring would be removed upon completion to allow normal groundwater flow. The conceptual design for soil disposal, groundwater management, and LNAPL recovery under this alternative is the same as described in Section 12.1.1 for Source Area Alternative 1.

Based on the conceptual design for this alternative, approximately 22,400 tons of soil would be excavated for off-Site disposal. Due to the subsurface disturbances during excavation work, LNAPL may be mobilized adjacent to the excavation. Provisions would be needed for LNAPL recovery and disposal during the excavation work. Based on past experience during the interim action to the east of the Property, an estimated 1,000 gallons of LNAPL may be recovered from the source area excavation. Backfill and surface restoration would be done as described in Section 12.1.1 for Source Area Alternative 1.

Inaccessible source areas would be remediated by natural source zone attenuation as described for Alternative 1 in Section 12.1.1.

Institutional controls would supplement the active remediation performed under Source Area Alternative 3 so that the alternative is protective of human health and the environment. Environmental covenants would be used to establish requirement for groundwater recovery or use within the Site. The environmental covenants would address the Property and the portions of the Site located on Port of Everett and KC properties where soil or groundwater above cleanup levels would remain, as described in Section 12.1.1 for Source Area Alternative 1. The RMP described in Section 12.1.1 for Alternative 1 would also be included in this alternative to ensure the alternative is protective of workers conducting subsurface work on the adjacent areas.

Institutional controls would:

- Limit future use of the Property to industrial or commercial uses.
- Prohibit recovery and use of groundwater from the Site unless it is adequately treated.
- Require inspection and maintenance of the surface pavement over the source areas.

Institutional controls would also include access agreements with landowners as appropriate to access and maintain monitoring wells included in the long-term monitoring program.

The restoration time frame for this alternative is expected to be similar to Alternative 1, as discussed in Section 12.1.1.

12.2 Groundwater remediation alternatives

Two remediation alternatives for groundwater have been identified, as illustrated on Figure 12-5. Groundwater Remediation Alternative 1 could be combined with any of the source area alternatives to provide a comprehensive remedy addressing the entire Site. Groundwater Alternative 1 utilizes MNA to achieve the cleanup standard for the groundwater plume downgradient of the source areas. Groundwater Alternative 2 includes active removal of the dissolved-phase contaminants passing through a PRB in addition to MNA for remediation of the groundwater plume. The selected groundwater remediation alternative would be implemented in conjunction with the selected source area remediation alternative. A description of the two groundwater remediation alternatives is provided in Sections 12.2.1 and 12.2.2.

12.2.1 Groundwater Alternative 1: Monitored natural attenuation

Groundwater Alternative 1 incorporates MNA to address groundwater contamination within the plume downgradient of the source areas. Available data for groundwater indicate that Site COCs in groundwater are effectively attenuating under existing conditions as groundwater flows to the west, through the Port of Everett property (Section 6.4). Analytical results from three monitoring wells near the shoreline of Port Gardner Bay (MW-A5, MW-A6, and MW-A8) show that contaminant concentrations are either below the laboratory reporting limit or below cleanup levels. As discussed previously and shown on Figure 12-5, a CPOC would be established on Port of Everett property conditional on approval by the Port and Ecology. Existing monitoring well MW-A4 plus one or more new wells installed on Port of Everett property would serve as the CPOC for groundwater. The conceptual CPOC shown on Figure 12-5 is located on Port of Everett property, downgradient of the source areas.

For conceptual design of this remediation alternative, the existing monitoring well network would be supplemented with a new monitoring well north of monitoring well MW-A4. The actual number of CPOC monitoring wells will be specified in the DCAP and Engineering Design Report. As shown by the current plume extent on Figure 12-5, natural attenuation is currently reducing concentrations of Site constituents to below the PCLs upgradient of the proposed CPOC. Figure 6-21 demonstrates that concentrations of Site constituents have been trending downward over time. Figure 6-22 shows that measurements of MNA parameters suggest that active biodegradation is occurring within the source area. These findings provide additional evidence for the effectiveness of natural attenuation for remediation of the groundwater plume at the Site (Section 6-4).

In accordance with the current Ecology MNA guidance (Ecology, 2005), the conceptual monitoring program for this alternative area is designed to:

- Demonstrate that natural attenuation is occurring according to expectations.
- Verify that the plume is not expanding beyond the CPOC.
- Verify that cleanup levels are attained at the CPOC.
- Verify that there is no unacceptable impact to downgradient receptors.
- Detect any new releases of COCs that could impact the effectiveness of the natural attenuation remedy.
- Demonstrate the efficacy of institutional controls put in place to protect potential receptors.
- Verify attainment of remediation objectives.

The conceptual monitoring program for Groundwater Alternative 1 would include development of a detailed MA validation and long-term sampling work plan to describe the monitoring program. This work plan would identify the monitoring well network and monitoring analytes required for both characterization/validation sampling and long-term groundwater monitoring. Characterization/validation sampling would be used to demonstrate the effectiveness of MNA with respect to contaminant mass reduction, attenuation rates, and temporal trends. Long-term groundwater monitoring would be used after characterization/validation monitoring to confirm that the contaminant plume is progressing toward achievement of numerical cleanup goals.

For the conceptual design of Groundwater Alternative 1, it was assumed that characterization/validation sampling would consist of semiannual monitoring of seven monitoring wells for one year and that one or more new monitoring wells, screened from 5 to 15 feet bgs with a total depth of 15 feet, would be installed to monitor plume migration and groundwater quality at an off-Site CPOC located on Port of Everett property (Figure 12-5). Monitoring parameters and analytes included in the conceptual design include TPH-G, TPH-D, TPH-O, and BTEX, as well as the full suite of MNA geochemical parameters for the degradation of TPH (i.e., DO, nitrate/nitrite, orthophosphates, iron[II] oxide, sulfate, temperature, pH, specific conductance, total alkalinity, ORP, and total organic carbon). It is assumed that reporting for characterization/validation sampling would follow each semiannual monitoring event during the first year.

Groundwater monitoring would continue under Alternative 1 until monitoring results indicate that the cleanup standard for the Site has been attained. Ecology guidance documents indicate that the cleanup standard is typically considered attained if monitoring results from four consecutive quarters (i.e., one year) of monitoring data from the CPOC meet the cleanup levels. For Site groundwater monitoring, it has been assumed that the cleanup standard will have been attained when two consecutive years of monitoring results for a well are below cleanup levels. Since the Site groundwater monitoring program consists of semiannual monitoring, the cleanup standard evaluation will be based on results from four consecutive monitoring events. If four consecutive semiannual monitoring results (i.e., monitoring results for a two-year period) for a monitoring well are below the cleanup level, the well will be assumed to meet the cleanup standard and it will be removed from the monitoring program.

As requested by Ecology, a 50-year time period was used for estimating the cost for this alternative. For the purposes of the FFS, it was further assumed that long-term groundwater monitoring would follow characterization/validation sampling for an additional 20 years and include semiannual monitoring of the seven monitoring wells for TPH and a limited suite of geochemical parameters (DO, ORP, temperature, and pH) for a period of five years, followed by 15 years of annual monitoring. It was assumed that routine reporting for each monitoring event would be provided to Ecology for long-term groundwater monitoring, as is presently being done for the Site.

12.2.2 Groundwater Alternative 2: Funnel and gate

Groundwater Alternative 2 consists of a subsurface barrier wall arranged in a funnel and gate arrangement to provide active groundwater treatment along with MNA to achieve the cleanup standard. Redundant treatment with a PRB would remove COCs just downgradient of the western source area (Figure 12-5), and MNA (which is already achieving the PCLs at the CPOC under existing conditions), would further degrade Site COCs while groundwater flows to the CPOC. The funnel-and-gate approach under this alternative uses a low-permeability barrier wall as the funnel that would direct groundwater to a PRB in a gate configuration. The PRB would adsorb dissolved COCs from the groundwater as it passes through the gate. Any COCs that remain in groundwater passing the gate, as well as any COCs that are downgradient of the funnel and gate, would attenuate naturally as groundwater moves to the CPOC, as described for Groundwater Alternative 1. The funnel-and-gate configuration would be located downgradient of the source areas and would be sized to intercept the full width of the groundwater plume (Figure 12-5).

For the conceptual design used for this FFS, the low-permeability funnel would be a soil-bentonite barrier wall constructed using the slurry wall technique, as described in Section 11.5. An estimated 300 linear feet of barrier extending to a depth of 15 feet would be constructed, resulting in about 4,500 vertical square feet of impermeable barrier. The conceptual design considered for the gate would be a perforated concrete vault, approximately 20 feet long and 15 feet deep, that would hold the sorbent medium (Figure 12-5). The medium selected for the conceptual design is granular activated carbon (GAC), but other media, such as a sorbent clay, may be considered during final design if this alternative is selected for implementation. The conceptual layout is shown in Figure 12 5; the final design and layout would likely differ from that used for this FFS.

In order to avoid groundwater mounding upgradient of the funnel and gate and to help redistribute flow downgradient of the gate, two high-porosity trenches would be installed along both the upgradient and downgradient sides of the barrier wall funnel. These trenches would be backfilled with coarse rock and fitted with perforated piping to facilitate groundwater flow. A total of 600 linear feet of trench would be needed to avoid mounding, based on the conceptual design assumptions. Construction of the funnel and gate, including the collection and distribution trenches, would generate approximately 400 CY (650 tons) of excavated soil; for conceptual design, it has been assumed that excavated soil would require off-Site disposal in a solid waste landfill.

The gate would be a permeable barrier constructed of a perforated concrete vault containing a material that would absorb TPH and other Site COCs. As noted above, GAC was selected as the sorptive medium for the FFS. The quantity of GAC included for this alternative was based on the estimated mass of COCs in groundwater, which was based on groundwater monitoring data. It was assumed that this quantity of GAC would be sufficient to last several years, but it was not expected to last until the Site was restored. Monitoring would be performed to assess the effectiveness of the adsorbent. It was further assumed that the sorptive medium would be maintained as needed (including periodic replacement) to achieve cleanup objectives if this alternative is chosen. For estimating the cost of this alternative, it was assumed that the media would be replaced in years 6, 15, and 30. The approximate location and preliminary, conceptual alignment of the system is shown on Figure 12-5. The funnel-and-gate system is expected to substantially remove dissolved COCs passing through the gate and to decrease the mass of contaminants that must attenuate to achieve the cleanup standard for Site groundwater.

In order to evaluate the performance of the funnel and gate, the removal of dissolved COCs from the groundwater, and the effectiveness of MNA in achieving the cleanup standard, a groundwater monitoring program would be implemented. The groundwater monitoring program for this alternative is the same as the monitoring program described in section 12.2.1 for Groundwater Alternative 1 and was assumed to continue through the assumed restoration time of 50 years. This program would also be implemented in the same way that was described for Groundwater Alternative 1.

13.0 Evaluation of alternatives

The MTCA regulations in WAC 173-340-350(8) provide general requirements for completing feasibility studies to select a preferred remediation alternative for the Site. In order for a cleanup action to be selected under MTCA, WAC 173-340-360 specifies that the cleanup action must meet the following requirements:

1. Protect human health and the environment.
2. Comply with cleanup standards.
3. Comply with applicable state and federal laws and regulations.
4. Provide for compliance monitoring.
5. Prevent or minimize present and future releases of hazardous substances.
6. Rely primarily on a method other than dilution and/or dispersion to achieve the cleanup standard.
7. Use permanent solutions to the maximum extent practicable.
8. Provide a reasonable restoration time frame.
9. Consider public concerns.

The remediation alternatives described in Section 12 have been designed to meet the minimum requirements noted above by combining one of the source area alternatives with one of the groundwater alternatives. The remediation alternatives selected for the Site also will incorporate institutional controls as outlined in Section 12, as it is infeasible to permanently remove all affected soil and groundwater for this Site.

The source area alternatives will be evaluated separately from the groundwater alternatives. The evaluation will identify the best-performing source area alternative and the best-performing groundwater alternative. In the DCAP, the source area and groundwater alternatives will be combined to comprehensively address Site cleanup and achieve cleanup objectives. Each group of alternatives will be evaluated against the criteria specified in WAC 173-340-360(3)(f)—protectiveness, permanence, cost, long-term effectiveness, management of short-term risks, technical and administrative implementability, public concerns, and restoration time frame. In addition, the alternatives will be evaluated against sustainability concerns to assess the life-cycle impact of the alternative on the global ecology.

13.1 Source area alternatives

The comparison of remediation alternatives for the source areas is presented in Table 13-1 and summarized below. Ratings from 1 to 10 were used for this evaluation, with 10 being exceptional and 1 being very low. Thus, a rating of 10 indicates that an alternative fully achieves the criterion, a rating of 5 indicates that the alternative partially achieves the criterion, and a rating of 1 indicates that the alternative does not significantly address the criterion.

In general, the remediation alternative with the overall highest rating for all evaluation criteria and considering disproportionate costs, after review and approval by Ecology, will be selected as the preferred alternative in the DCAP.

13.1.1 Protectiveness

Protectiveness is gauged primarily on the level of risk reduction achieved by the alternative and the time required for the alternative to achieve risk reduction objectives and the cleanup standard. LNAPL at the Site is essentially immobile under existing conditions and it appears to have degraded significantly under normal Site conditions. The limited extent of the downgradient plume also indicates that there is limited existing risk associated with continued releases to groundwater. Protectiveness for all three alternatives would be affected by Site constituents remaining in the inaccessible areas; however, all three alternatives remove all accessible soil contaminated with LNAPL or residual LNAPL saturation. As shown in Table 13-1, Alternatives 1 and 2 were assigned a rating of 8 for protectiveness and Alternative 3 was assigned a slightly higher rating of 9. Protectiveness is similar for all three alternatives as similar quantities of LNAPL would be removed.

13.1.2 Permanence

Permanence refers to the ability to reduce the toxicity, mobility, or volume of hazardous substances at a site, including the permanent destruction of hazardous substances. None of the three alternatives would result in permanent destruction of all Site COCs. None of the source removal alternatives would actively remove COCs from the inaccessible areas. For these reasons, the definition of *permanence* used in the rating of the three alternatives is the reduction in toxicity, mobility, or volume of hazardous substances in those areas that are technically feasible to actively remediate. Site COCs remaining are expected to be remediated by natural source zone attenuation, which would provide additional COC degradation and toxicity reduction. All three alternatives would remove accessible soils contaminated with LNAPL or residual LNAPL saturation and were therefore rated similarly. Alternative 3 relocates the greatest quantity of Site COCs and was assigned a rating of 9. Alternatives 1 and 2 relocate the same quantity of affected Site soil. For Alternative 2, the stabilized source area soils remaining after remediation would be somewhat less appropriate for natural source zone attenuation than the undisturbed soils remaining under Alternative 1. In addition, the stabilized source area soils remaining after stabilization would still contain residual COCs and would need to be managed appropriately if they were later excavated, such as for utility work or property redevelopment. Because the volume of soil remaining in the source areas is significantly smaller than the volume of soil in the inaccessible source area, any difference in permanence between Alternatives 1 and 2 would likely be negligible. Therefore, a rating of 8 was assigned to both Alternative 1 and Alternative 2.

13.1.3 Cost

The cost evaluation addresses estimated costs related to implementation of an alternative, including costs for design and construction, operation and maintenance, monitoring, and reporting. The costs for operation, maintenance, monitoring, and reporting are recurring annual costs that will occur in the future. As requested by Ecology, it has been assumed that these costs would be incurred for a period of 50 years for each alternative. The cost estimates for the three source area alternatives, based on the conceptual designs described in Section 12, are presented in Table 13-2 and include the local sales tax of 9.7%, a 10–15% contingency for construction, and a 10% contingency for long-term monitoring/maintenance. Alternative 2 was given a 15% construction contingency because Site-specific pilot testing has not been completed and a 15% contingency for operation and maintenance costs due to the uncertainty regarding the degree to which ISS could impede natural attenuation of stabilized COCs. If the restoration time frame was extended significantly, costs for Alternative 2 could be higher.

The total estimated cost for implementation and long-term monitoring and maintenance for Alternatives 1 through 3 are approximately $6.5, $8.0, and $8.2 million, respectively. Annual monitoring and maintenance costs are similar for each alternative. The implementation and long-term operation and maintenance costs were used to estimate the net present value (NPV) of the costs over a 50-year period for each alternative. The net discount rate used for the NPV calculations was 1.6% and was taken from the federal Office of Management and Budget Circular A-94 that was updated in November 2017. The 50-year NPV estimated for Alternatives 1 through 3 are $6.1, $7.6, and $7.8 million, respectively. The NPV costs were used for rating and comparing the alternatives.

All three alternatives would have significant costs and leave the same extent of impacted media in the inaccessible areas. As shown in Table 13-1, Alternative 1 was rated highest, with an assigned cost rating of 9, and Alternative 3 was rated lowest, with a cost rating of 4. Alternative 2, with intermediate cost, was assigned a rating of 5.

13.1.4 Long-term effectiveness

Long-term effectiveness assesses the degree of certainty and reliability of the alternative and whether treatment residue remains from implementation of the alternative that would require ongoing management. All three alternatives remove accessible soils contaminated with LNAPL or residual LNAPL saturation, therefore were rated similarly. As shown in Table 13-1, Alternative 3 was rated 8, and Alternatives 1 and 2 were rated 7. All three alternatives would require long-term, active management of affected soil and groundwater due to the inability to actively remediate the inaccessible areas. Alternatives 1 through 3 would all require the same long-term response plans and institutional controls to address affected media in the inaccessible areas. Alternative 3 was rated the highest because slightly more contaminated material would be removed from the site. Alternatives 1 and 2 were both rated 7, as stabilization of source area soils included in Alternative 2 is expected to hinder bioremediation and therefore provides little benefit compared to Alternative 1.

For all three alternatives, affected soil and groundwater would remain in the inaccessible areas for an extended period of time. These COCs would be remediated by natural source zone attenuation. None of the alternatives would appreciably decrease existing Site risks, as they would result in only partial remediation of affected Site media at the time of implementation.

13.1.5 Management of short-term risks

Short-term risks are the risks to human health and the environment during implementation of the alternative. Alternatives with more invasive construction or transportation requirements would inherently have greater short-term risks. As shown in Table 13-1, all three alternatives would have substantial short-term risks due to soil excavation, stockpiling, and off-site shipment of affected soil. All three alternatives have potential to mobilize LNAPL during implementation, thereby increasing the potential for worker exposure; this potential risk is somewhat greater for Alternative 3, as the excavation is more extensive. While the excavation for Alternative 2 is less extensive, ISS is included and would result in additional short-term risks associated with implementing two different remedial techniques. Construction for Alternative 2 would require two separate construction mobilizations with different personnel and equipment. Well-established measures, such as Site-specific training, implementation of safe work practice protocols, and standard protocols for work on hazardous waste operations and emergency response sites, would be implemented to mitigate the short-term risks associated with implementation of the selected alternative. For these reasons, Alternative 1 was rated highest (8) because it would require the lowest level of invasive construction work. Alternatives 2 and 3 were assigned a rating of 4 because they are considered roughly equivalent for short term risks, with Alternative 3 requiring a larger excavation area and Alternative 2 requiring two different remediation techniques, two separate mobilization events, and two sets of construction equipment.

13.1.6 Technical and administrative implementability

This criterion is based on whether implementation of the alternative is technically possible to implement relative to its complexity, administrative/regulatory requirements, size, access, and integration with existing Site conditions. Removal of LNAPL from inaccessible areas (the Terminal Avenue Overpass, Federal Avenue, and former Everett Avenue) would require removal of permanent structures and numerous utilities and is impracticable for all three alternatives. It is expected that inaccessible COCs would be remediated by natural degradation processes. All three alternatives would include fairly complex

RMP agreements to establish risk mitigation procedures with the City of Everett, Port of Everett, and BNSF property owners to address worker safety and proper management of affected groundwater and/or soil during future subsurface construction or dewatering activities that may occur within currently inaccessible areas of the Site. Similar access agreements and permits are required for all three alternatives. All three alternatives would require open excavations in wet soils, which are inherently challenging to implement, particularly due to the existing surrounding features that must be protected. The remediation technologies used in the three alternatives are proven, and the alternatives are considered implementable. Therefore, all three alternatives were assigned ratings above 5.

Alternative 3 requires a greater excavation area than Alternative 1; therefore, it was rated lower. While Alternative 2 would have the same excavation area as Alternative 1, ISS would require a second construction mobilization with different remediation equipment, thereby adding considerable complexity to the remediation; therefore, Alternative 2 was rated lower. Site-specific pilot testing required for Alternative 2 has not yet been completed, therefore it was rated the lowest. Implementing the excavations for all three alternatives (which would require temporary shoring) without affecting improvements on adjacent properties or on properties owned and operated by others also increases the complexity involved in obtaining access agreements and permits. For these reasons, Alternative 1 was rated highest (9), Alternative 2 was rated 4, and Alternative 3 was rated 6.

13.1.7 Public concerns

Public concerns are potential community concerns with design and implementation of the remediation alternative. All three alternatives would likely be accepted by the general public and other property owners. All three alternatives would leave the same extent of impacted soil in place within the inaccessible areas, where active remediation is infeasible for all three alternatives. Alternatives 2 and 3 would require greater amounts of construction-related traffic, and therefore were rated lower than Alternative 1. The Port of Everett has also indicated that ISS would likely not be permitted on port property. Therefore Alternative 2 was assigned the lowest rating (4). Alternative 1 was rated 8 and Alternative 3 was rated 7.

13.1.8 Restoration time frame

The restoration time frame assesses the time required to complete remediation and involves the practicability of achieving more rapid Site restoration, with consideration given to a number of factors, including Site risks, Site use and potential use, effectiveness and reliability of institutional controls, and toxicity of hazardous substances present. Together, these factors assess the effectiveness of the alternative, the timely reduction of risk, and achieving cleanup goals. The restoration time for the inaccessible Site areas where constituents are present is similar for all of the alternatives. Alternative 2 was rated slightly lower because ISS is expected to hinder the natural attenuation of remaining source area COCs. Alternatives 1 and 3 were rated 7 and Alternative 2 was rated 6.

13.1.9 Sustainability

Sustainability considers the life-cycle impacts of the alternative on the global environment: alternatives requiring more energy, more manufactured materials, more transportation, or more active operations would be considered less sustainable than alternatives using lesser amounts. This criterion is not cited in the MTCA regulations, but it is considered appropriate for evaluating long-term remediation alternatives. As noted in Table 13-1, Alternative 1 was rated highest for this criterion because it has the least extensive construction and transportation requirements. Alternatives 2 and 3 would require greater construction and transportation work than Alternative 1. Alternative 3 would require more waste transportation and utilize more landfill capacity than Alternatives 1 and 2, and was therefore rated lower. For these reasons, Alternative 1 was rated 8, Alternative 2 was rated 6, and Alternative 3 was rated 4.

13.1.10 Source area alternatives evaluation summary

The evaluation discussed above for the source area remediation alternatives is summarized in Table 13-1. Based on the individual criterion ratings assigned to the three alternatives, the ratings total, which is the sum of individual ratings, is shown at the bottom of Table 13-1. Comparison of the ratings totals shows that Source Area Alternative 1, LNAPL Area Excavation and Natural Source Zone Attenuation, was the highest rated source area remediation alternative. Alternative 2, LNAPL Area Excavation and Source Area Stabilization, had the lowest total rating.

13.2 Groundwater alternatives

The two groundwater remediation alternatives described in Section 12 are evaluated against the same criteria used for evaluating the source area alternatives above. The evaluation criteria cited in the MTCA regulations are considered in addition to sustainability. The ratings are summarized in Table 13-3 and discussed below.

13.2.1 Protectiveness

Protectiveness is gauged primarily on the level of risk reduction achieved by the alternative and the time required for the alternative to achieve risk reduction objectives and the cleanup standard. Both alternatives are considered highly protective of the environment. Groundwater Alternative 2 offers a slightly lower degree of protectiveness than Alternative 1 because it includes an engineered component to remove dissolved COCs from groundwater. However, dissolved COCs in groundwater are already below PCLs at the proposed CPOC. Because Alternative 2 could decrease the effectiveness of natural attenuation processes by removing substrate from groundwater and inaccessible areas and would require long-term maintenance of engineered components, it is rated 7 for this criterion, while Alternative 1 is rated 8.

13.2.2 Permanence

Permanence refers to the ability to reduce the toxicity, mobility, or volume of hazardous substances at a site, including the permanent destruction of hazardous substances. Both groundwater alternatives would significantly reduce the toxicity of Site COCs and either permanently destroy COCs through biodegradation or immobilize them through adsorption to the PRB media. However, Alternative 2 relies on active operation and maintenance for effectiveness; thus, it is rated 7 for this criterion, while Alternative 1 is rated 9.

13.2.3 Cost

The cost evaluation considers the estimated costs related to implementation of an alternative, including costs for initial design and construction, operation and maintenance, monitoring, and reporting. The estimated costs for the two alternatives, based on the conceptual designs discussed in Section 12, are presented in Table 13-4. The cost estimate assumes one new additional monitoring well will be installed. The actual number of new monitoring wells will be specified in the DCAP and Engineering Design Report. As noted above, the NPV of the long-term implementation and monitoring costs were used for cost evaluation. The NPV calculations for the groundwater alternatives were done using the same assumptions and evaluation time discussed in Section 13.1.3 for the source area alternatives. The two groundwater alternatives would have similar long-term monitoring costs, as noted in Table 13-4. The total estimated cost for Alternative 2 ($2.1 million) is more than three times the total estimated cost of Alternative 1 ($0.6 million). The 50-year NPV cost for Alternative 2 is about $2.0 million, which is over three times the NPV cost for Alternative 1. Due to this substantial difference in cost estimates and since PCLs are currently being met at the anticipated CPOC location, Alternative 1 was assigned a cost rating of 9 while Alternative 2 was assigned a rating of 4.

13.2.4 Long-term effectiveness

Long-term effectiveness consists of the degree of certainty and reliability of the alternative and whether treatment residue remains from implementation of the alternative that would require management. Both alternatives incorporate natural attenuation, which has been active at the Site and is currently achieving PCLs at the anticipated CPOC location. As natural attenuation is a passive remediation technology that relies totally on indigenous, natural processes that include biodegradation, the two groundwater alternatives are expected to be effective for as long as COCs are present. Because active maintenance would be required to maintain effectiveness of sorbent media in the PRB under Alternative 2, and because the PRB may affect intrinsic biodegradation downgradient of the funnel and gate due to altering the substrate composition in that area, Alternative 2 was rated 6, lower than Alternative 1, which was rated 9.

13.2.5 Management of short-term risks

Short-term risks are the risks to human health and the environment during implementation of the alternative. Alternatives with more invasive construction or transportation requirements would inherently have greater short-term risks. Alternative 2 has higher risk associated with implementation due to the intrusive work needed to install the funnel and gate system and for off-Site transportation and disposal of soil and groundwater removed from the excavations. Conventional construction methods would be used, short-term construction risks can be effectively managed, and thus a rating of 6 was assigned to Alternative 2. Alternative 1 has only minimal subsurface construction (i.e., monitoring well installation) and, therefore, has minimal short-term risks and was assigned a higher rating of 9.

13.2.6 Technical and administrative implementability

This criterion is based on whether implementation of the alternative is technically possible relative to complexity, administrative/regulatory requirements, size, access, and integration with existing Site conditions. Both alternatives are technically implementable; however, Alternative 1 would be much simpler to implement due to the substantially smaller construction requirements. However, it would be necessary to work with the Port of Everett to maintain groundwater monitoring wells over the long term and to locate the CPOC on their property. In addition to the considerations for Alternative 1, Alternative 2 would require extensive construction on property owned by the Port of Everett and leased to Vigor Marine. Negotiations and contractual conditions for installation of Alternative 2 would be more complicated than those for Alternative 1. Access agreements have been established previously with both the Port and Vigor Marine for installation and sampling of monitoring wells. Due to the large difference in implementability considerations, Alternative 1 was given a rating of 8 while Alternative 2 was given a rating of 5.

13.2.7 Public concerns

Public concerns are potential community concerns with design and implementation of the alternative. As noted in Table 13-3, both groundwater remediation alternatives are considered to be equally acceptable to the public. Both are considered to be readily accepted by the public, and each alternative was given a rating of 7.

13.2.8 Restoration time frame

The restoration time frame involves capability of achieving Site remediation and the practicability of achieving more rapid Site restoration, with consideration given to a number of factors, including Site risks, Site use and potential use, availability of alternative water supply, effectiveness and reliability of institutional controls, and toxicity of hazardous substances present at the Site. Together, these factors are a measure of the urgency of reducing risk and achieving cleanup goals. As previously noted, groundwater located on the Port of Everett property, where the anticipated CPOC will be located, is currently below the PCLs for the Site. As shown in Table 13-3, both alternatives were assigned a rating of 9.

13.2.9 Sustainability

Sustainability considers the life-cycle impacts of the alternative on the global environment; alternatives requiring more energy, more manufactured materials, more transportation, or more active operations would be considered less sustainable than alternatives using lesser amounts. Both remediation alternatives for groundwater are considered sustainable. Alternative 1 relies totally on a passive technology that involves indigenous, natural processes, and was assigned a higher rating of 9 for sustainability than Alternative 2, which was assigned a rating of 6. The PRB requires active monitoring and maintenance to assure effectiveness. Construction of the funnel and gate would generate a significant amount of waste that would require off-Site transportation and disposal. Additional waste generation may occur in the future under Alternative 2 due to maintenance of the PRB.

13.2.10 Groundwater alternatives evaluation summary

The evaluation of the groundwater remediation alternatives is presented in Table 13-3 and discussed above. Based on the ratings assigned to the individual evaluation criteria, the ratings total, which is the sum of individual ratings, is shown at the bottom of Table 13-3. The ratings total for Alternative 1 is substantially higher than the rating total for Alternative 2.

14.0 Preferred alternative

This section identifies and describes the preferred remediation alternative. The evaluation presented in Section 13 provides the basis for selecting the preferred approach for remediating the Site. The preferred source area alternative and the preferred groundwater alternative will be combined as the comprehensive Site remedy.

In accordance with MTCA requirements, pursuant to WAC 173-340-360 (3)(e)(ii)(A-C), a disproportionate cost analysis is also presented to support selection of the preferred Site remedy. The disproportionate cost analysis is used to compare the cost and total benefits of higher cost alternatives to those of lower cost alternatives. Costs are disproportionate to benefits if the incremental costs of the higher cost alternative exceed the benefits. A direct comparison of the ratio of the cost to the benefits may be made to select a preferred alternative. All alternatives were given a total rating score in Section 13 (Tables 13-1 and 13-3), which summarizes the overall benefit of each alternative. These ratings were then used to assign an overall benefit score for each alternative. The overall benefit score is the sum of the rating scores for all criteria except cost. A unit cost per benefit is then provided by taking the NPV cost estimated for the conceptual-level design described in this FFS and dividing it by the overall benefit score of each alternative. This unit cost per benefit for each alternative may then be used to directly compare the cost/benefit for all the alternatives. Results of the disproportionate cost analysis are summarized in Table 14-1.

14.1 Source Area remediation alternative

The three source area remediation alternatives are compared in Table 14-1. The three alternatives are similar in that they all incorporate institutional controls, and they all leave some affected soil in place, either within the two defined source areas or in the inaccessible areas. The three alternatives provide equally for long-term degradation of LNAPL and Site COCs from inaccessible areas. All three alternatives include removal and off-site disposal of affected soil from the source areas and a risk management plan to address affected media remaining within the inaccessible area.

In Table 14-1, the overall benefit for each alternative is quantified as the total of the ratings presented in Table 13-1 for all criteria except cost. The maximum possible overall benefit for each alternative is 80. Alternative 1 had the highest overall benefit score of 63, followed by Alternative 3 which had a benefit score of 54. Alternative 2 had the lowest overall benefit rating of 47.

Alternative 3 was rated highest for permanence, as shown in Table 14-1. However, Alternative 3 was rated only slightly better than Alternatives 1 and 2 for permanence. The estimated NPV costs for the three alternatives are shown on Table 14-1. Alternative 1 has the lowest estimated NPV cost of $6.1 million. The highest cost alternative is Alternative 3, which is approximately 27% higher than the cost for Alternative 1. The estimated NPV cost of Alternative 2 is $7.6 million, which is about 24% more than the NPV cost of Alternative 1.

The cost-to-benefit ratios are calculated by dividing the estimated NPV cost by the overall benefit score; the calculated ratios are summarized in Table 14-1. The alternative with the lowest cost-to-benefit ratio is preferred, as it provides the greatest benefit for the given expenditure. As shown in Table 14-1, Alternative 1, LNAPL Area Excavation and Natural Source Zone Attenuation, has the lowest cost-to-benefit ratio and would provide the most benefit per dollar spent on remediation. The overall benefit rating for Alternative 1 was also slightly higher than for the other two alternatives.

Alternative 1 has a cost-to-benefit ratio of $98,000. The most permanent alternative (Alternative 3) has the second highest cost to benefit ratio of $145,000. While Alternative 3 has the highest permanence, the permanence rating for Alternative 1 is only slightly lower. The 48% increase in cost to benefit associated with Alternative 3 compared to Alternative 1 is disproportionate to its slight improvement in permanence. The cost/benefit ratio for Alternative 2, the lowest rated alternative for overall benefit, also had the lowest cost-to-benefit ratio of $162,000, about 65% higher than Alternative 1. All three alternatives would incorporate similar institutional controls for long-term management of potential Site risks.

The results summarized in Table 14-1 indicate that Alternative 1 will provide the largest overall benefit for the lowest cost. While Alternative 1 is not the highest rated for protectiveness, permanence, and long-term effectiveness, its ratings are only slightly lower than those of Alternative 3, which had the highest ratings for these criteria.

As a result of the disproportionate cost evaluation described above and summarized in Table 14-1, the preferred source area remediation alternative is Alternative 1: LNAPL Area Excavation and Natural Source Zone Attenuation. This alternative meets the RAOs and the ARARs and has the highest rating for overall benefit (Table 14-1). The disproportionate cost evaluation considered the ratings for all evaluation criteria addressed in Section 13. Alternative 1 would provide the greatest benefit relative to the cost, would result in highly manageable short-term risks, and would use essentially the same approach as the other three alternatives for long-term management of residual impacted soil remaining at the Site. The substantially increased cost of Alternatives 2 and 3 compared to Alternative 1 that would be incurred to stabilize or remove impacted soils beyond the LNAPL/saturated areas within the source areas on the Property is not warranted given the significant extent of LNAPL and impacted soils that would remain in inaccessible areas. Alternative 1 would also be readily implementable with local contractors and was rated as the most sustainable alternative. Groundwater is currently below the PCLs at the anticipated CPOC located downgradient of the two defined source areas, indicating that Site groundwater poses low risk to human health and the environment and that the source area material removal or stabilization provided by the other source area alternatives would provide minimal additional benefit at substantially higher cost.

Under current conditions, subsurface contamination in the two defined source areas on the ADC/ExxonMobil properties and on the Port of Everett property is old, weathered, and, if left undisturbed, immobile. Under existing conditions, soil contamination is essentially limited to the areas where historic operations occurred and to which it migrated when it was unweathered. The contamination is effectively contained beneath the existing surface pavement cover on the Property, adjacent streets, or adjacent industrial properties. Alternative 1 would provide further protection by removal of the most highly contaminated soils located on ExxonMobil/ADC property and on Port of Everett property. It is expected that remaining Site COCs would be continually degraded by natural source zone attenuation processes.

Costs have been included in Alternative 1 to continue monitoring for LNAPL, to ensure an appropriate RMP is developed and implemented, and to maintain surface pavement cover as part of the preferred remedy. Costs have also been included to monitor the effectiveness of natural source zone attenuation. Environmental covenants would also be recorded on the Property to require that future development projects would appropriately manage affected soil and groundwater that may be encountered and provide adequate protection of indoor air quality. Environmental covenants would be established for the portions of the Site that are owned by other parties (i.e., the City of Everett, Port of Everett, and BNSF). These parties would be consulted to obtain their consent to proposed environmental covenants on their properties. The City of Everett would also be consulted so that proposed environmental covenants are consistent with current and future land-use plans.

As described in Section 12, Alternative 1 includes an RMP to address work that may be performed within the inaccessible areas where affected soil and groundwater would remain after implementing the preferred alternative. The RMP would ensure that risks to workers and the public are mitigated during work affecting the inaccessible areas, and also would ensure that any affected soil, affected groundwater, or LNAPL recovered from the inaccessible areas would be properly managed.

The evaluation presented in this FFS indicates that Source Area Alternative 1 is the preferred remediation alternative for the Site source areas.

14.2 Groundwater remediation alternative

The groundwater remediation alternatives are also compared in Table 14-1. The overall benefit and cost were compared to calculate a cost to benefit ratio in a similar manner as described in Section 14.1 for source area alternatives. Groundwater Remediation Alternatives 1 and 2 both provide permanence, as both remove and/or destroy contaminants present in groundwater, although Alternative 1 is rated somewhat higher since it does not require active maintenance to retain its effectiveness. Under existing conditions, groundwater downgradient of the western source area, located on Port of Everett property, is below the PCLs; Alternative 1 would maintain existing conditions in the downgradient groundwater plume. Directly comparing the benefits of the two alternatives indicates that Alternative 1 would achieve greater overall benefit than Alternative 2, primarily due to its ease of implementation, better sustainability, and lower short-term risks. The NPV cost for Alternative 2 is also about 4 times the NPV cost of Alternative 1, which results in a cost-to-benefit ratio for Alternative 2 that is nearly 4.8 times the ratio for Alternative 1 (Table 14-1). Also, Alternative 1 does not rely on engineering controls and long-term operations that are included in Alternative 2. Alternative 1 would not generate waste for disposal in a commercial landfill, whereas Alternative 2 would require off-Site disposal of soils with low levels of contamination from remedy construction and generate spent sorbent in the future.

The evaluation presented in this SC-FFS indicates that Groundwater Remediation Alternative 1 is the preferred approach to remediate Site groundwater.

14.3 Preferred comprehensive site remedy

The comprehensive Site remedy identified by this FFS combines Source Area Alternative 1 with Groundwater Remediation Alternative 1.

The comprehensive Site remedy would consist of the following elements:

- excavation and landfill disposal of the most highly affected soil within the two source areas located on ExxonMobil/ADC property and on Port of Everett property;
- natural source zone attenuation to remediate COCs remaining in the source areas and inaccessible areas, including a monitoring program to assess the effectiveness of the remedy;
- a groundwater monitoring program to assess potential LNAPL mobility in the vicinity of the inaccessible areas and to assess groundwater quality downgradient of the source areas, including Port of Everett property;
- MNA to continue to degrade groundwater COCs upgradient of the anticipated CPOC, which would be located on Port of Everett property, downgradient of the source areas, and in the vicinity of existing downgradient monitoring wells;
- risk management planning by ExxonMobil/ADC with the City of Everett, Port of Everett, and BNSF property owners to address worker safety and management of LNAPL, affected soil, and/or affected groundwater resulting from potential future work within inaccessible areas on or near Federal Avenue, former Everett Avenue, and/or the overpass; and
- environmental covenant(s) to require that affected groundwater, soil, and/or soil vapor that may potentially be exposed during future construction is properly managed in accordance with MTCA and the solid and dangerous waste regulations.

The source area component of the Site remedy, which is based on Source Area Alternative 1, would remove the most highly affected soil and provide long-term management of both the source areas and the inaccessible areas. The conceptual excavation areas shown in Figure 12-2 represent accessible areas where potentially mobile LNAPL may be present based on historical observation of LPH in wells or TPH levels that exceeded residual saturation concentrations during several decades of environmental investigations and interim remedial activities at the Site. These areas would be used to guide excavation, with the objective to remove accessible soils containing LNAPL or hydrocarbon concentrations above residual saturation. Performance samples for soil remediation will be collected from the base of the excavation and from accessible sidewalls (i.e., sidewalls where sheet piling does not block access to the sidewall) to confirm removal of soils containing LNAPL. Accessible sidewall soil samples will be collected after the planned extent of excavation has been reached and field screening indicates that LNAPL or residually saturated soils are not present. If samples taken from the accessible sidewalls or the base of the excavation exceed remediation levels based on the residual saturation concentrations described below, additional excavation will be conducted, and the sidewall or excavation base will be resampled to confirm removal of soils containing LNAPL.

Remediation levels for LNAPL will be based on residual saturation concentrations. In the absence of site-specific data, LNAPL will be assumed to be present when TPH concentrations exceed the following lower limits of the residual saturation concentrations for each hydrocarbon class:

- TPH-D: 4,800 mg/kg.
- TPH-O: 5,810 mg/kg.
- TPH-G: 2,470 mg/kg.

These values may be reevaluated if site-specific data are collected during preparation of the DCAP and the Engineering Design Report. Any revisions to these values along with supporting site-specific data and analysis would be presented in the DCAP and the Engineering Design Report. Further details on soil sampling and soil management will be developed as part of the DCAP and the Engineering Design Report.

Groundwater will be managed as described in Section 12.1.1, and a detailed groundwater management plan will be presented in the DCAP.

Remaining Site COCs in source areas and inaccessible areas would be remediated by natural source zone attenuation. The groundwater component of the Site remedy, which is based on Groundwater Alternative 1, would rely on MNA to continue to degrade groundwater COCs in the plume that is downgradient of the source areas and the inaccessible portions of the Site. It is expected that a CPOC would be established on the Port of Everett property west of Federal Avenue in the vicinity of existing groundwater monitoring wells; this location is necessary due to the source area located west of Federal Avenue. Groundwater monitoring data collected in the vicinity of the anticipated CPOC indicate that natural attenuation has achieved the PCLs described in this FFS. The number of CPOC monitoring wells will be specified in the DCAP and Engineering Design Report.

The comprehensive Site remedy would provide an appropriate remedy for the Site, where releases occurred decades ago and are highly weathered and immobile. Institutional controls would ensure that Site workers would be protected, and that future use of the ExxonMobil/ADC properties are limited to industrial use. An environmental covenant would be in place to ensure that any future exposure of affected groundwater and/or soil will be handled in accordance with appropriate solid and dangerous waste regulations. In addition, the Risk Management Plan described in Section 12.1.1 would establish procedures and plans to manage worker safety and establish protocols for proper management and disposal of soil and water if exposed in the future (e.g., future utility maintenance or development activities).

It is expected that natural attenuation, in combination with the source area remediation by excavation and natural source zone attenuation, would continue to achieve groundwater cleanup levels well upgradient of the shoreline.

In accordance with WAC 173-340-410, the comprehensive Site remedy will include monitoring to verify the protectiveness of the remediation and to assess the effectiveness of natural source zone attenuation at achieving the required cleanup levels for soil and groundwater set forth in Tables 5-1 and 5-2, respectively. The details of the confirmation monitoring program will be included in the DCAP and Engineering Design Report and will include regularly scheduled collection of groundwater samples at the CPOC and designated Site monitoring wells, inspections of the Site cap, and collection of soil samples in areas where COCs remain above cleanup levels.

The total estimated NPV cost for the preferred Site remedy would be approximately $6.7 million, which includes the cost for 50 years of monitoring and maintenance. This remedy would comprehensively address Site contamination and continue to limit migration of Site COCs via intrinsic biodegradation. The comprehensive Site remedy is sustainable and relies primarily upon noninvasive and natural remediation techniques after initial construction has been completed. Due to the presence of affected soil and groundwater within the inaccessible areas, COCs will be present at the Site for a significant time.

15.0 References

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Tables

TABLE 3-1: CHRONOLOGY OF HISTORICAL ON-SITE ENVIRONMENTAL INVESTIGATIONS

ExxonMobil/ADC Property, Ecology Site ID 2728, Everett, Washington

Date	Consultant	Location	Reference	Activities	Tasks Performed	Notes
May-85	RZA	ExxonMobil Parcel	RZA 1985	Borings, monitoring well installation	2-inch-diameter monitoring wells B-1 through B-5 (MW-1 through MW-5 in several reports) installed.	B-1, B-2, B-4, and B-5: Petroleum odor noticed in borings; evidence found of contamination below groundwater table.
Mar-88	RZA	ExxonMobil Parcel	AMEC E&E 2010a	Borings, monitoring well installation	2-inch-diameter monitoring wells MW-6 through MW-18 installed.	Soil and groundwater samples collected. LPH (1.29 feet) measured in MW-14.
Jan-90	ESE	ADC Parcel	AMEC E&E 2010a	Borings	Hand augers AD-01 through AD-19 to depths ranging from 1 to 4.5 feet.	Soil samples collected.
Feb-90	ESE	ADC Parcel	AMEC E&E 2010a	Borings, monitoring well installation	HSA borings W-1 through W-7. 2-inch-diameter monitoring wells W-1 through W-6 installed.	W-7 was backfilled.
Jun-90	ESE	ADC Parcel	AMEC E&E 2010a	Hand-auger borings	Hand-auger borings W-8 through W-17 to depths of 6–10 feet.	No soil data found for W-8 through W-17. Gauging data indicate that free product was observed in 10 of the 17 monitoring wells located at and around the ADC Parcel.
Oct-90	RZA	ExxonMobil Parcel	AMEC E&E 2010a	Shallow grid soil sampling, bio-feasibility study	Hand augers B-1 through B-25. Two soil samples were studied to conduct a slurry flask bio-feasibility study.	0-3 feet bgs. Rapid biodegradation of TPH-G fraction was observed. Biodegradation of TPH (undifferentiated) was not achieved.
Nov-90	Unknown	ExxonMobil Parcel	AMEC E&E 2010a	Monitoring well decommissioning	B-3 (MW-3), B-4 (MW-4), and MW-7 destroyed.	No documentation of well decommissioning.
March–June 1991	RZA	Parcels surrounding ExxonMobil Parcel	AMEC E&E 2010a	Borings, monitoring well installation	Six percussion soil borings to depths ranging from 5 to 5.5 feet bgs, 2-inch diameter monitoring wells MW-19 through MW-24, and 4-inch diameter monitoring wells MW-27 through MW-30 installed. Soil boring B-21-91 advanced to depth of 29 feet bgs.	MW-25 and MW-26 were inaccessible or dry and later renamed as B-25 and B-26. No well decommissioning records were found.
Jun-91	RZA and ESE	The Property	AGRA 1996g	Quarterly groundwater monitoring	Groundwater monitoring event. New 2-inch diameter monitoring wells MW-25 and MW-26 installed. Gauged wells: RW-1, B-1, B-2, B-5, MW-6, MW-8 through MW-13, MW-15 through MW-18, AD-19, W-1 through W-6, and W-8 through W-15.	B-1, MW-8, AD-19, W-1, W-6, W-9, W-11, W-12, W-13, and W-15 contained LPH and were not sampled.
Nov-91	RZA AGRA	ExxonMobil Parcel	AMEC E&E 2010a	Borings, recovery well	8-inch diameter recovery well RW-2 installed. Deep soil borings B-1A, B-8A, and B-15A advanced.	Soil borings advanced in vicinity of existing wells B-1, B-8, and B-15. No analytical data found for this event.

TABLE 3-1: CHRONOLOGY OF HISTORICAL ON-SITE ENVIRONMENTAL INVESTIGATIONS

ExxonMobil/ADC Property, Ecology Site ID 2728, Everett, Washington

Date	Consultant	Location	Reference	Activities	Tasks Performed	Notes
Dec-91	RZA AGRA	ExxonMobil Parcel	AGRA 1996g	Quarterly groundwater monitoring, aquifer and tidal study	Quarterly groundwater monitoring. Gauged wells: RW-1, B-1, B-2, B-5, MW-6, MW-8 through MW-13, MW-15 through MW-30, and AD-19. Aquifer study involved 24-hour pumping from MW-10 at a rate of 1 to 2 gpm and measuring response in MW-18, RW-1, and RW-2 for 48 hours.	B-1, MW-8, MW-11, MW-26, MW-27, MW-29, and AD-19 contained LPH and were not sampled. Hydraulic conductivity at the Site was estimated as 4 to 9.5 feet/day. Minimum tidal influence was observed.
1992	RZA AGRA	NA	NA	Discussions with Ecology	Ecology discussed enforcement with Mobil and RZA AGRA. Ecology decided to allow Site to go independent.	
Dec-93	RZA AGRA	West of ExxonMobil Parcel	AMEC E&E 2010a	Off-Property borings, monitoring well installation, GPR survey	2-inch diameter monitoring wells MW-31 through MW-33 and MW-35 through MW-37 were installed; B-34 advanced and backfilled. GPR survey was conducted to assess whether underground product lines had been removed.	Survey did not identify any subsurface linear features.
Dec-93	RZA AGRA	ExxonMobil Parcel and off-Property to the west	AGRA 1996g	Quarterly groundwater monitoring	Groundwater monitoring event. Gauged wells B-1, B-2, MW-6, MW-8 through MW-13, MW-15 through MW-18, MW-27 through MW-33, MW-35 through MW-37.	B-1, MW-27, and MW-29 contained LPH and were not sampled.
Dec-93	RZA AGRA	West of ExxonMobil Parcel	AMEC E&E 2010a	Test pits, recovery trench	Excavated five test pits, TP-1 through TP-5, to depths ranging from 3 to 3.5 feet bgs. Recovery trench installed along the western border of ExxonMobil Parcel.	Monitoring well MW-21 was reportedly decommissioned during the recovery trench installation activities. However, a 2002 decommissioning record was found that stated that MW-21 was decommissioned in 2002.
1995			NA	Agreed Order DE-95TC-N402		Required evaluation of LPH.
Jul-95	RZA AGRA	ADC Parcel	AGRA 1996g	Quarterly groundwater monitoring	Groundwater monitoring event. Gauged wells: W-3, W-5, W-9, W-10, W-12 through W-15.	W-9, W-12, and W-13 contained LPH and were not sampled.
Oct-95	U.S. Coast Guard Puget Sound Marine Safety Office & City of Everett	North of the Property	AMEC E&E 2010a	Investigation of petroleum product discharge into Everett Harbor	Camera surveys of the sewer lines made.	Outfall located approximately 175 yards northwest of the ADC Parcel; LPH seepage observed in section of CSO line.
Nov-95	RZA AGRA	Site	AGRA 1996g	Groundwater monitoring	Groundwater monitoring event. Gauged wells: RW-1, RW-2, B-1, B-2, MW-6, MW-8 to MW-13, MW-15 to MW-18, MW-27 to MW-37, and NRW-1.	B-1, MW-18, MW-29, and MW-30 contained LPH and were not sampled.

TABLE 3-1: CHRONOLOGY OF HISTORICAL ON-SITE ENVIRONMENTAL INVESTIGATIONS

ExxonMobil/ADC Property, Ecology Site ID 2728, Everett, Washington

Date	Consultant	Location	Reference	Activities	Tasks Performed	Notes
Dec-95	RZA AGRA	Site	AGRA 1996g	Groundwater monitoring	Groundwater monitoring event. Gauged wells: RW-2, B-2, MW-8, MW-9, MW-18, MW-15 through MW-18, MW-27, and MW-28.	RW-2, MW-9, MW-18, and MW-28 contained LPH and were not sampled.
Mar-96	AGRA	North of the Property	AMEC E&E 2010a	Borings	Direct-push soil borings GP-1 through GP-13. Borings associated with the CSO line repair.	The collected soil sample results indicated that soil surrounding the damaged portion of the CSO had petroleum hydrocarbon impacts. LPH accumulation was noticed in temporary screens installed in soil borings. No groundwater samples were collected from temporary screens.
Apr-96	City of Everett		AMEC E&E 2010a	Meeting	Meeting held to discuss options for repairing the section of CSO line.	Decisions made regarding replacement of the settled portion of the line and slip lining of the remaining portion of the line.
May-96	AGRA	ADC Parcel	AGRA 1996d	Borings	Bobcat borings BB-1 through BB-14.	Soil samples collected.
Jun-96	AGRA	ADC Parcel	AGRA 1996d	Borings, monitoring wells, and test pits	4-inch diameter recovery well VRW-1 and 2-inch diameter monitoring well MW-38 installed. Seven test pits TP-1-96 through TP-7-96 excavated.	Wells were installed on the northeast corner of the property. Test pits were located throughout the ADC Parcel.
Aug-96	AGRA	Site	AMEC E&E 2010a	Monitoring wells	Gauged wells at the property.	LPH found in B-1, VRW-1, MW-27, MW-29, MW-30, MW-38, W-1, W-9, W-15.
Feb-97	PTI	Site	PTI 1997	LPH recovery technical memorandum	Technical memorandum to summarize environmental investigations, LPH recovery activities, and geology.	PTI concluded that long-term, passive (LPH only) recovery may be the most effective method of LPH recovery. PTI also concluded that active LPH and groundwater recovery that had been performed up to that time had been effective for short durations, but recovery structures did not continue to recover LPH for extended periods of time when active recovery was employed.

TABLE 3-1: CHRONOLOGY OF HISTORICAL ON-SITE ENVIRONMENTAL INVESTIGATIONS

ExxonMobil/ADC Property, Ecology Site ID 2728, Everett, Washington

Date	Consultant	Location	Reference	Activities	Tasks Performed	Notes
November 1997 through January 1998	Pacific Environmental Group, Inc.	Kimberly-Clark property	Pacific Environmental Group, Inc. 1998	Borings, monitoring wells	Direct-push borings Probe-1 through Probe-15 were advanced, and 2-inch diameter HSA monitoring wells KC-1 and KC-2 were installed inside the KC warehouse.	Groundwater samples were collected from temporary screens installed in each boring. LPH not identified in soil borings or monitoring wells. TPH-D and TPH-O were detected above MTCA Method A cleanup levels in borings advanced in the vicinity of repaired CSO line. Samples not collected in vicinity of former ASTs.
1998			NA	Agreed Order DE98TC-P-N223		Required remedial investigation/focused feasibility study.
Jul-98	Exponent	Site	Exponent 1998a	Remedial Investigation and Focused Feasibility Study	Exponent summarized the history of the Property and evaluated feasible remedial options for the Site.	Exponent recommended the installation of LPH recovery trenches and installation of a low-permeability cap over the property.
Jul-98	Exponent	Site	Exponent 1998b	Final Interim Action Work Plan and Engineering Design Report	Exponent presented design for interim measures at the Property.	Exponent provided specifications for demolition of existing Site structures and installation of LPH recovery trenches, water treatment system, and low-permeability cap over the Property.
Oct-99	Kleinfelder	The Property	Exponent 2000	Monitoring wells installation	Monitoring wells W-10R, W-15R, and MW-40R.	Wells installed to replace wells W-10, W-15, and MW-40.
Dec-99	Dames and Moore/URS	South and southeast of the Property	URS 2000a	Geotechnical drilling and piezometer installation	DM-6, DM-7, and DM-8 were sampled for environmental samples.	Work associated with CSTO Project.
Sep-00	URS	South, east, and southeast of the Property	URS 2000b	Borings	Phase II investigation for the CSTO Project. Push-probe borings UG-1 through UG-12.	Groundwater samples collected from temporary screens installed in UG-2 and UG-8. Estimated 7,600 cubic yards of petroleum-contaminated soil present along the overcrossing alignment.
Jul-01	URS	Johnston Petroleum parcel	URS 2001a and b	Borings	Phase II investigation for Johnson Petroleum parcel. Push-probe borings JP-1 through JP-7.	Soil samples collected. Groundwater samples collected from JP-1, JP-4, and JP-7. No significant contamination found.

TABLE 3-1: CHRONOLOGY OF HISTORICAL ON-SITE ENVIRONMENTAL INVESTIGATIONS

ExxonMobil/ADC Property, Ecology Site ID 2728, Everett, Washington

Date	Consultant	Location	Reference	Activities	Tasks Performed	Notes
Feb-02	ERI	Site and vicinity	ERI 2002a	Monitoring well decommissioning and re-installment	Abandonment of monitoring wells (MW-22, MW-23, MW-24, MW-35, and MW-37) and piezometer DM-6 due to proximity to the CSTO Project. Re-installed well W-2 screened from 3 to 23 feet bgs.	No soil samples taken during W-2 installation. The reported abandonment of MW-21 in 2002 contradicts the reported decommissioning of MW-21 due to installation of the recovery trench to the west of the Property in December 1995.
2002	Reid Middleton	CSTO	Reid Middleton 2002	Memorandum to Ecology	Southeast corner of the asphalt cap over the ExxonMobil Parcel removed. Steel piles for concrete foundation were installed.	No information regarding contaminant soil excavation and removal was found.
2002-2007	Kleinfelder, ERI, AMEC	Site	Various	Groundwater monitoring	Monthly LPH gauging and quarterly groundwater monitoring.	LPH greater than 0.02 foot thick is bailed manually and oleophilic socks are replaced.
Jul-02	ERI	West of the ExxonMobil Parcel	ERI 2002b	Well decommissioning	Monitoring wells MW-20, MW-21, and one unidentified well were decommissioned.	The record contradicts the records that indicate that MW-21 was decommissioned during the December 1993 recovery trench installation.
Feb-07	AMEC/Bravo Environmental	Site	AMEC E&E 2007	Video survey of storm drain system	AMEC contracted Bravo to conduct a video survey of the storm drain system installed as part of 1999 interim measure to verify that groundwater from the Property is not infiltrating into the stormwater system through possible cracks and fissures in the piping and catch basins.	No significant cracks or fissures within the stormwater system were observed.
2007–present	AMEC	Site	AMEC E&E 2010a	Groundwater monitoring	AMEC requested to change to semiannual groundwater monitoring in 2007.	Request was accepted by Ecology.
2008	AMEC	West of the Property	AMEC E&E 2008b	Monitoring wells	Off-property monitoring wells MW-A1 and MW-A2 installed on the west side of Federal Avenue.	Monitoring wells MW-A1 and MW-A2 are incorporated into existing groundwater monitoring network.
Feb-08	AMEC	Site	AMEC E&E, 2008a	Tidal study	Measured tidal response in W-3, W-6, MW-11, MW-28, & MW-40R.	Minimal response in each well, except MW-11.
Jun-08	AMEC	Site	2010 updated survey included as Appendix C	Well head elevations survey	True North Land Surveying of Seattle, Washington, surveyed recovery and monitoring wells located on-Site.	Recovery wells LPH-1 to LPH-9 and monitoring wells W-1, W-2, W-3, W-6, W-10R, MW-10, MW-11, W-15R, W-17, RW-2, MW-19, MW-27, MW-28, MW-29, MW-30, MW-40R, MW-A1, and MW-A2.

TABLE 3-1: CHRONOLOGY OF HISTORICAL ON-SITE ENVIRONMENTAL INVESTIGATIONS

ExxonMobil/ADC Property, Ecology Site ID 2728, Everett, Washington

Date	Consultant	Location	Reference	Activities	Tasks Performed	Notes
2010	AMEC	Site	AMEC E&E 2010a	Focused Feasibility Study Work Plan	Summarized Site history, previous environmental investigations and interim remedial activities, known environmental conditions, preliminary conceptual site model, and remaining data gaps.	FFS Work Plan included a sampling and analysis plan to guide data gaps investigation and identified applicable remedial technologies to be evaluated n the FFS.
2010	AMEC	Site	AMEC E&E 2010a	Agreed Order DE 6184		Required FFS and Draft CAP.
2010	AMEC	Site	AMEC E&E 2011f	Sampling for City of Everett Force Main	Borings CE-1 to CE-8 advanced on Federal Avenue, former Everett Avenue, and the BNSF property to characterize soils in the alignment of City's planned force main.	Analytical results were provided to City of Everett and used to characterize soil excavated for the force main project for disposal purposes.
2011	AMEC	Site	AMEC E&E 2011b	Data gaps investigation	Seven deep borings (AB-1 to AB-5, AP-6, MW-7ab), six shallow borings (AP-1 through AP-5, AP-7), five new off-Property monitoring wells (MW-A3 through MW-A7), aquifer testing, and tidal influence study.	A plume of groundwater with petroleum hydrocarbon impacts was identified west & northwest of the Property. Groundwater downgradient and upgradient from the Property was not affected by COCs. Geochemical parameters were consistent with an anaerobic environment in which active petroleum biodegradation appears to be occurring. No continuous silt layer was identified beneath the Property. Monitoring wells MW-A3 through MW-A7 incorporated into existing groundwater monitoring network.
2011	AMEC	Site	AMEC E&E 2011a	Tidal influence investigation	A stilling well with transducer was installed on the Everett Pier to automatically record tidal elevations. Pressure transducer/ data loggers were installed in monitoring wells W-3, W-6, MW-11, MW-19, MW-28, MW-40R, and MW-A1 through MW-A7 to record groundwater levels every 6 minutes for 6 days.	Monitoring wells W-3, MW-11, MW-A1, MW-A2, MW-A3, MW-A5, and MW-A6 are tidally influenced, with tidal fluctuations ranging from 0.1 foot to 1.1 feet. MW-19, MW-28, MW-40R, MW-A4, and W-6 exhibited minimal tidal influence, and MW-A7 was unaffected by tidal elevation. A potentiometric surface map showed groundwater flow toward the west.
2011	AMEC	Former Everett Avenue	AMEC E&E 2011g and h	Observations of seeps along former Everett Avenue	AMEC recorded photographs in the field to document observations of petroleum product seeps through the pavement on former Everett Avenue.	

TABLE 3-1: CHRONOLOGY OF HISTORICAL ON-SITE ENVIRONMENTAL INVESTIGATIONS

ExxonMobil/ADC Property, Ecology Site ID 2728, Everett, Washington

Date	Consultant	Location	Reference	Activities	Tasks Performed	Notes
2012	AMEC	Federal Avenue and former Everett Avenue	AMEC 2012b	Observations during City of Everett force main replacement	AMEC observed excavation and drilling activities during installation of the City's force main and recorded notable subsurface features when relevant, including the presence of LPH if encountered.	AMEC documented the presence of LPH in borings and/or trenches along much of the alignment on former Everett Avenue, and at selected locations along Federal Avenue.
2013–2014	AMEC	Site	AMEC 2014a	Data gaps investigation	A total of 33 soil borings were drilled on the Property and nearby properties, and soil samples were analyzed to delineate areas of affected soil at the Site. One of the borings was completed as a new monitoring well (MW-A8).	Higher COC concentrations were found primarily on the Property and in the western portion of the former ADC garage. Contamination from the Site extends to the former ADC garage and former Everett Avenue. Contamination on KC property north of former Everett Avenue likely originates from sources on the KC property. Monitoring well MW-A8 incorporated into groundwater monitoring network.

Abbreviations

ADC = American Distributing Company
AMEC = AMEC Environment & Infrastructure, Inc.
AMEC E&E = AMEC Earth & Environmental, Inc.
AST = aboveground storage tank
bgs = below ground surface
CAP = Cleanup Action Plan
COC = constituent of concern
CSO = combined sewer outflow
CSTO = California Street Overcrossing
Ecology = Washington State Department of Ecology
ERI = Environmental Resolutions, Inc.
ESE = Environmental Science and Engineering, Inc.
FFS = Focused Feasibility Study
gpm = gallons per minute
GPR = ground penetrating radar
HSA = hollow-stem auger
KC = Kimberly-Clark
Kleinfelder = Kleinfelder, Inc.
LPH = liquid petroleum hydrocarbons
MTCA = Model Toxics Control Act
PTI = PTI Environmental Services
RZA = Rittenhouse-Zeman & Associates, Inc.
RZA AGRA = RZA AGRA Earth & Environmental, Inc.
TPH = total petroleum hydrocarbons
TPH-D = total petroleum hydrocarbons-diesel range organics
TPH-G = total petroleum hydrocarbons-gasoline range organics
TPH-O = total petroleum hydrocarbons-residual range organics

TABLE 4-1: CHRONOLOGY OF HISTORICAL INTERIM REMEDIAL MEASURES

ExxonMobil/ADC Property, Ecology Site ID 2728, Everett, Washington

Date	Consultant	Location	Reference	Activities	Tasks Performed	Notes
April–May 1988	RZA	ExxonMobil Parcel	PTI 1997	Recovery trench installation, SVE and groundwater treatment system test (oil-water separator and air stripper), infiltration gallery, pumping subsurface fluids	Installation of recovery trench near MW-14, SVE system and groundwater treatment system to evaluate feasibility of extracting LPH. Infiltration gallery installed in the vicinity of MW-14. Subsurface fluids were pumped with a vacuum truck from the sumps.	Decommissioned in 1998 during construction of low-permeability cap at the Property. The gallery was T-shaped and 45 feet long with two 55-gallon drums installed at both ends as sumps. 1,400 gallons of liquid removed, 50 gallons was LPH. As a result, LPH thickness in MW-14 decreased to 0.40 foot by August 1988.
Mar-89	RZA	ExxonMobil Parcel	RZA 1989	Automated groundwater extraction and treatment system	An automated groundwater extraction and treatment system was installed in the location of the infiltration gallery. The system included fluid extraction sump stationed in RW-1 (formerly MW-14), oil-water separator, air stripper, and re-infiltration gallery.	The groundwater extraction and treatment system was shut down in March 1990 due to flooding of the re-infiltration gallery, and has not been restarted.
Nov-91	RZA AGRA	ExxonMobil Parcel	PTI 1997	Borings, recovery well	8-inch diameter recovery well RW-2 installed.	No analytical data found for this event.
Dec-93	RZA AGRA	West of ExxonMobil Parcel	AGRA 1993	Test pits, recovery trench	Recovery trench installation along the western border of ExxonMobil Parcel.	
Jun-96	AGRA	North of the Property	AGRA 1996b and c	CSO line repairs	Excavation of settled portion of pipe replaced. Slip-lining of remaining CSO line. CSO line excavation dewatering.	1,450,800 gallons of groundwater and 23,050 gallons of LPH were removed during CSO line excavation and dewatering.
Jun-96	AGRA	LPH Vacuum Recovery Pilot Test	AGRA 1996a, d,e, and f	LPH vacuum recovery pilot test	14-day test included SVE and groundwater/LPH pumping system.	125 gal of LPH and 28,228 gallons of groundwater removed from VRW-1 during test.
Nov-98	Kleinfelder	ADC Parcel	Exponent 2000	Survey, geotechnical evaluation	Initial survey. Asbestos survey prior to demolition.	Demolition activities included four buildings on the ADC parcel. Asbestos abatement activities were conducted in November 1998, and demolition was completed in January 1999.
Dec-98	Kleinfelder	Water management and treatment system	Exponent 2000	Installation of treatment system	A water management and treatment system consisting of an oil–water separator, a settling tank, and a carbon polishing unit was constructed at the Property.	System treated approximately 2.5 million gallons of water between December 1998 and September 1999. Approximately 19,900 gallons of oily water and 450 gallons of sludge were collected between December 1998 and September 1999.
Dec-98	Kleinfelder	The Property	Exponent 2000	Interim remedial action	Removed TPH-impacted soil, graded the property, removed purge water.	162 tons of contaminated shallow soil and vegetation removed from within the ADC firewall area during demolition and transported to TPS Technologies facility for disposal. 3.5 tons of class 3 PCS taken to CRS Associated. Marine Services, Inc. removed 110 gallons of purge water.
1999	Kleinfelder	The Property	Exponent 2000	Interim remedial action	Monitoring well abandonment. Interceptor trench construction along the western and northern property boundaries. Low-permeability cap construction over the property. Recovery wells LPH-1 through LPH-9 installed in interceptor trench. Stormwater collection system that connects to the City of Everett sewer system was installed.	Monitoring wells MW-6, MW-8, MW-9, MW-12, MW-13, MW-15, MW-16, MW-17, MW-38, WP-1, B-1, B-2, W-4, W-8, W-11, W-12, W-14, AD-11, AD-12, AD-13, AD-15, AD-19, W-10, W-15, and MW-40 abandoned. Completed Site grading, installation of two layers of geotextile fabric, asphalt-treated base material, and paving fabric and asphalt cap.
2002–present	Kleinfelder, ERI, AMEC E&E	Site	Various	Petroleum recovery	Monthly removal of LPH.	LPH greater than 0.02 foot thick is bailed manually, and oleophilic socks are replaced.

TABLE 4-1: CHRONOLOGY OF HISTORICAL INTERIM REMEDIAL MEASURES

ExxonMobil/ADC Property, Ecology Site ID 2728, Everett, Washington

Date	Consultant	Location	Reference	Activities	Tasks Performed	Notes
Jul-08	Floyd│Snider	North-northeast of the Property	AMEC E&E 2010a	Excavation and disposal of PCS and dewatering the excavation	Soil associated with Puget Sound Outfall 5 Overflow Structure project was excavated and disposed of. In addition, dewatering occurred during excavation.	Soil was field screened. Soil exhibiting obvious signs of contamination was disposed of as Class II soil without sampling. Soil that appeared to be "clean" was sampled and then disposed as Class II soil. Water from the excavation was sampled for the City sewer discharge requirements.
2010	AMEC E&E	Federal Avenue and Port of Everett property	AMEC E&E 2011e	Removal of abandoned pipes and affected soil	AMEC decommissioned pipelines west of the Property to prepare for upgrades to the storm sewer line planned by the City of Everett.	A total of 76.55 tons of construction debris, 243 tons of soil, 487 linear feet of piping, 65,669 gallons of non-regulated liquid, four 55-gallon product/ water drums, and four 55-gallon solid waste drums were removed and disposed of off Site. Samples from base of excavation showed contaminated soil left in place.
2011–2012	AMEC	BNSF and KC properties	AMEC 2012a	Interim removal action	Excavation and off-Site disposal of surface asphalt, affected soil, and recovered LPH and treatment of the recovered groundwater from the secondary source areas on the BNSF and KC properties. Monitoring wells MW-27 through MW-30 abandoned.	Approximately 3,785 tons of material was excavated and disposed of at a permitted landfill, approximately 2,530 gallons of LPH was removed, and 1,489,246 gallons of petroleum-affected groundwater was removed and treated. Affected material was evident and left in place at all side wall areas of the completed excavation on the BNSF property and on the north and east sidewalls on the KC property.

Abbreviations

ADC = American Distributing Company
AMEC = AMEC Environment & Infrastructure, Inc.
AMEC E&E = AMEC Earth & Environmental, Inc.
BNSF = BNSF Railway Company
CSO = combined sewer outflow
ERI = Environmental Resolutions, Inc.
KC = Kimberly-Clark
Kleinfelder = Kleinfelder, Inc.
LPH = liquid petroleum hydrocarbons
PCS = petroleum-contaminated soil
PTI = PTI Environmental Services
RZA = Rittenhouse-Zeman & Associates, Inc.
RZA AGRA = RZA AGRA Earth & Environmental, Inc.
SVE = soil vapor extraction
TPH = total petroleum hydrocarbons

TABLE 5-1: PRELIMINARY CLEANUP LEVELS FOR GROUNDWATER[1]

ExxonMobil/ADC Site, Ecology Site ID 2728, Everett, Washington

Values in micrograms per liter (µg/L)

Constituent	CAS Number	Groundwater, MTCA Method A Cleanup Level	Groundwater, MTCA Method B Cleanup Level		Groundwater, MTCA Most Restrictive ARAR	Surface Water, MTCA Method B Cleanup Level		Surface Water ARAR - Aquatic Life - Marine/Acute (WAC 173-201A- 240)	Surface Water ARAR - Aquatic Life - Marine/Chronic (WAC 173-201A- 240)	Surface Water ARAR - Aquatic Life - Human Health (WAC 173-201A- 240)	Surface Water ARAR - Aquatic Life - Marine/Acute (CWA §304)	Surface Water ARAR- Aquatic Life - Marine/Chronic (CWA §304)	Surface Water ARAR - Human Health Consumption of Organisms (CWA §304)	EPA Human Health SW Criteria - Marine (40 CFR 131.45)	Method B Groundwater Screening Level Protective of Indoor Air[2]	PQL	Preliminary Cleanup Level[3]
Volatile Organic Compounds																	
Benzene	71-43-2	5	0.8	c	5	23	c	--	--	1.6	--	--	16	--	2.4	0.5	1.6
Ethylbenzene	100-41-4	700	800	nc	700	6,900	nc			270	130			31	2800		31
Xylenes	1330-20-7	1,000	1600	nc	10,000										310		310
Semivolatile Organic Compounds																	
1-methylnaphthalene	90-12-0	--	1.5	c				--	--		--	--	--		--	0.5	1.5
Total cPAHs[4]	--	0.1	0.023	c	0.2	0.22	c	--	--	0.0021	--	--	1.30E-04	1.60E-05	--	0.1	0.1[5]
Total Petroleum Hydrocarbons																	
Gasoline	86290-81-5	800						--	--		--	--	--		--	800	800
Diesel	NA	500						--	--		--	--	--		--	500	500
Motor oil	NA	500						--	--		--	--	--		--	500	500

Notes

1. All levels downloaded from Washington State Department of Ecology Cleanup Levels and Risk Calculations website at https://fortress.wa.gov/ecy/clarc/CLARCHome.aspx.
2. Method B groundwater screening level protective of indoor air, lowest of carcinogenic or non-carcinogenic, in the Washington State Department of Ecology 2015 Vapor Intrusion Updated Excel table issued on 4/6/2015.
3. The preliminary cleanup level is the lowest value of the presented ARARs because MTCA method A values are based on protection of drinking water, which is not a complete pathway.
4. The cleanup levels and remediation levels established for benzo(a)pyrene shall be used, respectively, as the cleanup levels and remediation levels for mixtures of cPAHs (WAC 173-340-708[8][e]).
5. The PCL for total cPAHs was revised so that PCL was no lower than PQL for project laboratory (WAC 173-340-705[6]).

Abbreviations

-- = not available
ARAR = applicable or relevant and appropriate requirement
c = carcinogenic
CAS = Chemical Abstracts Service
CFR = Code of Federal Regulations
cPAH = carcinogenic polycyclic aromatic hydrocarbons
CWA = Clean Water Act
MTCA = Model Toxics Control Act
NA = not applicable
nc = noncarcinogenic
PCL = preliminary cleanup level
PQL = practical quantitation limit
SW = surface water
WAC = Washington Administrative Code

Table 5-2: PRELIMINARY CLEANUP LEVELS FOR SOIL[1]

ExxonMobil/ADC Site, Ecology Site ID 2728, Everett, Washington

Values in milligrams per kilogram (mg/kg)

Constituent	CAS Number	Soil, MTCA Method A Cleanup Level, Unrestricted Land Use	Soil, MTCA Method B Cleanup Level, Unrestricted Land Use		Soil Cleanup Level Protective of Groundwater (Unsaturated)[2]	Soil Cleanup Level Protective of Groundwater (Saturated)[2]	Practical Quantitation Limit	Preliminary Cleanup Level (Unsaturated)	Preliminary Cleanup Level (Saturated)
Volatile Organic Compounds									
Benzene	71-43-2	0.03	18	c	0.009	0.0006	0.005	0.009	0.005[3]
Ethylbenzene	100-41-4	6	8,000	nc	0.3	0.02	0.005	0.3	0.02
Xylenes	1330-20-7	9	16,000	nc	2.8	0.16	0.005	2.8	0.16
Semivolatile Organic Compounds									
1-methylnaphthalene[3]	90-12-0	NA[4]	34	c	0.08	0.004	0.50	0.08	0.5[3]
Total cPAHs[5]	NA	0.1	0.19	c	1.9	0.1	0.02	0.2	0.1
Total Petroleum Hydrocarbons									
Gasoline	86290-81-5	30/100[6]			NA	NA	0.5		30
Diesel	NA	2,000			NA	NA	5.0		2,000
Lube Oil	NA	2,000			NA	NA	5.0		2,000

Notes

1. All levels downloaded from Washington State Department of Ecology Cleanup Levels and Risk Calculations website at https://fortress.wa.gov/ecy/clarc/CLARCHome.aspx.
2. The calculations for soil cleanup levels protective of groundwater are presented in Table 5-3. The soil to groundwater cleanup level is based on a groundwater cleanup level of 31 µg/L, which is protective of surface water.
3. PCLs for benzene and methylnaphthalene were revised so that PCLs were not lower than the PQL for the project laboratory (WAC 173-340-705[6]).
4. There is no MTCA Method A cleanup level specified for 1-methylnaphthalene; MTCA Method B cleanup level for direct contact with soil is 34.5 mg/kg.
5. The cleanup levels established for benzo(a)pyrene shall be used as the cleanup levels for mixtures of cPAHs (WAC 173-340-708[8][e]).
6. The preliminary cleanup level for TPH-G is 30 mg/kg if benzene is present, and 100 mg/kg if it is not present. Since benzene has been detected in site soils, the preliminary cleanup level is set to 30 mg/kg.

Abbreviations

c = carcinogenic
CAS = Chemical Abstracts Service
cPAH = carcinogenic polycyclic aromatic hydrocarbons
MTCA = Model Toxics Control Act
NA = not available
nc = noncarcinogenic

Table 5-3: GROUNDWATER PROTECTION CALCULATIONS[1]

ExxonMobil/ADC Site, Ecology Site ID 2728 Everett, Washington

Chemical	CAS	C_w[2] (µg/L)	Chemical Specific Constants			C_s[5] (Unsaturated) (mg/kg)	C_s[5] (Saturated) (mg/kg)
			K_{oc}[3] (ml/g)	K_d[4] (L/kg)	H_{cc}[5]		
Volatile Organic Compounds							
Benzene	71-43-2	1.6	62	0.06	0.133	0.009	0.0006
Ethylbenzene	100-41-4	31	204	0.20	0.162	0.26	0.015
Xylenes[6]	1330-20-7	310	233	0.233	0.138	2.8	0.16
Semivolatile Organic Compounds							
Benzo(a)pyrene	50-32-8	0.1	9.70E+05	969	6.39E-06	1.9	0.1
1-methylnaphthalene	90-12-0	1.5	2.53E+03	2.53	1.59E-02	0.08	0.004
Total Petroleum Hydrocarbons							
Diesel	--	500.00	--	--	--	--	--
Gasoline	86290-81-5	800.00	--	--	--	--	--
Heavy Oil	--	500.00	--	--	--	--	--

Notes

1. Groundwater calculations provided by the Washington State Department of Ecology; Wood did not reproduce these calculations.
2. C_w values obtained from Table 5-1.
3. K_{oc} values obtained from the Washington State Department of Ecology CLARC online database.
4. K_d values were calculated using MTCA Equation 747-2.
5. Constants and soil concentration values were obtained from a letter by the Washington State Department of Ecology dated 4/9/2018.
   Use H_{cc} at 13 degrees Celsius.
6. Values used for o-xylene.

Abbreviations

-- = not available
µg/L = micrograms per liter
CAS = Chemical Abstracts Service
CLARC = Cleanup Levels and Risk Calculations
C_s = soil concentration
C_w = groundwater preliminary cleanup level
H_{cc} = Henry's law constant (dimensionless)
K_d = distribution coefficient
K_{oc} = soil organic carbon-water partitioning coefficient
L/kg = liters per kilogram
mg/kg = milligrams per kilogram
ml/g = milliliters per gram
MTCA = Model Toxics Control Act

TABLE 6-1: GROUNDWATER SAMPLE ANALYTICAL RESULTS [1,2]

ExxonMobil/ADC Property, Ecology Site ID 2728, Everett, Washington

Well ID		LPH-1	LPH-2	LPH-3	LPH-4	LPH-5	LPH-6	LPH-7	LPH-8	LPH-9	MW-10	MW-11	MW-19	MW-40R	MW-A1	MW-A2		MW-A3
Date Sampled	PCL	01/06/2015	01/06/2015	01/07/2015	01/07/2015	01/07/2015	01/07/2015	01/08/2015	01/08/2015	01/08/2015	01/06/2015	01/06/2015	01/05/2015	01/06/2015	01/06/2015	01/05/2015	01/05/2015 FD	01/06/2015
TPH (µg/L)																		
TPH as Gasoline	800	100 U	100 U	100	100 U	100 U	100 U	100 U	140	390	290	100 U	130 NJ	610	100 U	110	110	100 U
TPH as Diesel	500	100 U	130	200	**8,600**	450	240	140	140	**970**	**690**	100 U	180 NJ	**790**	**730 NJ**	320	320	110 NJ
TPH as Motor Oil Range	500	100 U	100 U	100 U	**4,100**	230	100 U	100 U	130	180	100 U	100 U	100 U	100 U	100 U	100 U	100 U	100 U
PAHs (µg/L)																		
Total cPAHs	0.1	0.0725 U	0.0717 U	0.0717 U	0.0717 U	0.0725 U	0.0717 U	0.0732 U	0.0717 U	0.0717 U	0.0725 U	0.0717 U	0.0725 U	0.0725 U	0.0725 U	0.0725 U	0.0725 U	0.0725 U
VOCs (µg/L)																		
Benzene	1.6	**4.3**	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U

Well ID		MW-A4	MW-A5	MW-A6	MW-A7	MW-A8	RW-2	Sump 1	Sump 2	W-1	W-2		W-3	W-6	W-10R	W-15R	W-15R FD	W-17
Date Sampled	PCL	01/06/2015	01/05/2015	01/05/2015	01/05/2015	01/05/2015	01/06/2015	01/08/2015	01/08/2015	01/07/2015	01/07/2015	01/07/2015 FD	01/07/2015	01/08/2015	1/7/2015	01/08/2015	01/08/2015	01/08/2015
TPH (µg/L)																		
TPH as Gasoline	800	100 U	100 U	100 U	100 U	100 U	340	100 U	**1,900**	300	490 J	**1,000 J**	100 U	450	350	**2,500**	**2,900 J**	**1,000**
TPH as Diesel	500	100 U	240	100 U	100 U	100 U	270	100 U	**11,000**	**1,900**	**1,300**	**970**	250	390	**870**	**3,000**	**3,000**	**990**
TPH as Motor Oil Range	500	100 U	100 U	100 U	100 U	100 U	100 U	100 U	**2,900**	230	100 U	100 U	100 U	100 U	150	100 U	100 U	290
PAHs (µg/L)																		
Total cPAHs	0.1	0.0725 U	0.0717 U	0.0725 U	0.0717 U	0.0725 U	0.0725 U	0.0747 U	**10.45**	**0.1712**	0.0725 U	0.0717 U	0.0717 U	0.0732 U	0.0725 U	0.0717 U	0.0717 U	0.0725 U
VOCs (µg/L)																		
Benzene	1.6	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.53	0.50 U	0.72	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	**1.9**	**2.1**	0.50 U

Notes:
1. Data qualifiers are as follows:
   J = The result is an approximation.
   NJ = The result is estimated and the identification is tentative due to a poor match with the reference standard.
   U = not detected at or above the laboratory reporting limit shown.
2. Bolded values exceed the PCLs summarized on Table 5-1.

Abbreviations:
µg/L = micrograms per liter
cPAHs = carcinogenic polycyclic aromatic hydrocarbons
FD = field duplicate
PAHs = polycyclic aromatic hydrocarbons
PCL = preliminary cleanup level
TPH = total petroleum hydrocarbons
VOCs = volatile organic compounds

TABLE 6-2: HISTORY OF LNAPL RECOVERY AT THE SITE

ExxonMobil/ADC Property, Ecology Site ID 2728, Everett, Washington

LNAPL Activity	Date	Gallons of Water Recovered	Gallons of LNAPL Recovered	Comments
May 1988 LNAPL Infiltration Trench	5/12/1988	1,150	250	A 45-foot-long trench with two sumps constructed. Vacuum truck used to recover water and LNAPL from sumps; diminishing recovery of LNAPL noted after two events.
	5/26/1988	1,200	50	
March 1989 Groundwater Extraction and Treatment	March 1989 to March 1990	NA	NA	Groundwater extraction and treatment system was installed in the location of the May 1988 infiltration gallery. Fluid extraction at RW-1, a former monitoring well, and re-infiltration into a 190-foot long trench. Groundwater pumped at 2 to 3 gallons per minute. No LNAPL recovered or observed.
June 1989 Bailing	June to August 1989	NA	7	LNAPL noted in MW-8 and MW-18; wells bailed and limited LNAPL recovered.
December 1990 Test Pit Installation	December 1, 1993	NA	0	Five test pits installed to 4 feet below ground surface and blackish LNAPL was observed; insufficent LNAPL was present to allow for recovery of oil.
June 1996 LNAPL Vacuum Recovery Pilot Test	May to June 1996	28,228	125	After investigations identifed LNAPL in a number of borings, a 4-inch-diameter vacuum recovery well (VRW-1) was installed at the northeast corner of the ADC property. The system was operated in three modes—skimmer, vacuum, and depression mode—with greater submersion of a total fluids pump and higher vacuums. LNAPL recovery was variable and the the test ran for fourteen days.
June 1996 LNAPL Recovery Trench Pilot Test	June 1996	1,000s	0	Three test pits were installed with two monitoring wells. For the recovery test, one test pit and two wells were evacuated with a vacuum truck. No measureable LNAPL was observed in the wells or the selected test pit.
June 1996 CSO Dewatering	June 1996 to July 1996	1,450,800	23,050	City of Everett repairs to the CSO line in the former Everett Avenue ROW just south of the Kimberly Clark Building. Repairs were coordinated with a dewatering project to recover LNAPL from three dewatering wells. Dewatering began on June18 and continued through July 10. LNAPL daily production peaked at 7,550 gallons on June 21, 1996, and decreased asymmtotically to zero by July 4, 1996.
January 1997 LNAPL Bailing	January 1997	NA	12.33	LNAPL was hand-bailed from a series of eight wells over eight separate events.
LNAPL Interceptor Trench	January 1999 to Present	NA	None since March 2010	A 485-foot-long passive LNAPL recovery trench was installed along the western and northern sides of the Exxon-Mobil/ADC Property. The trench is 3 feet wide, approximately 4.5 feet deep, backfilled with permeable material, and uses a downgradient barrier to LNAPL migration (former concrete footings or 16-mil HDPE). The trench is equiped with nine LNAPL recovery wells. Since installation approximately 16 years ago, only trace quanitities of LNAPL have been noted.
BNSF Soil Excavation	November 2010 to Mid-February 2011	1,489,246	6,019	Dewatering during excavation to approximately 10 feet deep. LNAPL recovered by vacuum truck during excavation as LNAPL accumulated on water surface within the excavation.
City of Everett Force Main	May 2012 through July 2012	3,000,000	unknown	Dewatering using dewatering points installed in fomer Everett Avenue toward the west and then south along Federal Avenue. The City did not record the volume of LNAPL recovered during this project.
Passive LNAPL Recovery from Wells and Sumps	March 2010 to August 2016	NA	33.9	Passive LNAPL recovery from wells, groundwater monitoring wells, and sumps frrom March 2010 through August 2016. Recovery methods including pumping oil from well, and using sorbent materials.

Abbreviations:
BNSF = BNSF Railway Company
City = City of Everett
CSO = combined sewer overflow
HDPE = high density polyethylene
LNAPL = light non-aqueous phase liquid
NA = not applicable
ROW = right of way

TABLE 7-1: HYDRAULIC PARAMETERS FROM AQUIFER AND SLUG TESTS

ExxonMobil/ADC Property, Ecology Site ID 2728, Everett, Washington

Test Type	Well Name	Hydraulic Conductivity (cm/sec)	Transmissivity (gpd/ft)	Storativity [1]	Source
Aquifer Test	MW-10	1.84E-03	627	0.01	AGRA (drawdown at observation well) [2]
	MW-10	3.35E-03	1136	0.006	AGRA (recovery at observation well) [2]
	MW-10	1.80E-03	608	0.008	AGRA (elastic response at observation well) [2]
	MW-18	2.01E-03	685	0.004	
	RW-1	1.41E-03	482	0.34	AGRA (delayed response at pumping well) [2]
Slug Test	MW-A1	2.65E-02	--	--	AMEC (rising head) [3]
	MW-A5	6.35E-03	--	--	
	MW-A6	9.28E-03	--	--	

Notes:
1. Storativity is dimensionless.
2. Undated AGRA pump test data included as an appendix to Remedial Investigation and Focused Feasibility Study, Mobil and ADC/Miller Properties, Everett, Washington (Exponent, 1998a).
3. Geometric mean of 5 slug test results (AMEC Earth & Environmental, 2010c).

Abbreviations:
ADC = American Distributing Company
AGRA = AGRA Earth & Environmental, Inc
cm/sec = centimeters per second
gpd/ft = gallons per day per foot of drawdown

TABLE 13-1: COMPARISON OF SOURCE AREA REMEDIATION ALTERNATIVES

ExxonMobil/ADC Site, Ecology Site ID 2728 Everett, Washington

Standards/Criteria		Alternative 1: LNAPL Area Excavation and Natural Source Zone Attenuation	Alternative 2: LNAPL Area Excavation and Source Area Stabilization	Alternative 3: Source Area Excavation
Protectiveness	Pros	Removes accessible LNAPL for placement in an engineered landfill. Remaining source area soils are undisturbed, supporting natural source zone attenuation Controls are included to implement appropriate action if LNAPL remaining in inaccessible areas becomes mobilized.	Removes accessible LNAPL for placement in an engineered landfill. Stabilizes remaining source area soils and limits groundwater flow through the stabilized soil. Controls are included to implement appropriate action if LNAPL remaining in inaccessible areas becomes mobilized.	Removes source area soils with placement in an off-Site engineered landfill. Controls are included to implement appropriate action if LNAPL remaining in inaccessible areas becomes mobilized.
	Cons	LNAPL and COCs would remain in inaccessible areas. COCs remain in unexcavated portion of source areas. Excavation could induce mobility in LNAPL outside the excavation area.	LNAPL and COCs would remain in inaccessible areas. Excavation could induce mobility in LNAPL outside the excavation area. Stabilization of source area soils would likely inhibit natural source zone attenuation and extend restoration time.	LNAPL and COCs would remain in inaccessible areas. Larger excavation than Alternative 1 and 2, therefore a greater risk of inducing mobility for LNAPL outside the excavation area.
	Rating	8	8	9
Permanence	Pros	Removes the accessible LNAPL for placement in an engineered landfill, reducing Site toxicity and impacted source area volume but not destroying contaminants. Natural source zone attenuation is expected to provide continued intrinsic degradation of LNAPL and COCs remaining after LNAPL excavation.	Removes the accessible LNAPL for placement in an engineered landfill, reducing Site toxicity and impacted source area volume but not destroying contaminants. Stabilizes remaining source area contamination to the extent practicable. Stabilization materials have long effective life. Natural source zone attenuation is expected to provide continued intrinsic degradation of LNAPL and COCs remaining in inaccessible areas.	Removes source area contamination to the extent practicable for placement in an engineered landfill, reducing Site toxicity and contaminant volume slightly more than Alternatives 1 and 2, but not destroying contaminants. Natural source zone attenuation is expected to provide continued intrinsic degradation of LNAPL and COCs remaining in inaccessible areas.
	Cons	Affected soil would remain in source areas and LNAPL would remain in inaccessible areas.	Affected soil would remain in stabilized source area soils and in inaccessible areas. LNAPL would remain in the inaccessible areas. Stabilization of source area soils would likely inhibit natural source zone attenuation and extend restoration time.	Affected soil and LNAPL would remain on Site primarily in inaccessible areas.
	Rating	8	8	9

TABLE 13-1: COMPARISON OF SOURCE AREA REMEDIATION ALTERNATIVES

ExxonMobil/ADC Site, Ecology Site ID 2728 Everett, Washington

Standards/Criteria		Alternative 1: LNAPL Area Excavation and Natural Source Zone Attenuation	Alternative 2: LNAPL Area Excavation and Source Area Stabilization	Alternative 3: Source Area Excavation
Cost	Pros	Lowest cost estimate.	Second lowest cost estimate.	None.
	Cons	Significant initial implementation cost. Long-term costs for response plans, maintenance, and monitoring.	Significant initial implementation cost, greater than lowest cost alternative. Long-term costs for response plans, maintenance, and monitoring.	Significant initial implementation cost. Highest cost. Long-term costs for response plans, maintenance, and monitoring.
	Rating	9	5	4
Long-Term Effectiveness	Pros	The most highly contaminated material in source areas would be removed and placed in an off-Site landfill. Relies on intrinsic degradation processes for remediation of Site COCs and LNAPL (inaccessible areas) remaining after excavation.	The most highly contaminated material in source areas would be removed and placed in an off-Site landfill. Relies on intrinsic degradation processes for remediation of Site COCs and LNAPL (inaccessible areas) remaining after excavation. Soil stabilization uses natural components that have a long-term viability.	The most highly contaminated material in source areas would be removed and placed in an off-Site landfill. Relies on intrinsic degradation processes for remediation of COCs and LNAPL in inaccessible areas after excavation.
	Cons	Long-term, active Site management would be required. Surface cover would require periodic maintenance. Limited soil contamination would remain in source areas until fully degraded. Long-term response plans and institutional controls would be required to address remaining affected soil and/or LNAPL outside of excavation and in the inaccessible areas.	Long-term, active management would be required. Surface cover would require periodic maintenance. Long-term response plans and institutional controls would be required to address remaining affected soil and/or LNAPL outside of excavation and in the inaccessible areas. Stabilized soil would likely hinder natural degradation processes for remaining COCs in source areas.	Long-term, active Site management would be required. Long-term response plans and institutional controls would be required to address remaining affected soil and/or LNAPL in the inaccessible areas.
	Rating	7	7	8
Management of Short-Term Risks	Pros	Reduced potential for short-term risk relative to Alternatives 2 and 3 due to smaller construction/transportation requirements. Proven construction methodologies are available to mitigate potential short-term risks during work.	Proven construction methodologies are available to mitigate short-term risks during work.	Reduced potential for short-term risk relative to Alternative 2 due to single construction method. Proven construction methodologies are available to mitigate short-term risks during work.
	Cons	Significant excavation, with significant potential for releases to air and surface water during construction and transportation and with significant potential for worker exposure. Significant potential to adversely affect adjacent improvements. Shoring would be required to mitigate risks of structural failure.	Significant excavation, with significant potential for releases to air and surface water during construction and transportation, and with significant potential for worker exposure. Significant potential to adversely affect adjacent improvements. Shoring would be required to mitigate risks of structural failure. Soil mixing creates substantial potential for worker exposure. Added complexity of implementing two different remedial techniques. Two separate mobilizations required using two different sets of equipment.	Larger excavation than Alternative 1, with greater potential for releases to air and surface water during construction and increased potential for worker exposure. Increased transportation increases short-term risks. Greater potential to adversely affect adjacent improvements; increased shoring would be required compared to Alternative 1 to mitigate risks of structural failure.
	Rating	8	4	4

TABLE 13-1: COMPARISON OF SOURCE AREA REMEDIATION ALTERNATIVES

ExxonMobil/ADC Site, Ecology Site ID 2728 Everett, Washington

Standards/Criteria		Alternative 1: LNAPL Area Excavation and Natural Source Zone Attenuation	Alternative 2: LNAPL Area Excavation and Source Area Stabilization	Alternative 3: Source Area Excavation
Technical and Administrative Implementability	Pros	Somewhat less invasive than Alternative 3. Could be implemented with local contractors. Natural source zone attenuation is non-invasive and can be readily implemented.	Portions of the work could be performed by local contractors. Soil stabilization is a frequently used technology. Natural source zone attenuation is non-invasive and can be readily implemented.	Could be implemented with local contractors. Natural source zone attenuation is non-invasive and can be readily implemented.
	Cons	Excavation would be difficult due to Site conditions. Requires excavation through water, increasing the potential for releases to adjacent properties or surface water. Groundwater management would be difficult; permitting and safeguards would be difficult to implement. Requires agreements with City of Everett, Port of Everett, and KC property owner concerning remaining LNAPL in inaccessible areas. Potential for inducing LNAPL movement from inaccessible areas.	Excavation would be difficult due to Site conditions. Requires excavation through water, increasing the potential for releases to adjacent properties or surface water. Groundwater management would be difficult; permitting and safeguards would be difficult to implement. Requires agreements with City of Everett, Port of Everett, and KC property owner concerning remaining LNAPL in inaccessible areas. Potential for inducing LNAPL movement from inaccessible areas. Specialty contractor and equipment would be needed for soil stabilization. Second mobilization would be required. Site-specific pilot testing has not been completed.	Excavation would be difficult due to Site conditions. Requires excavation through water, increasing the potential for releases to adjacent properties or surface water. Groundwater management would be difficult; permitting and safeguards would be difficult to implement. Requires agreements with City of Everett, Port of Everett, and KC property owner concerning remaining LNAPL in inaccessible areas. Higher potential for inducing LNAPL movement from inaccessible areas than Alternatives 1 & 2.
	Rating	9	4	6
Public Concerns	Pros	Expected to be accepted by public.	Expected to be accepted by public.	Expected to be accepted by public.
	Cons	Some concern may result due to contamination left in soil/source areas and inaccessible areas and the long-term risk management approach.	Some concern may result due to contamination left in soil/source areas and inaccessible areas and the long-term risk management approach. Greatest amount of construction related traffic. Port of Everett will likely not permit ISS on port property.	Some concern may result due to contamination in inaccessible areas and the long-term risk management approach. Community concern may result due to increased truck transportation relative to Alternative 1.
	Rating	8	4	7
Restoration Time Frame	Pros	Shortest initial construction time. Partial removal of source area contamination may somewhat shorten restoration time. Source area COCs remaining after implementation are expected to attenuate by natural processes. LNAPL and COCs in inaccessible areas are expected to slowly degrade by natural degradation processes.	Partial removal and ISS of source area contamination would be completed in a short time, but slightly longer than for Alternative 1. COCs remaining in source areas after implementation would have reduced mobility. LNAPL and COCs in inaccessible areas are expected to slowly degrade by natural degradation processes.	Removal of source area contamination may somewhat shorten Site restoration time. LNAPL and COCs in inaccessible areas are expected to slowly degrade by natural degradation processes.
	Cons	Site COCs would remain in source areas and inaccessible areas following remediation activities and slowly attenuate by natural degradation processes. LNAPL would remain in inaccessible areas and slowly attenuate by natural degradation processes.	Construction time longer than Alternative 1 and longer than Alternative 3. Site COCs and/or LNAPL would remain in the inaccessible areas following remediation activities. COCs would remain in source areas for an extended time. Stabilized soil may slightly hinder natural attenuation processes for COCs in source area.	Construction time longer than Alternative 1. Site COCs and/or LNAPL would remain within inaccessible areas following active remediation.
	Rating	7	6	7

TABLE 13-1: COMPARISON OF SOURCE AREA REMEDIATION ALTERNATIVES

ExxonMobil/ADC Site, Ecology Site ID 2728 Everett, Washington

Standards/Criteria		Alternative 1: LNAPL Area Excavation and Natural Source Zone Attenuation	Alternative 2: LNAPL Area Excavation and Source Area Stabilization	Alternative 3: Source Area Excavation
Sustainability	Pros	Resource use for excavation and transportation is lower than for Alternatives 2 and 3. Non-invasive processes applied for remediation of portion of source areas and inaccessible areas.	Resource use is comparable to Alternative 3. Non-invasive processes applied for remediation of inaccessible areas.	Resource use is comparable to Alternative 2. Non-invasive processes applied for remediation of inaccessible areas.
	Cons	Significant requirements for waste transportation and use of landfill capacity for disposal. Requires long-term monitoring program for remaining LNAPL and COCs in source areas and inaccessible areas.	Significant requirements for waste and material transportation and significant use of landfill capacity for disposal. Requires long-term monitoring program for remaining LNAPL and COCs in the source areas and inaccessible areas.	Greatest requirements for waste transportation and landfill capacity for disposal. Requires long-term monitoring program for remaining LNAPL and COCs in the inaccessible areas.
	Rating	8	6	4
RATING TOTAL		**72**	**52**	**58**
OVERALL BENEFIT		**63**	**47**	**54**

Notes:
Comparison Ratings:
10 = Exceptional. This rating indicates an alternative fully achieves the criterion.
5 = Medium. Alternative partially achieves the requirements for the criterion.
1 = Very Low. The alternative does not achieve the requirements for the criterion.
Rating total = sum of ratings for all nine criteria. Overall benefit = sum of rating for all criteria except cost

Abbreviations:
COC = contaminants of concern
KC = Kimberly-Clark Corporation
LNAPL = light nonaqueous phase liquid

TABLE 13-2: PRELIMINARY COST ESTIMATE FOR SOURCE AREA ALTERNATIVES

ExxonMobil/ADC Property, Ecology Site ID 2728

Everett, Washington

Description	Rate	Units	Alternative 1: LNAPL Area Excavation and Natural Source Zone Attenuation		Alternative 2: LNAPL Area Excavation and Source Area Stabilization		Alternative 3: Source Area Excavation	
			Quantity	Cost	Quantity	Cost	Quantity	Cost
Contractor Cost								
Mobilization/Demobilization	$100,000	LS	4	$400,000	6	$600,000	5	$500,000
Site Setup	$50,000	LS	2	$100,000	3	$150,000	3	$150,000
Structures Removal and Restoration	$75,000	LS	2	$150,000	3	$225,000	3	$225,000
Soil Stabilization (1% bentonite, 10% cement)	$57	CY	0	$0	5,500	$314,000	0	$0
Existing Asphalt Removal	$12	CY	600	$8,000	800	$10,000	800	$10,000
Asphalt Paving	$140	TON	1,200	$168,000	1,600	$224,000	1,600	$224,000
Soil Excavation (including sloping)	$17	CY	11,900	$203,000	11,900	$203,000	14,800	$252,000
Stockpile/placement of clean sloping for fill	$10	CY	1,000	$10,000	1,000	$10,000	600	$6,000
Backfill Import	$26	TON	16,800	$437,000	13,300	$346,000	22,400	$583,000
Soil Transport & Disposal	$87	TON	16,800	$1,462,000	16,000	$1,392,000	22,400	$1,949,000
Sheet Pile Shoring	$33	SF	15,700	$519,000	15,700	$519,000	24,000	$792,000
Stormwater Treatment System Operation	$43,000	MO	4	$172,000	5	$215,000	5	$215,000
Security Fence	$38	LF	600	$23,000	600	$23,000	600	$23,000
SUBTOTAL				**$3,652,000**		**$4,231,000**		**$4,929,000**
Sales Tax	9.7	%		$354,000		$410,000		$478,000
CONTRACTOR COST				**$4,006,000**		**$4,641,000**		**$5,407,000**
Consultant Cost								
Field Investigation	$100,000	LS	1	$100,000	2	$200,000	1	$100,000
Access Agreements	$100,000	LS	1	$100,000	1	$100,000	1	$100,000
Well Abandonment	$800	LS	20	$16,000	20	$16,000	20	$16,000
Surveying	$2,300	Day	15	$35,000	15	$35,000	15	$35,000
Design	$50,000	LS	3	$150,000	4	$200,000	3	$150,000
Permitting	$40,000	LS	2	$80,000	2	$80,000	2	$80,000
Project Management	$2,500	MO	20	$50,000	20	$50,000	20	$50,000
Sampling and Analysis	$50,000	LS	2	$100,000	4	$200,000	3	$150,000
Archeological Oversite	$5,000	LS	1	$5,000	1	$5,000	1	$5,000
Construction Management	$15,000	WK	20	$300,000	28	$420,000	28	$420,000
Construction Report	$50,000	LS	1	$50,000	2	$100,000	1	$50,000
Institutional Controls	$75,000	LS	1	$75,000	1	$75,000	1	$75,000
Risk Management Planning	$60,000	LS	1	$60,000	1	$60,000	1	$60,000
CONSULTANT COST				**$1,121,000**		**$1,541,000**		**$1,291,000**
CAPITAL COST SUBTOTAL				**$5,127,000**		**$6,182,000**		**$6,698,000**
CONTINGENCY	1	%	10	$513,000	15	$927,000	10	$670,000
TOTAL CAPITAL COST				**$5,640,000**		**$7,109,000**		**$7,368,000**
Operation and Maintenance								
Years 1 through 5								
NSZA Rate Measurements	$500	EA	25	$12,500	25	$12,500	25	$12,500
Gauging & Bailing	$1,300	EA	60	$78,000	60	$78,000	60	$78,000
Non-Hazardous Oil Disposal	$250	Drum	10	$2,500	10	$2,500	10	$2,500
Project Management	$29,000	Annual	5	$145,000	5	$145,000	5	$145,000
Years 6 through 50								
Gauging & Bailing	$1,300	EA	175	$227,500	175	$227,500	175	$227,500
Non-Hazardous Oil Disposal	$250	Drum	55	$13,800	55	$13,800	55	$13,800
NSZA Rate Measurements	$500	EA	50	$25,000	50	$25,000	50	$25,000
Project Management	$6,000	Annual	45	$270,000	45	$270,000	45	$270,000
O&M COST SUBTOTAL				**$761,800**		**$761,800**		**$761,800**
Contingency	1	%	10	$76,000	15	$114,000	10	$76,000
TOTAL O&M COST				**$837,800**		**$875,800**		**$837,800**
TOTAL ESTIMATED COST				**$6,478,000**		**$7,985,000**		**$8,206,000**
50 Year NPV (1.6% net discount rate)				**$6,145,000**		**$7,591,000**		**$7,829,000**

Abbreviations:

CY = cubic yard
EA = each
LF = linear feet
LS = lump sum
MO = month
NPV = net present value
NSZA = natural source zone attentuation
O&M = operation and maintenance
SF = square feet
WK = week

TABLE 13-3: COMPARISON OF GROUNDWATER REMEDIATION ALTERNATIVES

ExxonMobil/ADC Site, Ecology Site ID 2728 Everett, Washington

Standards/Criteria		Alternative 1: Monitored Natural Attenuation	Alternative 2: Funnel and Gate
Protectiveness	Pros	Protective of human health and the environment. Intrinsic biodegradation is active at Site and is presently achieving PCLs at proposed CPOC. Relies on natural constituent degradation processes that are currently active at Site.	Protective of human health and the environment. Provides more robust means to remove groundwater COCs. Combines engineered component with ongoing natural attenuation processes.
	Cons	Effectiveness must be maintained for long-term attenuation of COCs from inaccessible areas.	Requires long-term operation and maintenance to maintain effectiveness. Could decrease effectiveness of natural attenuation process by removing substrate from groundwater. Inaccessible areas would require long-term maintenance of engineered components.
	Rating	8	7
Permanence	Pros	Permanently destroys or reduces toxicity of COCs by natural processes. Natural attenuation is currently active at the Site.	Immobilizes COCs on sorbent media. Destroys or reduces toxicity of non-adsorbed COCs by natural processes.
	Cons	Relies on natural environmental conditions that could change.	Relies on active maintenance and natural environmental conditions that could change. Implementation time would be associated with funnel and gate construction.
	Rating	9	7
Cost	Pros	Lower cost than Alternative 2. Total cost less than half of Alternative 2.	None. High cost alternative.
	Cons	Long-term monitoring required to confirm effectiveness.	Long-term monitoring and maintenance required to maintain and confirm effectiveness. Construction cost substantially higher than Alternative 1.
	Rating	9	4
Long-Term Effectiveness	Pros	Intrinsic biodegradation is effective at present for releases that occurred more than 50 years ago and is expected to remain effective in the future due to reliance on indigenous organisms and natural processes.	Proven technologies used for this alternative that are known to be effective. The PRB has a fixed life but is backed up by MNA.
	Cons	No active control over natural attenuation rate.	Active maintenance required to maintain effectiveness of sorbent media in the PRB. The PRB may affect intrinsic biodegradation downgradient of the funnel and gate due to altering the substrate composition in that area.
	Rating	9	6
Management of Short-Term Risks	Pros	Very limited construction required for implementation, thereby minimal potential for short-term risk.	Funnel and gate construction occurs in area with fairly low levels of groundwater contamination.
	Cons	Minor potential for short-term risk due to installation of monitoring wells.	Excavation required for installation of funnel and gate system, creating short-term health and safety risks during implementation.
	Rating	9	6
Technical and Administrative Implementability	Pros	Simple alternative that can be implemented within 1–2 days by multiple local contractors, with minimal permitting requirements and access agreements that already have been negotiated.	Proven technologies that can be readily installed by specialty contractors.
	Cons	Access agreements required for monitoring wells and CPOC.	Construction occurs on third party property and within active industrial areas, requiring more complex access agreements and scheduling to avoid adversely affecting ongoing industrial operations. Access agreements required for monitoring wells and CPOC. Ongoing access needed to inspect and maintain funnel and gate.
	Rating	8	5
Public Concerns	Pros	Expected to be accepted by public.	Expected to be accepted by public.
	Cons	May be some concern due to reliance on intrinsic biodegradation, a passive remedy.	May be some concern due to ultimate reliance on a passive remedy.
	Rating	7	7
Restoration Time Frame	Pros	Natural attenuation is currently achieving cleanup standard at anticipated CPOC.	Natural attenuation is currently achieving cleanup standard at anticipated CPOC.
	Cons	None. Natural attenuation has been effective at Site.	Funnel and gate would not affect restoration time frame.
	Rating	9	9

TABLE 13-3: COMPARISON OF GROUNDWATER REMEDIATION ALTERNATIVES

ExxonMobil/ADC Site, Ecology Site ID 2728 Everett, Washington

Standards/Criteria		Alternative 1: Monitored Natural Attenuation	Alternative 2: Funnel and Gate
Sustainability	Pros	Minimal requirements for materials, equipment, and transportation to implement this alternative. Remedy relies on natural, passive processes that are already active at Site.	Readily available materials are used for remedy construction. The remedy operates using a combination of natural processes and an engineered component that requires limited active operation.
	Cons	None. Natural attenuation has been effective at Site.	The PRB requires active monitoring and maintenance to ensure effectiveness. A significant amount of waste would be generated from construction that would require off-Site transportation and disposal. Additional waste generation may occur in the future due to maintenance of the PRB.
	Rating	9	6
RATING TOTAL		**77**	**57**
OVERALL BENEFIT		**68**	**53**

Notes:
Comparison Ratings:
10 = Exceptional. This rating indicates an alternative fully achieves the criterion.
5 = Medium. Alternative partially achieves the requirements for the criterion.
1 = Very Low. The alternative does not achieve the requirements for the criterion.
Rating total = sum of ratings for all nine criteria. Overall benefit = sum of rating for all criteria except cost

Abbreviations:
COC = constituent of concern
CPOC = conditional point of compliance
MNA = monitored natural attenuation
PCL = preliminary cleanup level
PRB = permeable reactive barrier

TABLE 13-4: PRELIMINARY COST ESTIMATE FOR GROUNDWATER ALTERNATIVES

ExxonMobil/ADC Property, Ecology Site ID 2728

Everett, Washington

Description	Rate	Units	Alternative 1: Monitored Natural Attenuation		Alternative 2: Funnel and Gate	
			Quantity	Cost	Quantity	Cost
Contractor Cost						
Mobilization/Demobilization	$50,000	LS		$0	1	$50,000
Site Setup	$20,000	LS		$0	1	$20,000
Structure Removal and Restoration	$150,000	LS		$0	1	$150,000
Low Permeability Barrier Wall	$25	SF		$0	4,500	$113,000
Low Permeability Barrier Import	$21	TON		$0	1,000	$21,000
Reactive Barrier Vault	$50,000	EA		$0	1	$50,000
Reactive Media	$2,500	TON		$0	80	$200,000
Asphalt Paving	$140	TON		$0	60	$9,000
Soil Transport & Disposal	$87	TON		$0	2,000	$174,000
SUBTOTAL				**$0**		**$787,000**
Sales Tax	9.7	%		$0		$76,300
CONTRACTOR COST				**$0**		**$863,300**
Consultant Cost						
Field Investigation	$25,000	LS	0	$0	1	$25,000
Monitoring Well Installation	$2,500	EA	1	$3,000	1	$3,000
Surveying	$2,000	Day	1	$2,000	3	$6,000
Design	$60,000	LS	0	$0	1	$60,000
Permitting	$20,000	LS	0	$0	1	$20,000
Project Management	$2,500	MO	1	$2,500	4	$10,000
Sampling and Analysis	$10,000	LS	1	$10,000	2	$20,000
Construction Management	$15,000	WK	0.5	$8,000	8	$120,000
Construction Report	$5,000	LS	1	$5,000	4	$20,000
CONSULTANT COST				**$30,500**		**$284,000**
CAPITAL COST SUBTOTAL				**$30,500**		**$1,147,300**
CONTINGENCY	10	%		$3,000		$115,000
TOTAL CAPITAL COST				**$34,000**		**$1,262,000**
Monitoring and/or Maintenance						
Years 1 through 5						
Reactive Media Excavation and Disposal	$30,000	Round	0	$0	0	$0
Reactive Barrier Media Replacement	$50,000	Annual	0	$0	0	$0
IDW Disposal	$1,000	Annual	5	$5,000	5	$5,000
Groundwater Monitoring	$15,000	EA	10	$150,000	10	$150,000
Reports	$5,100	EA	10	$51,000	10	$51,000
Project Management		Annual	5	$0	5	$0
Years 6 through 50						
Reactive Barrier Excavation and Disposal	$30,000	Annual	0	$0	3	$90,000
Reactive Barrier Media Replacement	$50,000	Annual	0	$0	3	$150,000
IDW Disposal	$500	Annual	15	$7,500	15	$7,500
Well Maintenance	$2,000	EA	10	$20,000	10	$20,000
Groundwater Monitoring	$15,000	EA	15	$225,000	15	$225,000
Reports	$5,100	EA	15	$76,500	15	$76,500
Well Decommissioning	$600	EA	16	$9,600	16	$9,600
Project Management		Annual	15	$0	15	$0
O&M COST SUBTOTAL				**$544,600**		**$784,600**
Contingency	10	%		$54,460		$78,460
TOTAL O&M COST				**$599,060**		**$863,060**
TOTAL ESTIMATED COST				**$633,000**		**$2,125,000**
50 Year NPV (1.6% net discount rate)				**$545,000**		**$1,992,000**

Abbreviations:

EA = each

IDW = investigation-derived waste

LS = lump sum

MO = month

NPV = net present value

O&M = operation and maintenance

SF = square feet

WK = week

TABLE 14-1: DISPROPORTIONATE COST ANALYSIS FOR REMEDIATION ALTERNATIVES

ExxonMobil/ADC Site, Ecology Site ID 2728 Everett, Washington

	Item	Source Area Alternatives			Groundwater Alternatives	
		1: LNAPL Area Excavation and Natural Source Zone Attenuation	2: LNAPL Area Excavation and Source Area Stabilization	3: Source Area Excavation	1: Monitored Natural Attenuation	2: Funnel and Gate
Description of Alternatives[1]						
Components	Total Estimated NPV Cost[2] (2018 $)[3]	**$6,145,000**	**$7,591,000**	**$7,829,000**	**$545,000**	**$1,992,000**
	Institutional Controls	Yes	Yes	Yes	Yes	Yes
	Engineering Controls	Yes	Yes	Yes	No	Yes
	Contamination left in place	Yes	Yes	Yes	Yes	Yes
	Waste Disposal Off Site (tons)	16,800	16,000	22,400	Minimal	2,000
	LNAPL Recovery	Yes	Yes	Yes	No	No
	LNAPL Removal during Construction (gal)	800	800	1,000	Minimal	Minimal
Disproportionate Cost Analysis						
	Criteria	**Score**	**Score**	**Score**	**Score**	**Score**
DCA & Relative Benefits Ranking Comparison	Protectiveness	8	8	9	8	7
	Permanence	8	8	9	9	7
	Long-Term Effectiveness	7	7	8	9	6
	Management of Short-Term Risks	8	4	4	9	6
	Technical and Administrative Implementability	9	4	6	8	5
	Public Concerns	8	4	7	7	7
	Restoration Time Frame	7	6	7	9	9
	Sustainability	8	6	4	9	6
	Overall Benefit Rating	63	47	54	68	53
	Ratio of Cost/Benefit	$98,000	$162,000	$145,000	$8,000	$38,000

Notes:

1. The comprehensive Site remedy will consist of one soil/source area alternative and one groundwater alternative.
2. 50 years, 1.6 percent net discount rate.
3. Amounts are in US dollars.

Abbreviations:

DCA = disproportionate cost analysis
gal = gallons
LNAPL = light nonaqueous phase liquid
NPV = net present value