



**Updated Supplemental Remediation Investigation  
Report  
Former Pope & Talbot Wood-Treating Site  
ECSI ID #959  
St. Helens, Oregon**

*Prepared for:*

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**Project No. 0034-001-005**

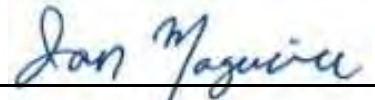
**January 17, 2020**

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EXPIRES: 06/30/2021

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## 1.0 INTRODUCTION

Cascadia Associates, LLC (Cascadia), on behalf of the Port of Columbia County (“Port”; formerly Port of St. Helens), has updated the Supplemental Remedial Investigation (RI) Report for the Former Pope & Talbot (P&T) wood-treating facility (Environmental Cleanup Site Information [ECSI] #959) located in St. Helens, Oregon. This updated supplemental RI was conducted to address deficiencies in the original RI (GeoEngineers, 2000) and initial phases of the supplemental RI (AMEC, 2014) as noted by the Oregon Department of Environmental Quality (DEQ) in a series of comment letters between March 18, 2010 (DEQ, 2010a) and August 2019 (DEQ, 2019c).

The former P&T wood-treating site is located at 1550 Railroad Avenue in St. Helens, Oregon (**Figure 1-1**), and is currently owned by the Port. To be consistent with prior environmental reports, the upland portion of the 1550 Railroad Avenue Port-owned property is referred to herein as the “Site”. Please note for clarity that the “Site” is different from the term “Locality of Facility” (LOF) used in this and prior reports to include upland and offshore contaminated areas.

The Site and its LOF have been the subject of a Remedial Investigation/Feasibility Study (RI/FS) since DEQ issued an Order of Consent No. WMCSR-NWR-95-05 (Order) in 1995. The 1995 Order named the Port and P&T as potentially responsible parties (PRPs). Between 1996 and 2006, multiple investigation activities were completed on behalf of the PRPs, including the initial RI, which was predominately focused on the upland areas (GeoEngineers, 2000). In May 2007, following the completion of a baseline Human Health Risk Assessment (HHRA) (Kennedy/Jenks Consultants, 2006), P&T submitted a draft outline for a Feasibility Study (FS) report to DEQ (Bridgewater Group, Inc., 2007), which was predominately focused on residual contamination beneath the Site’s upland areas. In August 2007, DEQ issued a letter stating that it was not able to evaluate the proposed cleanup alternatives because the offshore extent of contamination had not been fully delineated (DEQ, 2007b). In November 2007, P&T declared bankruptcy and the Port became the sole PRP responding to the 1995 Order.

### 1.1 SITE AREA DESIGNATIONS

In 2008, DEQ approved formally subdividing the upland portion of the Site into two parcels: Area 1 and Area 2 (DEQ, 2008). Area 1 is 25.15 acres in size and includes the locations of the former wood-treating plant, former transfer table, loading platforms (including docks), and the underground portion of the creosote pipeline. Area 2 covers 17.32 acres and includes the northeastern portion of the Site, which has been minimally impacted by historical creosote wood-treating activities.

**Figure 1-2** presents the entire Site, significant historical features, and the Area 1/Area 2 division.

The U.S. Army Corps of Engineers (USACE) Ordinary High-Water Mark (OHWM) is a jurisdictional benchmark for administering its regulatory program in navigable waterways under Section 10 of the Rivers and Harbors Act and Section 404 of the Clean Water Act. The OHWM, as defined in 33 CFR 328.3, is the line on the riverbank established by fluctuations of water and indicated by

physical characteristics such as a clear, natural line impressed on the bank, shelving, changes in the character of the soil, destruction of terrestrial vegetation, or the presence of litter and debris. For purposes of the RI/FS, land above the OHWM is referred to as “upland” and the portion of the riverbank/sediment below the OHWM is referred to as “in-water.” The OHWM at the Site appears to correspond to a vertical elevation of approximately 14 feet relative to the North American Vertical Datum of 1988 (NAVD88).

The 2000 RI, 2006 HHRA, and 2006 ERA concluded that upland portions of Area 2 would not be part of active remediation to address residual creosote (AMEC, 2008). DEQ approved a Conditional No Further Action (NFA) request for Area 2 provided the Port met the following conditions:

1. Any soil excavated on the Site would have to be sampled according to a soil management plan approved by DEQ and the soil managed appropriately based on sampling results;
2. Any excavation would be managed under an appropriate health and safety plan;
3. Use of groundwater at the Site would be restricted; and
4. Soil erosion would be controlled using best management practices.

Most supplemental RI activities occurred within Area 1 and in-water areas offshore of Area 1. However, this Updated Supplemental RI Report includes the findings of shoreline inspections conducted adjacent to Area 2. Data presented are generally those collected since 2010 and the start of the supplemental RI (**Section 1.2**), with some exceptions as noted within the report.

## 1.2 OBJECTIVES AND PHASES OF THE SUPPLEMENTAL REMEDIAL INVESTIGATION

The following RI data gaps required resolution prior to moving forward with completion of the FS:

1. Define the lateral and vertical extent of creosote as a nonaqueous phase liquid (NAPL) in offshore sediment adjacent to the Site;
2. Further define the upland extent of NAPL and/or contaminated soil areas potentially contributing to offshore contamination;
3. Further assess groundwater conditions beneath Area 1 and the quality of groundwater discharging into the adjacent surface water bodies (Scappoose Bay and Milton Creek); and
4. Further evaluate risk to aquatic receptors near but outside the offshore extent of NAPL.

Between 2008 and 2013, multiple supplemental RI activities were conducted on behalf of the Port to delineate the nature and extent of creosote-related impacts within Scappoose Bay and Milton Creek adjacent to the former wood treatment operations (i.e., Area 1). In July 2011, DEQ requested the characterization of dissolved-phase creosote constituents in sediment porewater outside the NAPL delineated areas. The initial porewater assessment was completed in 2012, except for beneath the unstable former transfer table dock. The transfer table dock deck was removed,

allowing sediment beneath the dock to be investigated in October 2013. On May 22, 2014, a draft Supplemental RI report, with updates to the HHRA and ERA, was submitted to DEQ (AMEC, 2014). In March and September 2015, DEQ issued a series of comments on the draft Supplemental RI Report on (DEQ, 2015a, 2015b), which led to a dispute with the Port over the need for active remediation within approximately 6 acres of Scappoose Bay. Working closely with DEQ, the Port completed additional offshore data gap investigations between 2017 and 2018 to further assess risk to ecological receptors within the disputed offshore areas (Cascadia, 2017a, 2017b, 2017c 2018, 2019a). The results of these latest supplemental RI activities led DEQ to conclude that the objectives of the RI had been fulfilled. Completion of the RI objectives facilitated the identification of upland and in-water “priority action areas” (PAAs) requiring active remedy consideration in the FS versus those offshore areas where remedies less invasive than capping or dredging, such as enhanced or monitored natural attenuation, are likely to be appropriate (DEQ, 2019a). The PAAs are characterized by (1) creosote as NAPL in media (soil, groundwater, sediment, surface water) that is readily accessible to human and ecological receptors (e.g., groundwater seep in riverbank, upper 1 foot of sediment, surface water), and/or (2) contaminant concentrations that result in unacceptable ecological risk with a high degree of certainty (e.g., dissolved-phase constituents above ecological criteria).

NAPL is a term used to describe the petroleum hydrocarbons in creosote that exist as a separate, immiscible phase when in contact with water and/or air. Differences in the physical and chemical properties of water and NAPL result in the formation of a physical interface between the liquids which prevents the two fluids from mixing. The upland extent of NAPL includes areas where a distinct immiscible phase creosote liquid was observed in subsurface soil samples or measured in groundwater monitoring wells. The offshore extent of NAPL includes sediment, riverbank seeps, porewater, and surface water areas exhibiting a moderate to heavy petroleum sheens.

### 1.3 REPORT ORGANIZATION

This Supplemental RI Report contains the following sections.

1. Introduction.
2. Site Background – A summary of current and past land use, prior environmental studies conducted at the Site, the previous understanding of Site physical conditions (soil and groundwater), and the previous understanding of Site-related contamination.
3. Supplemental RI Activities – A summary of investigation activities conducted under the supplemental RI.
4. Updated Site Setting – A summary of the Site setting (geology and hydrogeology) based on the supplemental RI activities.

5. Nature and Extent of Contamination – A summary of Site contamination in soil, groundwater, groundwater seeps, sediment, sediment porewater, surface water, and the occurrence of NAPL.
6. Contaminant Fate and Transport – A description of contaminant transport from release areas to areas where contaminants are currently distributed in various Site media.
7. Beneficial Water Use Determination – An update of the Beneficial Water Use Determination (BWUD).
8. Data Completeness Evaluation – A summary of supplemental RI data collected and an evaluation of the completeness of those data (i.e., whether supplemental RI objectives have been met).
9. Conceptual Site Model – An updated summary of the Conceptual Site Model (CSM).
10. Risk Assessment Conclusions – A summary of project conclusions for human health and ecological receptors.
11. Hot Spots and Priority Action Areas – A summary of the determination of Site hot spots, as defined in DEQ guidance, and identification of priority action areas.
12. Conclusions – A summary of key conclusions from the RI and supplemental RI activities, including a statement of RI completion and next steps.

## 2.0 SITE BACKGROUND

A wood-treating facility was established at the Site in 1912, and wood-treating operations continued until 1960. The primary wood-treating formula used was creosote. Pentachlorophenol (PCP) and chromated copper arsenate were apparently used in limited quantities in 1953/1954. The Port purchased the property in 1963, and since then, the Site has either been vacant or leased for the following industrial uses:

- Pole peeling and pole storage facility (1974 to 1991);
- Storage yard for a marine construction/dredging company (1993 to 1998);
- Small private wood-working business (2000 to 2005);
- Marine log salvage and sawmill (2006 to 2008);
- Log storage, pole peeling, and sawmill (2009 to 2012); and
- Miscellaneous small-scale private businesses (2014 to present).

Historical site plans and aerial photographs are provided in **Appendix A**.

The Site was vacant between 1960 and 1974 after the wood-treating plant was removed by P&T. The Port arranged for the Site to be filled in the early 1970s in an effort to level and raise its surface grade by several feet. Fill material is reported to consist of dredge material generated from deepening of the Columbia River. This fill material overlies native alluvium that represented the ground surface during the time of wood-treating operations, and comprises the fill identified in RI boring logs, as further discussed in **Section 2.3.1**.

### 2.1 LAND USE

The Site encompasses 42 acres located within the city limits of St. Helens, Oregon. The Site is generally vacant, aside from a leased shop/warehouse building located in the western half of the Site. Adjacent land uses include railroad tracks and undeveloped land to the north and City-owned industrial development (formerly Boise Paper Solutions) to the northeast. Milton Creek forms the western Site boundary, and Scappoose Bay and the Multnomah Channel of the Willamette River form the southern and eastern Site boundaries. An aerial photograph showing Site conditions as of 2018 is provided in **Figure 1-2**.

The Site is currently designated as part of the Railroad Avenue Industrial Park (RAIP) by the Port. The RAIP is zoned as Heavy Industrial by the City of St. Helens (City of St. Helens, 2012; Port, 2012). The Heavy Industrial zoning designation is intended to provide appropriate locations for intensive manufacturing activities in areas separated from sensitive land uses, such as schools (City of St. Helens, 2014). Permitted and conditional uses for land zoned for Heavy Industrial use are described in the City of St. Helens Municipal Code, Section 17.32.140.

## 2.2 PREVIOUS STUDIES

Studies conducted prior to the 2000 RI Report are described in Section 3 of that report and are identified below.

### *Pre-RI Activities*

- The United States Environmental Protection Agency (EPA) conducted a site inspection in 1989 (Ecology & Environment, Inc., 1990).
- P&T conducted a “Vadose Zone Contamination Investigation” of the site in 1993 (Harding Lawson Associates [HLA], 1994).

Studies used as part of the original 2000 RI Report are identified below.

### *1996-1998 RI Activities*

- P&T and the Port initiated the RI in 1996 with an investigation of upland soil and groundwater and in-water sediment and surface water immediately adjacent to the Site’s shorelines (GeoEngineers, 2000). All media samples were submitted for chemical analysis for one or more of the following contaminants of potential concern (COPC): total petroleum hydrocarbons (TPH); volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), chlorinated phenols; dioxins/furans, and select metals (arsenic, cadmium, chromium, copper, lead, and zinc).
- In 1998, P&T and the Port further investigated surface soil, subsurface soil, groundwater, riverbank seeps, surface water, and bedrock (including permeability testing) for creosote-related constituents. Additionally, Site roadbed material (surface soil) was evaluated for the presence of polychlorinated biphenyls (PCBs; GeoEngineers, 2000).

Studies conducted after the data set used in the 2000 RI Report, but before the commencement of the supplemental RI in 2010, are summarized below.

### *1999-2006 RI/RA Activities*

- Annual groundwater monitoring was conducted in 1999, 2000, 2001, 2003, 2004, 2005, and 2006 (Bridgewater Group, Inc., 2004, 2005, 2006). Groundwater samples were analyzed for TPH, benzene, toluene, ethylbenzene, and total xylenes (BTEX); polycyclic aromatic hydrocarbons (PAHs); and dissolved metals (arsenic, cadmium, chromium, copper, lead, and zinc).
- Sediment sampling was completed in 2003, 2004, and 2005 as part of an ERA (Bridgewater Group, Inc., and Kennedy/Jenks Consultants, 2006). Offshore surface sediment samples obtained adjacent to the Site and from background locations were analyzed for one or more of the following constituents: PAHs, arsenic, total organic carbon (TOC), total sulfides, ammonia, grain size distribution, and bioassay testing.



- A baseline HHRA and ERA was completed in 2006 (Bridgewater Group and Kennedy Jenks Consultants, 2006).

## 2.3 PHYSICAL SITE CONDITIONS

The current understanding of Site physical conditions is largely unchanged from that presented in the 2000 RI Report.

The former P&T facility was constructed on an outcrop of Columbia River basalt bedrock thinly mantled with recent alluvial sediments. The Site, located along the western boundary of the Portland basin, is within a complex of streams, sloughs, and wetlands where regional groundwater discharges. The topography of the Site upland areas is relatively flat, with a gentle downward slope toward Area 2 from the central portion of Area 1. The shoreline along Scappoose Bay/Multnomah Channel and Milton Creek is generally characterized by relatively steep, vegetated embankments. The elevation of the Site ranges between approximately 15 and 25 feet (relative to NAVD88). Area 1 upland topography and in-water bathymetry is illustrated on **Figure 2-1**. The Site margins, particularly the northeastern portion, are prone to annual flooding. As mentioned above in **Section 1.1**, land above the OHWM (approximately 14 feet NAVD88) is referred to as “upland” and the portion of the riverbank/sediment below the OHWM is referred to as “in-water.”

### 2.3.1 Soil Conditions

Soil encountered at the Site consists of fill underlain by native soil, which in turn is underlain by basalt bedrock. A summary of the subsurface conditions is provided below; more detail on each of these units, based on information from the 2000 RI and 2014 supplemental RI, is provided in **Section 4.1**. **Figure 2-2** shows a conceptual cross section of each these units:

- The imported fill consists predominantly of dredge sand with localized areas of silt, coarse gravel, cobbles, wood chips, and metal and brick debris. For the purposes of this report, this unit is defined as the “Fill Zone.”
- Native soil beneath the Fill Zone consists primarily of silt with varying amounts of fine sand, clay, and organic matter. Basalt fragments was encountered near the transition to bedrock. For the purposes of this report, this unit is defined as the “Native Soil.”
- Basalt bedrock was generally encountered at depths between 6 and 35 feet below ground surface (bgs). Bedrock beneath the Site is part of the Grande Ronde flows of the Columbia River Basalt. For the purposes of this report, this unit is defined as the “Basalt Bedrock.”

### 2.3.2 Groundwater Conditions

Groundwater encountered beneath the Site is unconfined and resides seasonally within the Fill Zone and within the Native Soil and Basalt Bedrock (**Figure 2-2**). A summary of groundwater conditions is provided below, as supported by Table 4 and Appendix B of the 2000 RI Report.

- Shallow groundwater beneath the Site occurs from immediately below the ground surface to depths of about 12 feet bgs, depending on the season.
- The water table generally replicates the surface topography in the upland/central portion of the Site, with maximum groundwater elevations in the central portion of the Site and groundwater flow (discharge) to the nearest surface water body.
- Hydraulic conductivity within the Fill Zone is approximately 1 to 2 orders of magnitude greater than within the Native Soil. Hydraulic conductivity within the Native Soil is generally 2 to 3 orders of magnitude greater than in the underlying Basalt Bedrock, in the limited locations where the basalt had sufficient permeability for testing.

Additional details regarding the Site's hydrogeologic conditions are presented in **Section 4**.

## 2.4 PREVIOUS UNDERSTANDING OF SITE-RELATED CONTAMINATION

The previous understanding of the nature and extent of soil, groundwater, and surface water contamination for the Site was based on results of the RI, as presented in the 2000 RI Report. The approximate locations of upland RI explorations and sampling locations are shown in the 2000 RI Report, Figures 7 through 10, and are included on **Figure 2-3** in this report.

The previous understanding of the nature and extent of sediment contamination offshore from the Site was based primarily on surface sediment sampling and analysis performed for the ERA in 2003 through 2005, as presented in the ERA Summary Report (Bridgewater Group, Inc., and Kennedy/Jenks Consultants, 2006).

Previous environmental investigations and risk assessments and the associated reports addressed the entire Site; however, the following summary of contaminant conditions focuses on Area 1 of the Site.

### 2.4.1 Contaminants of Potential Concern

COPCs that have been identified for the Site are presented in the Final Work Plan (GeoEngineers, 1996). The list of COPCs was developed based on the EPA presumptive remedies guidance document (EPA, 1993) and data presented in Appendix C of the 2000 RI Report. In general, the Site's list of COPCs in upland soil, groundwater, surface water, and/or sediment resulting from the historical wood-processing and -treating activities that occurred at the Site consists of the following:

- TPH;
- VOCs and SVOCs;
  - PAHs make up the majority of SVOCs detected in Area 1, resulting from the use of creosote as the primary wood-treatment product;



- Certain petroleum-related VOCs, likely originating from the use of “fuel oil” as a creosote solvent or carrier oil;
- Certain metals, resulting from limited use of metal-based wood-treating chemicals during Site operations;
- Minor amounts of PCP and dioxins/furans, resulting from a very limited period (months) of PCP use reported at the Site; and
- Minor amounts of PCBs in surface soil, resulting from apparent presence of PCBs in roadbed oil placed on the Site surface after the wood-treating plant ceased operations and the dredge sand fill had been placed on the Site.

#### 2.4.2 Source Areas

The former wood-treating operations resulted in releases of related raw materials and wastes to the historical (1919 through 1959) ground surface within Area 1. Specific releases are not documented; for the purpose of the RI, sources are defined based on knowledge of historical operations and investigation results that are indicative of creosote releases to the former ground surface (i.e., contamination near the Fill Zone/Native Soil contact). During plant operations, leaks and spills of creosote, a dense non-aqueous phase liquid (DNAPL<sup>1</sup>), seeped into the ground and collected in the Native soil above the Basalt Bedrock within an approximately 4-acre portion of Area 1.

The main upland source area at the Site includes the former wood-treatment plant (i.e., retort pump house and retorts) and former creosote and fuel oil aboveground storage tanks (ASTs) located west and northwest of the wood-treatment plant. This area generally is encompassed by the extent of NAPL as defined through RI activities. Other ancillary operations located within Area 1 appear to have contributed to more localized subsurface contamination in upland areas, such as the yard west of the former ASTs, the buried creosote pipeline, and former transfer table (upland portion). Other ancillary operations immediately adjacent to Area 1, such as the historical wastewater discharge pipe, the former hog fuel loading dock and hopper, and the former transfer table dock, appear to have contributed to more localized contamination of surface and/or near-surface sediment in shoreline and in-water areas. Another significant source of in-water impacts is creosote contaminated wood debris derived from log peeling operations, hog fuel storage and other plant activities. This wood waste material appears to have been shed from the upland, over-water operations, and/or from log rafts historically moored along the shoreline. The woody material, much of it saturated with creosote, settled out over time and eventually was incorporated into the offshore sediment profile. Presently, creosote contaminated wood debris occurs along approximately 1,500 feet of the Scappoose Bay shoreline, extending from the manmade cove

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<sup>1</sup> The terms NAPL and DNAPL are used interchangeably in this report.

downstream to the boundary between upland Area 1 and 2. An additional area of creosote contamination was recently discovered offshore of Area 2.

### 2.4.3 Soil Contamination

Field evidence of creosote contamination was observed in soil samples obtained from most of the RI explorations completed in Area 1, generally near the Native Soil/Basalt Bedrock contact (2000 RI Report Appendix C, Tables C-1 through C-6). Soil contamination related to wood-treating compounds was not encountered at depths of less than 5 feet in any of the Area 1 explorations. In explorations completed within close proximity of the former wood-treating operations, creosote impacts were observed throughout the entire thickness of the Native Soil unit (depths ranging between about 5 feet bgs to the Native Soil/Basalt Bedrock contact at approximately 18 feet bgs). The vertical thickness of creosote-impacted soil appears to decrease with distance from the wood treatment plant and ASTs and is mainly limited to the vicinity of the Native Soil/Basalt Bedrock contact (depths greater than 10 feet bgs). The distribution of creosote-affected soil in the Area 1 explorations was initially interpreted to have resulted from creosote spreading laterally across the upper surface of Basalt Bedrock, and to a lesser extent along the Fill Zone/Native Soil contact; however, more recent data and analysis suggest lateral migration is a minor factor in creosote distribution, as discussed further in **Section 6.3**.

Soil impacted by TPH (specifically oil-range hydrocarbons) was encountered in explorations MW-4A/MW-4B and MW-5, which were completed behind the existing office/shop building at depths of 3 and 5 feet bgs. This localized area of oil-impacted soil located west-northwest of the former wood treatment operations does not exhibit a creosote signature.

### 2.4.4 Groundwater Contamination

In general, TPH, VOCs, and SVOCs associated with creosote were detected in groundwater samples obtained from monitoring wells and Geoprobe® explorations completed in the vicinity of the former wood treating operations (2000 RI Report Appendix C, Tables C-7 through C-16). BTEX represents the majority of VOCs detected in groundwater samples, whereas PAHs represent the majority of the SVOCs detected in groundwater samples. Relatively low levels of metals and chlorinated phenols were detected in Area 1 groundwater samples.

### 2.4.5 Nonaqueous-Phase Liquid

A visible creosote-petroleum product, described herein as NAPL, was observed in subsurface soil samples and in groundwater monitoring wells in Area 1 (represented by the shaded upland area shown on Figure 27 of the 2000 RI Report). NAPL present in this portion of the Site appears to have resulted from the proximity of this area to the former wood treating plant and the topography of the Basalt Bedrock surface. The specific gravity (density), viscosity, and interfacial tension of the NAPL that has periodically accumulated in monitoring wells MW-2 and MW-3A ranges between 0.99 and 1.041 grams per milliliter (g/mL), 30 and 48 centipoise, and 22.2 and 22.9 dynes per centimeter, respectively (Section 7.2.3.2 of 2000 RI Report). The bedrock significantly inhibits downward

vertical migration of the NAPL, based on the physical properties of creosote samples and *in-situ* hydrogeologic data gathered from RI rock core borings.

Chemical analysis of NAPL collected from the bottom of MW-2 and MW-3A indicated the residual creosote is dominated by diesel-range hydrocarbons (which did not match the diesel standard fingerprint) and PAHs (Tables C-18 through C-21 of 2000 RI Report).

Confirming the vertical and lateral extent of upland NAPL and/or areas of contaminated soil potentially contributing to offshore contamination was an objective of the supplemental RI (DEQ, 2010a). Defining the lateral and vertical extent of NAPL beneath Milton Creek and Scappoose Bay adjacent to Area 1 and Area 2 was identified as one of the most important RI data gaps and supplemental RI objectives (DEQ, 2010a).

#### 2.4.6 Seep Water

During periods of low surface water, small localized groundwater seeps have been observed along the steeper sections of the Scappoose Bay and Milton Creek shoreline adjacent to Area 1. Many of these seeps appear to daylight near the Fill Zone/Native Soil interface. Creosote-impacted seeps occasionally are accompanied by a sheen or visible NAPL, although at times the sheen has been a natural (organic) sheen not related to creosote. The platy relatively odorless biogenic sheens, (easily distinguished from the fluid and odoriferous petroleum sheens), likely emanate from areas where upland creosote contamination and wood debris is more completely biodegraded. BTEX and PAHs were detected in October 1998 seep water samples obtained from the Scappoose Bay and Milton Creek shorelines (Section 7.2.4, Figures 10, 23, 24, 25, and Tables C-24 and C-25 of the 2000 RI Report).

#### 2.4.7 Sediment

Shallow sediment conditions (upper 10 centimeters [cm]) along the Area 1 shoreline at the Site were explored by obtaining a series of discrete and composite sediment samples along eight transects and background locations as part of the RI and initial phases of the ERA. The approximate locations of RI and ERA sediment samples are shown on Figure 7 of the 2000 RI Report and on **Figure 2-3**.

Four rounds of surface sediment sampling and analysis were performed along and/or offshore of Site Area 1 and Area 2, with sampling events in 1996, 2003, 2004, and 2005.

The 1996 samples were collected as composite and discrete samples from segments along the Milton Creek and Scappoose Bay shorelines adjacent to Areas 1 and 2. The 2003, 2004, and 2005 samples were primarily collected offshore of Area 1 with a few surface sediment samples obtained upstream and downstream of the Site. The PAH concentrations measured in the 2003 to 2005 sediment samples (with total PAHs ranging from 0.04 to 192 milligrams per kilogram [mg/kg]) are generally consistent with the concentrations measured in the 1996 samples (with total PAHs ranging from 0.18 to 49 mg/kg), although variations were noted in specific samples collected

within close proximity of one another. These variations in sediment bulk chemistry appear to be a function of sediment heterogeneity (e.g., irregular creosote distribution, presence of treated wood debris, varying grain size distribution, and varying amounts of organic material) and not attributed to temporal changes in contaminant mass flux from upland source areas.

Two rounds of bioassay tests were performed for the 2006 ERA to evaluate potential risk to resident benthic invertebrate populations (Bridgewater Group, Inc., and Kennedy/Jenks Consultants, 2006, Section 2.3). The total PAH concentrations in the 18 samples submitted for bioassay testing ranged from 5 mg/kg (in a reference area sample) to 80 mg/kg. Bioassay testing comprised the following three tests:

1. 10-Day amphipod survival test (*Hyalella azteca*);
2. 10-Day midge survival test (*Chironomus tentans*); and
3. 10-Day midge growth test (*Chironomus tentans*).

All of the sediment samples passed the bioassay testing protocols, with no sediment samples causing a significant or marked toxicity response in test organisms compared to control samples. These results appear to indicate that standard screening benchmarks used to evaluate the potential toxicity of PAHs in sediment (e.g., threshold effect level, probable effect level, threshold effect concentration, median effect concentration, and extreme effect concentration) overestimate the toxicity of creosote-derived PAHs and TPH to benthic invertebrates. It is important to note that none of the sediment samples submitted for bioassay testing contained NAPL. Statistically significant toxicity is expected in sediments with NAPL or total PAH concentrations greater than 250 mg/kg (Anderson et al., 2011). However, the upstream reference samples used for statistical comparison exhibited significant organism mortality rates confounding the results of the bioassay testing conducted as part of the 2006 ERA.

Defining the extent of NAPL in surface sediment adjacent to Site Area 1 and Area 2 and monitoring the bioavailable fraction of residual creosote contamination in surface sediment became important supplemental RI objectives. A clearly related objective that primarily affects the FS was to evaluate whether or not migration of NAPL and/or dissolved-phase contamination into the biologically active zone of sediment (i.e., within 12 inches mudline) is actively occurring and/or is likely to occur in the future (via shoreline seeps or from deeper sediment contamination).

## 3.0 SUPPLEMENTAL RI ACTIVITIES

As discussed in **Section 1.2**, the supplemental RI work was intended to address data gaps in the RI previously completed for the Site in 2000, and tasks DEQ identified as necessary to be completed prior to preparing an FS. The data collection events discussed in this section comprise the following:

1. Groundwater quality monitoring in September 2010, August 2011, and February, May, and August 2012;
2. Area 1 shoreline NAPL inspections in 2010, 2011, and 2012;
3. TarGOST® investigation (Phase 1 delineation of NAPL) in 2011;
4. Offshore / upland borings and sediment / soil sampling and analysis (Phase 2 delineation of NAPL) in 2011;
5. Sediment porewater (*ex-situ*) with co-located bulk sediment sampling in July 2012 (high river stage and high groundwater elevation) and October 2012 (low river stage and low groundwater elevation);
6. Dock Area Investigation in 2013 (NAPL delineation and bulk sediment sampling);
7. Assess offshore groundwater discharge areas and surface sediment sheen occurrence in 2017;
8. Surface water, sediment porewater (*in-situ*) and co-located bulk sediment sampling in 2017; and
9. Area 2 shoreline NAPL inspection in 2018.

Supplemental RI has been completed under the following work plans:

- *Draft Supplemental Remedial Investigation Work Plan for Area 1* (Draft Supplemental RI Work Plan) dated August 13, 2010 (AMEC, 2010a). The Draft Supplemental RI Work Plan encompassed the tasks identified in the May 20, 2010 DEQ-provided scope of work and is a continuation of the 1995 Order.
- *Final Revised Supplemental Remedial Investigation Work Plan*, submitted to DEQ on January 3, 2011 (Supplemental RI Work Plan) (AMEC, 2011a).
- *Addendum to the Supplemental Remedial Investigation Work Plan for Area 1*, submitted to DEQ on May 24, 2011 (AMEC, 2011b).
- *Sediment Porewater Sampling (PWS) Work Plan* dated June 2012 (PWS Work Plan) (AMEC, 2012b).
- *Revised Work Plan for Limited Sediment Investigation (LSI)* (a.k.a., Beach Coring Investigation), dated September 27, 2012 (LSI Work Plan) (AMEC, 2012c).

- *Work Plan for Dock Area Investigation (DAI)*, dated September 16, 2013 (DAI Work Plan) (AMEC, 2013b).
- *Phase 1 and 2 Offshore Data Gap Investigation Work Plan*, April 26, 2017 (Cascadia, 2017a); and
- *Phase 3 Offshore Data Gap Investigation Work Plan*, dated August 29, 2017 (Cascadia, 2017c).

The following sections describe the specific objectives and scope of work for each supplemental RI data collection event. A list of sample/analysis locations and dates is provided in **Table 3-1**, and sampling/analysis locations are shown on **Figure 3-1**. Investigation results are discussed in **Section 4.0** (Updated Site Setting) and **Section 5.0** (Nature and Extent of Contamination). Details regarding field methods are provided in **Appendix B**.

### 3.1 GROUNDWATER MONITORING, 2010 THROUGH 2012

One of DEQ's objectives for the supplemental RI was to confirm current groundwater conditions beneath Area 1, the extent of DNAPL, and the quality of groundwater discharging from Area 1 uplands to the adjacent surface water bodies. Area 1 monitoring well locations are shown on **Figure 3-2**.

Groundwater monitoring data were overlain on top of the estimated lateral extent of NAPL in soil to identify areas of the Site where creosote NAPL may be functioning as a source of dissolved-phase groundwater contamination (source material). The term "source material" is adopted from EPA (EPA, 1991) and is generally defined as "material that contains hazardous substances, pollutants, or contaminants that act as a reservoir for migration of contamination to groundwater, surface water, to air, or acts as a source for direct exposure."

Eight new groundwater monitoring wells were installed as part of the supplemental RI to: (1) confirm the lateral extent of NAPL, (2) further investigate the presence of NAPL near Milton Creek, and (3) replace damage well MW-2 with MW-2A to further investigate the thickness of NAPL present in the source area. Following installation of the new wells, the monitoring well network in Area 1 comprised the following twenty (20) wells: MW-1, MW-2A, MW-3A, MW-3B, MW-4A, MW-4B, MW-5, MW-6A, MW-7, MW 8, MW-9, MW-10, and MW-18 through MW-25.

In accordance with the Supplemental RI Work Plan (AMEC, 2011a), four consecutive quarters of groundwater and NAPL monitoring have occurred at monitoring wells located within Area 1. Groundwater monitoring for the supplemental RI was conducted on the following dates:

- September 7 and 8, 2010 (baseline sampling conducted during supplemental RI work plan development);
- August 8 and 9, 2011 (first quarterly event);
- February 20 through 22, 2012 (second quarterly event);



- May 3 and 4, 2012 (third quarterly event); and
- August 14 and 15, 2012 (fourth quarterly event).

The scope of each investigation is summarized in the sections below. Groundwater samples were collected using low-flow sampling techniques with a peristaltic pump connected to new polyethylene tubing lowered to the middle of the screened interval. Groundwater quality parameters were measured during well purging to ensure that the samples were representative of formation water. Boring and well construction logs are provided in **Appendix C**, and the chemical analytical program is discussed in **Appendix D**.

### 3.1.1 September 2010

Groundwater quality monitoring was conducted on September 7 and 8, 2010, as part of developing the Supplemental RI Work Plan (AMEC, 2010b). Site monitoring wells were gauged to determine groundwater elevations, two surveyed surface water monitoring points were gauged to determine the surface water elevation, and monitoring wells in Area 1 were sampled. Monitoring wells MW-12A and MW-12B were not locatable during gauging event, and monitoring wells MW-7 and MW-8 were dry and could not be gauged or sampled.

Groundwater samples were collected from all existing monitoring wells in Area 1 except for those wells noted above. Specifically, samples were collected from monitoring wells MW-1, MW-3A, MW-3B, MW-4A, MW-4B, MW-5, MW-6A, MW-9, MW-10, and MW-18.

Groundwater samples were analyzed for the following constituents (**Table 3-1**):

- Fuels, including gasoline-range hydrocarbons by Method NWTPH-Gx and diesel- and oil-range hydrocarbons by Method NWTPH-Dx, and selected samples were also analyzed by Method NWTPH-HCID;
- Dissolved metals (arsenic, cadmium, chromium, copper, lead, and zinc) by EPA Method 6020;
- VOCs (BTEX only) by EPA Method 8260B; and
- PAHs by EPA Method 8270D SIM.

As requested by DEQ, a groundwater sample was collected from the base of the screened interval in MW-1 to assess whether or not constituent concentrations would be higher in groundwater samples collected from deeper in the screened interval and closer to the top of the Basalt Bedrock, where DNAPL may preferentially accumulate. In general, detected concentrations of BTEX, dissolved metals, PAHs, and total petroleum hydrocarbons were slightly higher in samples collected from the bottom of the screened interval as compared with samples collected from mid-screen. Detections from samples collected at the bottom of the screened interval were on average 17 percent higher than from samples collected at mid-screen (AMEC, 2010b).

### 3.1.2 August 2011

Between July 18 and July 25, 2011, eight additional groundwater monitoring wells (MW-2A and MW-19 through MW-25) were installed in Area 1 as part of the supplemental RI. Details regarding installation of the additional supplemental RI groundwater monitoring wells are provided in **Section 3.4.2.**

In accordance with the supplemental RI Work Plan (AMEC, 2011a), the first of four consecutive quarterly groundwater monitoring events was conducted on August 8 and 9, 2011 (AMEC, 2012a). Monitoring wells across the entire Site were gauged to determine groundwater elevations, two surveyed surface water monitoring points were gauged to determine the surface water elevation, and monitoring wells in Area 1 were sampled. Wells MW-8, MW-10, and MW-16 were not gauged because MW-8 was dry, an obstruction was present in MW-10 about 4 to 5 feet below the top of the casing, and MW-16 could not be located due to surface obstructions.

Groundwater samples were collected from monitoring wells MW-1, MW-2A, MW-3A, MW-3B, MW-4A, MW-4B, MW-5, MW-6A, MW-9, MW-18, and MW-19 through MW-25.

Groundwater samples were analyzed for the following constituents:

- Diesel-range hydrocarbons by Method NWTPH-Dx;
- Dissolved metals (arsenic, cadmium, chromium, copper, lead, and zinc) by EPA Method 6020; and
- PAHs by EPA Method 8270D SIM.

### 3.1.3 February, May, and August 2012

The remaining three quarterly groundwater quality monitoring events took place in February, May, and August 2012 (AMEC, 2013a). During each event, Site monitoring wells from both Area 1 and Area 2 were gauged to determine groundwater elevations, and two surveyed surface water monitoring points were gauged to determine the surface water elevation in Scappoose Bay and Milton Creek. All monitoring wells within Site Area 1 were sampled during each event, with a few exceptions as noted below.

The depth to groundwater was measured in Site groundwater monitoring wells on February 20, May 3, and August 14, 2012. Wells MW-8 and MW-16 were not gauged because MW-8 was dry, and MW-16 could not be located. Water levels in Scappoose Bay and Milton Creek were measured during each event.

The February sampling event was completed on February 20 to 22; the May sampling event was completed on May 3 and 4; and the August sampling event was completed on August 14 and 15. During each event, groundwater samples were collected from the existing network of monitoring wells in Area 1 except for MW-8 and MW-16, for the reasons stated above. Well MW-7 was sampled only in May, because it contained insufficient water to sample during the other events. Samples were



collected during all three events from monitoring wells MW-1, MW-2A, MW-3A, MW-3B, MW-4A, MW-4B, MW-5, MW-6A, MW-9, MW-10, and MW-18 through MW-25.

Groundwater samples were analyzed for the following constituents:

- Diesel-range hydrocarbons by Method NWTPH-Dx;
- Dissolved metals (arsenic, cadmium, chromium, copper, lead, and zinc) by EPA Method 6020; and
- PAHs by EPA Method 8270D SIM.

Additional groundwater samples were collected during the August 2012 event for the following additional analyses:

- Groundwater samples from monitoring wells MW-3A, MW-21, and MW-24 were collected and analyzed for freely dissolved PAHs in accordance with ASTM International (ASTM) Standard Test Method D 7363-11 (Determination of Parent and Alkyl Polycyclic Aromatics Using Solid-Phase Microextraction [SPME] and Gas Chromatography/Mass Spectrometry in Selected Ion Monitoring Mode). A total of 34 PAH analytes are reported by this method, which is designed to remove colloids suspended in groundwater samples. These samples were collected with the intention of comparing groundwater quality at selected monitoring wells in the upland source area to results from offshore sediment and porewater samples. It is important to note that the August 2012 groundwater samples from MW-3A were significantly more turbid than samples obtained from MW-21 and MW-24. The impact of turbidity on the analytical results in groundwater is discussed in more detail in **Section 5.4**.
- A sample of NAPL was collected from monitoring well MW-3A by lowering the tubing to the bottom of the screened interval after a water sample was collected from the middle of the screened interval. The sample was analyzed for 34 PAHs by EPA Method 8270 to assist in understanding the chemistry of source area NAPL as it relates to NAPL observed in offshore sediment.

### 3.2 SHORELINE INSPECTIONS

One of DEQ's objectives for the supplemental RI was to map the lateral and vertical extent of NAPL along the Site's shorelines during periods of low surface water levels. As mentioned in **Section 1.0**, during a September 2008 Site visit during low-water conditions, visual and olfactory evidence of creosote-impacted surface sediment was noted along various portions of the Scappoose Bay and Milton Creek shoreline adjacent to Area 1. Potential contributing sources to these surface sediment impacts include historical direct discharge (e.g., wastewater discharge, over-water dock/transfer table operations, hog fuel storage), upland NAPL migration, and/or discharge of contaminated groundwater. Additional investigation of surface and subsurface sediment contamination was requested by DEQ for evaluating the extent and source(s) of offshore contamination (DEQ, 2010a). To that end, annual low-water shoreline inspections were conducted between 2010 and 2012

adjacent to Area 1, and again in 2017/2018 along Area 1 and Area 2 shorelines to designate specific areas where NAPL (i.e., creosote sheen, product, and/or tar body) was observed in near-surface sediment, and to refine the locations and boundaries of visible creosote-impacted water seeps in the bank.

Area 1 shoreline inspections along Milton Creek and Scappoose Bay were subsequently performed in 2010, 2011, 2012, and 2017 during low water/low tide (generally in late September and early October), when much of the shoreline sediment within the intertidal zone was visible and directly accessible. Area 2 shoreline inspections along Scappoose Bay performed in 2018 are discussed below in **Section 3.7.6**. The shoreline inspections were designed to document observations and collect sufficient data to bound areas of NAPL impacts, and areas where sediment porewater would be expected to exceed ecological risk-based screening levels. The uppermost foot of sediment, which is the estimated biologically active zone at the Site, is the critical interval for these observations and assessment of risk. Unacceptable risk was defined by either the presence of NAPL or porewater concentrations of COPCs above acceptable levels, as discussed further in **Section 10.0**.

A summary of the scope of each shoreline inspection/investigation is provided in the sections below. Sediment sampling methodology is provided in **Appendix B**. Inspection locations and observations are summarized on **Figure 3-3**. The chemical analytical program, including data validation results, is summarized in **Appendix D**.

### 3.2.1 2010

On October 4 and 5, 2010, a visual inspection of the Area 1 shoreline was conducted under DEQ oversight to designate specific areas where petroleum sheen, creosote NAPL, and tar bodies were observed in near surface sediment within the intertidal zone of Scappoose Bay and the entire reach of Milton Creek bordering the Site (AMEC, 2010c). The designated, marked shoreline locations were incorporated into subsequent supplemental RI tasks designed to determine the vertical and lateral distribution of shoreline NAPL.

The visual inspection was conducted during daily low tides to observe conditions during maximum shoreline exposure. In Scappoose Bay, saturated sediments as far as 42 feet riverward from the OHWM shoreward were inspected. In Milton Creek, the full reach of the creek from the railroad bridge at the northeast corner of the Site to the discharge point at Scappoose Bay was inspected. Evidence of contamination was observed in multiple locations, indicated by sheen and staining of exposed surface sediments. Some of the sheen observed along Scappoose Bay and Milton Creek was biogenic in nature. The biogenic sheens lack the creosote odor and appear brittle, in that the iridescent appearance on the surface of water cracks, breaks apart, or disaggregates upon disturbance (e.g., touching the sheen). Moreover, biogenic sheens at the Site generally appear to be more blue or bluish purple in color than sheens attributed to creosote.

In contrast, the creosote-related sheens produce a strong odor and are non-brittle, in that the iridescent appearance on the water surface rapidly coalesces upon disturbance. When disturbed, areas of creosote-impacted sediment imparted a visible sheen on the overlying surface water. Within areas of shallow water, field personnel walked across the submerged sediment to look for sheen “blossoms”. A sheen “blossom” is the occurrence of a new sheen due to the migration of a droplet of NAPL (e.g., creosote) to the water surface overlying impacted sediment.

Along the shoreline below the OHWM, core samples and pothole samples were removed and investigated in place using visual and olfactory observations. Core samples were advanced to a maximum depth of approximately 18 inches and located using stakes and a hand-held Global Positioning System (GPS) device. DEQ participated in this inspection. The near-shore distribution of creosote was determined to be more heterogeneous and widespread than indicated during previous investigations.

### 3.2.2 2011

A low-water-level shoreline inspection and surface sediment sampling event was conducted on September 27 and October 6 to 7, 2011, along the east side of Milton Creek and along the Area 1 shoreline of Scappoose Bay (AMEC, 2012a). This field event was conducted to achieve two objectives:

- Compare/confirm 2011 shoreline conditions to conditions observed during the 2010 shoreline inspection at locations where creosote-impacted surface sediment was observed, and
- Collect surface sediment samples at areas of obvious or suspected impact to support the results of the HHRA and ERA.

The October 6 visit corresponded with the mean lower low water (MLLW) level, which is the average of the lowest tide recorded at a tidal station each day during the recording period. Surface water levels during the October 7 visit were 0.20 foot below MLLW. Potholes were advanced to depths of 12 to 18 inches below the sediment surface at locations with visual surface sheens, at locations previously staked (during the 2010 shoreline inspection), near previous seep locations, and near shoreline locations previously investigated during the Tar-specific Green Optical Screening Tool (TarGOST®) and sediment sampling events (**Section 3.3**).

Surface sediment samples were collected at areas of obvious or suspected creosote impact from four locations along the exposed shoreline in Milton Creek (SSED-MC-1 through SSED-MC-4) and nine locations along the exposed shoreline in Scappoose Bay (SSED-1 through SSED-9). Samples were generally collected within the upper 12 inches of sediment within the intertidal zone using a trowel.

Samples SSED-MC-2, SSED-1, SSED-3, and SSED-4 were archived in the laboratory freezer for potential future analysis. The remaining samples were analyzed for one or more of the following:

- TOC by SM 5310B MOD;
- Diesel-range hydrocarbons by Method NWTPH-Dx;
- PAHs by EPA Method 8270D SIM;
- VOCs by EPA Method 8260B;
- Extractable petroleum hydrocarbon (EPH) and volatile petroleum hydrocarbon (VPH) constituents by Method NWTPH-EPH and Method NWTPH-VPH; and
- Total metals (arsenic, cadmium, chromium, copper, lead, and zinc) by EPA Method 6020.

### 3.2.3 2012

A visual inspection of a focused segment of the Area 1 shoreline along Scappoose Bay was completed in October 2012 as part of the LSI (AMEC, 2013a). The LSI was designed to document observations and collect sufficient data to identify and delineate the extent of NAPL in near-surface sediment along an approximately 625-foot section of the Scappoose Bay shoreline adjacent to the former wood-treating operations, generally between the hog fuel dock and former transfer table (AMEC, 2012c).

During the Area 1 shoreline inspections in October 2010 and 2011, with oversight from the DEQ, surface and near-surface sediment within the intertidal zone exhibiting a creosote sheen was marked with wooden stakes, flagging, and georeferenced using a hand-held GPS receiver. During the 2012 LSI, exposed soil and sediment within the LSI Area between the bank and edge of surface water during low tide was visually inspected for evidence of creosote, paying particular attention to intact stakes, flagging, and existing georeferenced locations. Visible surface contaminants within the LSI Area were documented, and LSI sampling locations were recorded by GPS, photographed using a digital camera, and marked by a wooden stake and flagging.

Shallow hand borings were advanced to depths of 3.5 to 5 feet bgs if possible, and samples were selected for analysis based on similarity to proximal LSI locations, presence of wood debris, and/or observation of slight odor and moderate sheen.

Additional information on sediment sampling during the LSI is provided in **Section 3.5**.

## 3.3 TARGOST® NAPL DELINEATION, 2011

The supplemental RI activities included delineation of upland and offshore NAPL using TarGOST® to address DEQ's objectives 1 and 2, as outlined in **Section 1.2** (AMEC, 2011a). TarGOST® is a technology offered by Dakota Technologies, Inc. (Dakota), and is designed for the detection of NAPL-contaminated zones at wood-treating facilities using laser-induced fluorescence (LIF) technology. Details on the TarGOST® methodology are provided in **Appendix B**.

A total of 110 TarGOST® borings were completed at the Site between March 14 and March 23, 2011 (AMEC, 2011c). A total of 43 upland TarGOST® borings were completed within Area 1 and are designated as S0xx on **Figure 3-1**. The initial upland TarGOST® borings were completed near monitoring well MW-3A in order to calibrate the technology within a known source area. Two upland transects using TarGOST® were completed; one along Milton Creek and one along Scappoose Bay. TarGOST® borings were also completed in and around the inferred upland NAPL area to better define upland source areas requiring remedial action and to assist with effectively positioning new monitoring wells. Upland TarGOST® borings were generally spaced approximately 100 feet apart; however, additional borings were completed in areas of irregular contaminant distribution.

A total of 67 offshore TarGOST® borings were completed in Scappoose Bay and Milton Creek. These borings are designated SD0xx on **Figure 3-1** (AMEC, 2011c). The initial offshore TarGOST® borings were completed within the immediate vicinity of surface sediment that had exhibited creosote impact during the October 2010 shoreline inspection in an effort to calibrate the technology within the aquatic environment.

Periodically during these initial NAPL delineation efforts, soil macrocores were extracted and logged directly adjacent to (collocated with) select TarGOST® Geoprobe® borings. The purpose of the collocated Geoprobe® macrocores was to visually inspect soil or sediment at or near a TarGOST® boring location for comparison to the LIF response. TarGOST® sampling methodology is provided in **Appendix B**. Boring logs for the collocated Geoprobe® macrocores are provided in **Appendix C**.

### 3.4 OFFSHORE/UPLAND NAPL DELINEATION, 2011

The 2011 offshore/upland investigation was designed to collect information toward achieving DEQ's objectives 1 through 3 as outlined in **Section 1.2**.

The Addendum to the Supplemental Remedial Investigation Work Plan for Area 1 (Supplemental RI Work Plan Addendum) was submitted to the DEQ on May 24, 2011 (AMEC, 2011b). The Supplemental RI Work Plan Addendum included modifications to the scope of work presented in the Supplemental RI Work Plan (AMEC, 2011a). These modifications were based on observations made during the Phase 1 delineation of upland and offshore NAPL using TarGOST® (see **Section 3.3**) (AMEC, 2011c). The scope of work was also modified based on DEQ comments received on May 16, 2011 (DEQ, 2011a). The modifications presented in the Supplemental RI Work Plan Addendum were intended to provide a comprehensive and efficient data collection and analysis program designed to further characterize source-area NAPL and its potential migratory pathways to off-site locations. The modified scope of work was executed as described below. A discussion of deviations from the Supplemental RI Work Plan Addendum are provided in the 2nd Quarter 2011 Progress Report (AMEC, 2011d). Detailed field methodology is provided in **Appendix B**.

### 3.4.1 Delineation of Offshore NAPL—Depth-Discrete Sediment Sampling

The Delineation of Offshore NAPL—Depth-Discrete Sediment Sampling consisted of a focused sediment investigation based on the results of TarGOST® borings with the following specific objectives:

- To determine if the existing surface sediment dataset is representative of current conditions;
- To confirm the estimated lateral and vertical distribution of creosote NAPL based on TarGOST® results; and
- To further define the depth to the Basalt Bedrock surface and to visually assess whether creosote NAPL was present within the upper surface (i.e., 10 feet) of the Basalt Bedrock matrix.

The Phase 2 offshore borings were completed between July 12 and July 21, 2011. Thirty-one offshore borings were advanced in Scappoose Bay (SB-01 through SB-28 plus borings SB-08A, SB-08B, and SB-08C). Four borings were advanced in, or angled beneath, Milton Creek (MC-01, MC-02, MC-03, and MC-04), plus two angled borings approximately collocated with MC-01 and MC-02 (MC-01A and MC-02A, respectively). Boring locations are shown on **Figure 3-1**. Borings were advanced using a combination of vibracore and sonic drilling / sampling methods. A clamshell Van Veen sampler was used to collect surface sediment samples at selected locations. The borings ranged in depth from 6.1 to 26.5 feet below the mudline (bml; “mudline” generally refers to the surface water/sediment interface).

Soil/sediment samples were collected from the borings at three or more depth intervals:

- Generally, from a near-surface interval at depths of 0 to 0.3 foot bgs (surface samples);
- From just above the Basalt Bedrock contact; and
- Either from the mid-level in the boring or an area of suspected impact.

Suspected areas of creosote impact, determined either by visual or olfactory observations, were subjected to a sheen test. For sheen testing, a small portion of the soil/sediment was placed in a jar and covered with deionized water to see if a petroleum-related sheen formed on the water surface. Photoionization detector (PID) readings were collected at sampled intervals, and soil / sediment samples were field analyzed by ultraviolet fluorescence as a screening tool for creosote NAPL. Field screening of total PAHs, targeted PAHs, and extended diesel-range organics (EDRO) was performed using a siteLAB® portable ultraviolet fluorometer.

All sediment and soil samples from the July 2011 sampling event were analyzed, at a minimum, for the following constituents:



- Diesel-range hydrocarbons by Method NWTPH-Dx; and
- PAHs by EPA Method 8270D SIM.

The vast majority of surface sediment samples (i.e., collected at depths of 0 to 0.3 foot bml) from Scappoose Bay and Milton Creek were also analyzed for the following constituents:

- TOC by EPA Method 415.1/5310B; and
- Grain size.

Twenty sediment samples, including the majority of surface sediment samples collected in Scappoose Bay and Milton Creek, were analyzed for the full suite of 34 PAH homologues by EPA Method 8270D SIM Modified to assist in calculating equilibrium partitioning-based sediment toxic units, as discussed further in **Section 10.2**.

As requested by DEQ, two surface sediment samples collected near the historical transfer table and dock (SB-17 and SB-18) were also analyzed for the following constituents:

- Metals (arsenic, cadmium, chromium, iron, lead) by EPA Method 6020; and
- VOCs by EPA Method 8260B.

A total of three sediment samples collected in the man-made cove area. Two samples (SB-10 and SB-11, located just west of the peninsula), and one depth-discrete sample, (SB-14, located just east of the peninsula) were analyzed for the following:

- VOCs by EPA Method 8260B; and
- EPH and VPH.

Boring logs are provided in **Appendix C**. The chemical analytical program, including data validation results, is summarized in **Appendix D**.

### 3.4.2 Delineation of Upland NAPL—Additional Groundwater Monitoring Well Installation

Upland delineation of NAPL and additional groundwater monitoring well installation was conducted July 18 through 25, 2011 (AMEC, 2011d). Eight additional groundwater monitoring wells were installed in Area 1 of the Site: MW-2A, MW-19, MW-20, MW-21, MW-22, MW-23, MW-24, and MW-25 to address the following specific objectives:

- Confirm the lateral upland extent of NAPL beneath Area 1 as defined in the 2000 RI Report and by the 2011 TarGOST® investigation;
- Further evaluate NAPL mobility in groundwater beneath Area 1;
- Further investigate potential NAPL or source material near Milton Creek; and

- Replace monitoring well MW-2 (due to collapse of the polyvinyl chloride [PVC] sump in 2007) with MW-2A to investigate the thickness of NAPL present within the former wood treating plant and ASTs.

The groundwater monitoring well borings were advanced through the dredge sand fill and native silt/clay soil units and were extended approximately 1 foot into the upper surface of Basalt Bedrock using sonic drilling techniques. Core samples from well installation boreholes were logged and screened for evidence of NAPL. The field screening methods used were: (1) visual examination, (2) water sheen screening, and (3) headspace vapor screening using a PID.

The supplemental RI monitoring wells were constructed in accordance with Oregon Water Resources Department (OWRD) monitoring well construction standards. The base of each well was equipped with a 12-inch-long vertical solid sump to collect mobile NAPL that potentially may be present. The NAPL collection sump was completed within the upper 1 foot of the Basalt Bedrock, and the top of the sump/bottom of the well screen was set at the same depth as the Native Soil/Basalt Bedrock interface. A NAPL funnel was installed at the bottom of the screen interval in the sand pack to direct NAPL (if present) into the sump.

The new monitoring well locations are shown on **Figure 3-2**.

### 3.5 SHORELINE AND OFFSHORE TOXICITY ASSESSMENT, JULY AND OCTOBER 2012

After the Port completed the initial phases of the supplemental RI (mainly upland/offshore NAPL delineation), DEQ more clearly defined the objectives of the sediment characterization program in a letter dated July 6, 2011 (DEQ, 2011b), and in ongoing agency correspondence (meetings, phone calls, and e-mails). As stated in the Sediment Porewater Sampling Work Plan (AMEC, 2012b), the scope of the supplemental RI was refined to focus on the following objectives:

- Determine the bioavailable or bioaccessible concentrations of PAHs associated with creosote releases in sediment porewater occurring within and near the base of the benthic/biologically active sediment environment.
- Determine a correlation factor or coefficient, if possible, to apply to sediment data for use in Equilibrium Partitioning Sediment Benchmark Toxic Unit (ESBTU) modeling (EPA 2003, 2012).
- Evaluate potential temporal variability in bioaccessible PAH concentrations in porewater relative to different river stages and groundwater elevations.
- Delineate the boundary in sediment porewater riverward of NAPL-contaminated sediments for exceedances of the ambient water quality criteria (AWQC) and aquatic screening level values (SLVs) for pyrene and fluoranthene used in the HHRA and ERA.

The 2012 sediment porewater sampling and LSI were designed to collect information toward achieving DEQ's objectives 2 and 4, as outlined in (**Section 1.2**). To this end, the Port conducted a



high-water PWS sampling event in July 2012, and low-water PWS and LSI sampling events in October 2012 (AMEC, 2013a).

The 8- to 11-inch depth interval bml at each PWS sample location was targeted for porewater and bulk sediment subsample collection (i.e., within and near the base of the benthic/biologically active sediment environment). A subset of sediment from shallower depth intervals or strata bml (e.g., 1 to 4 inches and 4 to 7 inches) at each sample location was field screened for creosote-related compounds and held for potential chemical analytical testing. In some instances, the decision to analyze the shallower depth intervals was made during the field event.

Consistent with the PWS task, the biologically active zone (the uppermost foot of sediment) was considered to be the more critical interval for observation during the LSI. During the LSI event, borings generally were advanced by hand auger to 3.5 to 5 feet bgs where possible, whether or not evidence of impact was observed within the uppermost foot. The rationale for having visual observations of soil and creosote conditions within the upper 3.5 to 5 feet of each LSI boring was to evaluate the irregular distribution of NAPL in overlying surface sediment from the western side of the peninsula eastward just past the existing transfer table dock.

Whole or bulk sediment samples were collected for laboratory analysis from 26 locations during the July (high water) and October (low water) PWS events, and from 6 sampling locations during LSI event. Sediment samples were analyzed for the following constituents:

- TPH (LSI samples only) by Method NWTTPH-Dx;
- PAHs by EPA Method 8270D SIM; and
- TOC/black carbon by EPA Method 415.1/5310B.

Sediment porewater samples were collected for laboratory analysis (through collection of bulk sediment and laboratory extraction of porewater; see **Appendix D**) from 24 locations during the July high-water event, from 26 locations during the October low-water event, and from 6 locations during the LSI event. Sediment porewater samples were analyzed for 18 parent PAH compounds and 16 groups of alkylated PAH homologues (i.e., 34 total PAH concentrations) using SPME followed by gas chromatography/mass spectrometry (GC/MS) according to ASTM Standard D7363 and procedures developed based on research completed at the University of North Dakota (Hawthorne et al., 2005a/b). Sediment porewater samples were also analyzed for dissolved organic carbon (DOC) using Standard Method (SM) 5310C.

In addition to the planned analyses, the following bulk sediment samples were analyzed for PAHs in January 2013, outside of standard holding times, to confirm unexpected PAH results in the primary October 2012 sample from PWS-13:

- Additional volume from the October PWS-13 sediment sample (effectively duplicate and triplicate samples); and
- Sediment from locations PWS-22 and PWS-24 (near PWS-13) collected in July 2012.

**Figures 3-1 and 3-3** show the July and October 2012 PWS and LSI sampling locations. Detailed field methodology is provided in **Appendix B**. The chemical analytical program, including data validation results, is summarized in **Appendix D**.

### 3.6 DOCK AREA INVESTIGATION, 2013

The DAI focused on an area, primarily beneath the former transfer table dock, that was previously inaccessible for investigation purposes due to the presence of the dilapidated wooden deck. Removal of the overhead dock structure, required for safe investigation of the soil and sediment below, was completed in August 2013.

As mandated by DEQ and described in a September 2013 work plan (AMEC, 2013b), the objective of the DAI was to delineate the lateral and vertical extent of creosote-related contamination in nearshore soil and sediment beneath the former transfer table dock; in particular, to determine the source of creosote NAPL observed in surface soils and sediment beneath the dock (i.e., contaminated wood debris versus subsurface connections with upland NAPL). For the purpose of classifying samples for analysis and in data tables, samples collected from locations below the OHWM were designated as sediment, and samples collected from locations above the OHWM were designated as soil.

The DAI was completed between October 14 and 17, 2013, generally within the approximately 275-foot-long portion of the Scappoose Bay Area 1 shoreline below the former transfer table dock. Access to sampling locations within the DAI sampling area was complicated by water levels, tidal cycles, existing pilings, saturated sediment, and existing wood and metal debris sitting on and just below the sediment surface. Mud mats and plywood were used to extend access into softer sediments for the drilling rig and field personnel. Surficial wood and metal debris were removed, and pilings were cut to provide access to specific sampling locations and reduce safety hazards to the field crew.

In total, 6 sonic borings, 15 direct-push borings, 20 potholes, and 3 hand-auger borings were completed as part of the DAI.

- Sonic borings were completed using a track-mounted, mini-sonic drilling rig. In addition to the four sonic borings completed beneath the former transfer table dock (DAI-SB-01 through DAI-SB-04), two sonic borings (DAI-SB-20 and DAI-SB-21) were completed as requested by DEQ between the Former Operations Area and Scappoose Bay (in the vicinity of monitoring well MW-7) to evaluate potential subsurface migration of NAPL in that area of the Site. Sonic borings were utilized to determine the character of underlying Basalt Bedrock and the presence or absence of contaminant migration along the Native Soil/Basalt

Bedrock (nearshore) contact. Each sonic boring penetrated the underlying Basalt Bedrock by a depth ranging from 0.5 foot in boring DAI-SB-20 to 4 feet in boring DAI-SB-01.

- Direct-push borings were completed using a track-mounted Geoprobe® drilling rig. Nine direct-push borings were completed beneath the former transfer table (DAI-SB-05, -06, -07, -08, -09, -10, -15, -16, and -17), and a transect of six upland borings were advanced directly northwest of the former dock near monitoring well MW-10 (DAI-SB-11, -12, -13, -14, -18, and -19).
- Shallow hand tool excavations (potholes and hand-auger borings) were completed generally within the upper 30 inches of sediment using shovels or hand augers. Deeper hand auger borings were conducted at locations DAI-HA-02 and DAI-HA-03 to depths of 6.5 and 4 feet bgs, respectively.
- Soil, sediment, and bedrock cores obtained from borings were field screened for visual evidence of NAPL, photographed, and logged according to the Unified Soil Classification System (USCS) prior to sample collection. Soil and sediment samples from varying depths (dependent upon field observations) were collected from each sonic and direct-push boring. Sediment samples were also collected from two of the three hand-auger borings. Each sample was analyzed for the following constituents:
  - TPH by Method NWTPH-Dx; and
  - PAHs by EPA Method 8270 SIM.

Direct-push borings were completed in areas inaccessible to the sonic rig and in the DEQ-requested upland transect located at the top of the grade to the northwest of the former transfer table dock. The upland transect was completed in an attempt to define potential NAPL migration pathways between upland sources and nearshore sediment and included six borings (DAI-SB-11, DAI-SB-12, DAI-SB-13, DAI-SB-14, DAI-SB-18, DAI-SB-19). In addition to the transect, direct-push borings DAI SB-07, DAI-SB-10, DAI-SB-15, DAI-SB-16, and DAI-SB-17 were completed on the graded slope above the shoreline. These borings were all noted to contain subsurface NAPL. Samples were not collected if the matrix contained a significant amount of wood debris.

Detailed field methods from the DAI are provided in **Appendix B**. Boring logs and potholing and hand-auger observations are included in **Appendix C**. All DAI sample/observation locations are depicted on **Figures 3-1** and **3-3**.

### 3.7 OFFSHORE DATA GAP INVESTIGATION, 2017/2018

A phased offshore data gap investigation was completed between April 2017 and November 2018, to further assess the risks that bioavailable fractions of PAHs and TPH pose to aquatic invertebrate receptors outside the inferred NAPL areas in Scappoose Bay and Milton Creek. The data obtained during this investigation were intended to supplement previous RI data, and ultimately, to more

clearly define the offshore sediment areas that are sources of potentially significant ecological toxicity and surface water impacts (i.e., priority action areas). This information was deemed critical for selecting and designing an appropriate remedy for the Site and consisted of the following activities:

#### Phase 1

- A high-accuracy bathymetric survey of the Scappoose Bay river bottom was completed in April 2017;
- Installation of a stilling well in Scappoose Bay and monitoring of surface water conditions (i.e., water level and temperature) relative to an upland groundwater monitoring wells MW-6A and/or MW-25 between May and August 2017; and
- An offshore groundwater discharge survey was completed in June and July 2017.

#### Phase 2

- Map the occurrence and type of sheen in surface sediment adjacent to Site Area 1 in July 2017.

#### Phase 3

- Supplemental sediment porewater and surface water sampling using *in-situ* passive sampling devices (PSDs) containing low-density polyethylene (LDPE) outside offshore areas of creosote NAPL and sheen in surface sediment in September 2017.

#### Phase 4

- Map the occurrence and type of sheen in surface sediment adjacent to Site Area 2 in October and November 2018.

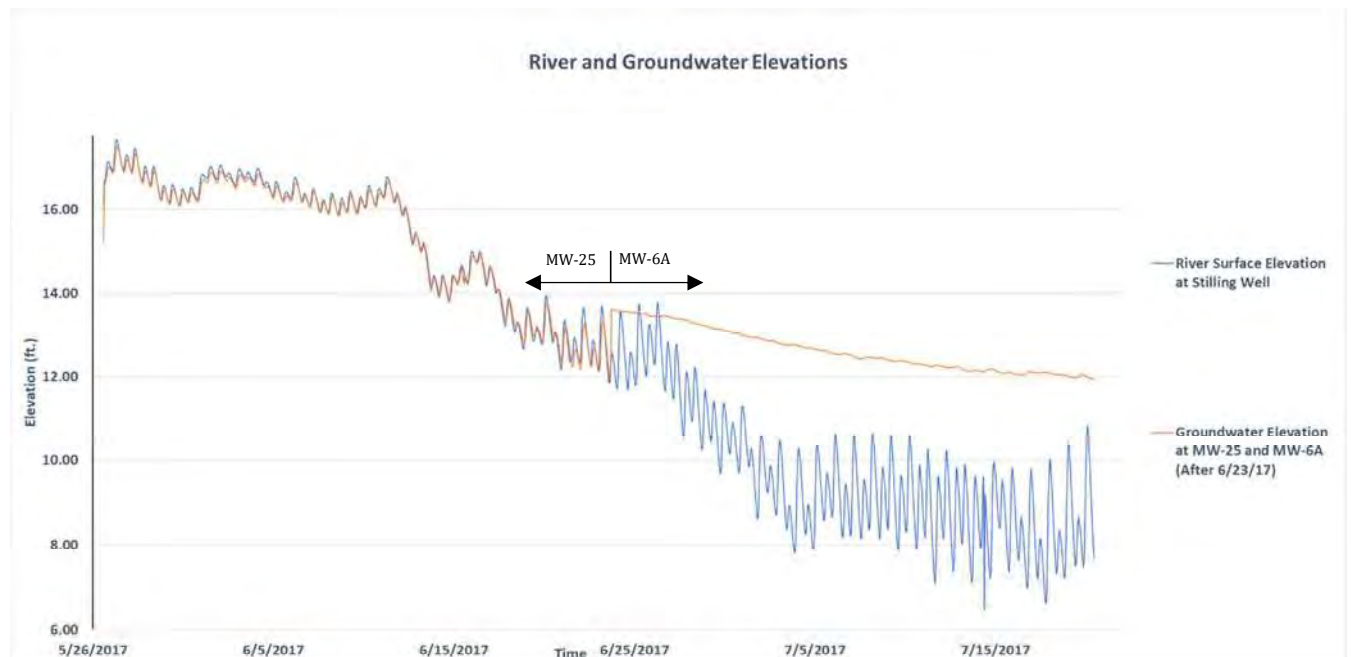
As described in the April 26, 2017 work plan (Cascadia, 2017a), the purpose of the Phase 1 and 2 investigations were to assess and map groundwater discharge areas and to better define and differentiate offshore areas exhibiting biogenic (e.g., decomposition of organic matter and/or reducing bacteria) versus petroleum (i.e., creosote-related) sheens in surface sediment adjacent to the Site. The results of the Phase 1 groundwater discharge study were used to target Phase 3 *in-situ* porewater and surface water sampling locations. Similarly, the results of the Phase 2 sheen study were used to guide the number and location of Phase 3 PSDs. The work conducted for the Phase 3 offshore data gap investigation was described in the August 29, 2017 work plan (Cascadia, 2017c) and incorporated the September 1, 2017 comments from DEQ (DEQ, 2017c). The Phase 4 creosote sheen mapping along the Area 2 shoreline was requested by DEQ in a September 27, 2018 email, and represents the final task of the offshore data gap investigation prior to finalizing the supplemental RI and initiating the FS.

### 3.7.1 High-Accuracy, High Resolution Bathymetric Survey, April 2017

On April 5, 2017, a high accuracy, high resolution bathymetric survey was completed by Solmar Hydro, Inc. of Portland, Oregon. The river bottom soundings are within 5.2 cm (mean error) of their true elevations. A map of sediment bathymetry relative to the Site is presented on **Figure 3-2**. In an effort to compare the river bottom mosaic with the Phase 1 and 2 investigation results, the color-coded bathymetry imagery was incorporated in subsequent **Figures 3-5** through **3-8** as referenced below.

### 3.7.2 Stilling Well Installation—River and Groundwater Elevation Monitoring, May - August 2017

On May 26, 2017, as requested in DEQ’s May 19 comment letter, Cascadia installed a surface water stilling well (i.e., 2-inch diameter PVC pipe casing attached to a timber pile) in Scappoose Bay adjacent to the Site, at the location shown on **Figure 3-2**. The vertical elevation of the stilling well top of casing was measured relative to the previously surveyed monitoring well MW-25 top of casing using an engineer’s level and survey rod. Additionally, a pressure transducer (LevelSCOUT® water level and temperature sensor) with an integrated datalogger was placed inside both the stilling well and monitoring well MW-25. Water level and temperature measurements were contemporaneously logged in the upland monitoring and stilling wells on an hourly basis. Graphical representations of both water level and temperature contrast are presented below.

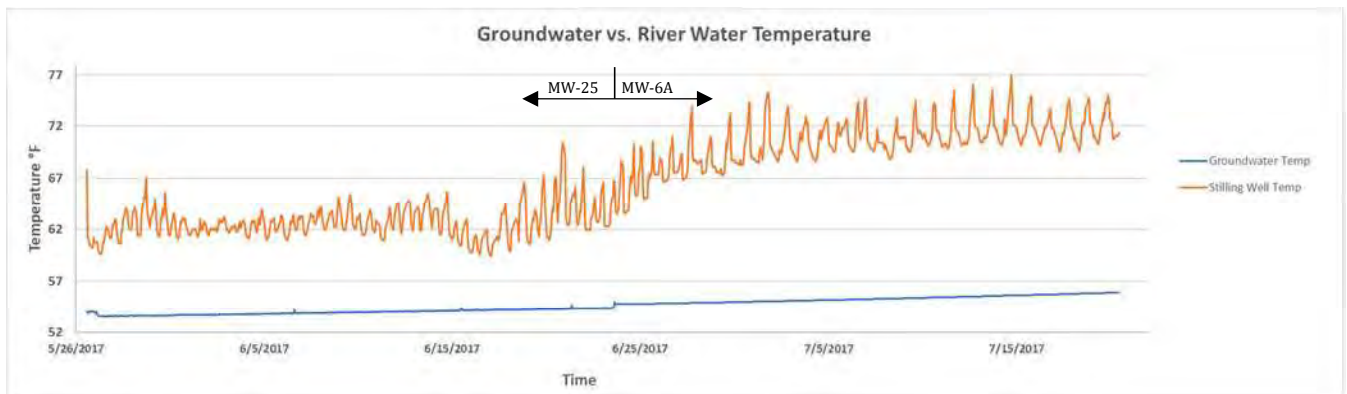


As indicated by initial water level data, monitoring well MW-25 was too close to Scappoose Bay and its screened interval was too long to evaluate groundwater responses to fluctuations in river stage. Specifically, water elevations in MW-25 between May 26 and June 23, 2017, were nearly identical to surface water stage in Scappoose Bay. For this reason, on June 23, 2017, Cascadia moved the



LevelSCOUT® transducer from MW-25 to monitoring well MW-6A, which is located approximately 100 feet farther inland. Monitoring well MW-6A was identified because the well is screened entirely within the Native Soil zone and was therefore expected to exhibit little to no response to the tidal cycles. As indicated by the water level graph presented above, groundwater levels in MW-6A indicate a significantly lower degree of hydraulic connection with surface water. Still, overall water level trends in MW-6A and the river stage are similar.

As indicated by the graph below, temperature contrasts between groundwater in MW-25 and MW-6A (after June 23, 2017) and surface water in the stilling well gradually increased from approximately 6-8 degrees Fahrenheit (°F) in late May 2017 to 13-15° F in mid- to late-July 2017.



Groundwater levels were measured in upland monitoring wells on July 21, 2017, following completion of the in-water groundwater discharge and sheen mapping activities described below. Depths to groundwater in monitoring wells were measured using an electric oil-water interface probe. At each well, the groundwater elevation was gauged within 0.01 foot of precision relative to the top of the well casing, which had been previously surveyed relative to the Site's vertical datum. Each monitoring well was checked for the presence of NAPL by carefully lowering the interface probe through the entire section of submerged casing. Consistent with prior groundwater monitoring events, approximately 6 inches of NAPL was detected in the base of monitoring well MW-3A. None of the other upland monitoring wells contained measurable NAPL. In general, groundwater elevations were similar to gauging events previously completed at the Site and indicate a generally flat groundwater gradient that gently slopes towards the Scappoose Bay and Milton Creek. The measured and inferred July 2017 groundwater elevations are presented on **Figure 3-4**.

### 3.7.3 Offshore Groundwater Discharge Survey, June – July 2017

The Phase 1 activities include the coordination and collection of paired water quality measurements (i.e., temperature, specific conductance, and/or dissolved oxygen [DO]) in surface water and porewater at various locations shown on **Figure 3-5**. Before undertaking a groundwater discharge study of 90 stations, as initially recommended (DEQ, February 24, 2017 email), Cascadia conducted a 10-station pilot test in June 2017. After discussing the results of the June 2017 pilot

test with DEQ, Cascadia returned to the Site in July 2017 to conduct and complete the groundwater discharge survey.

### *Pilot Test*

On June 13 and 14, 2017, Cascadia conducted a 10-station groundwater discharge survey pilot test at the approximate offshore locations/stations (GWPS-1 through GWPS-10) shown on **Figure 3-5**. The purpose of the pilot test was to evaluate the effectiveness of the approach and technology proposed for evaluating groundwater discharge to sediment in Scappoose Bay. The approach and technology are described in the April 26, 2017 work plan (Cascadia, 2017a).

Utilizing a peristaltic pump and stainless-steel tooling with a slotted, 5-cm screen (PushPoint Sampler), Cascadia attempted to collect sediment porewater from 10 discrete locations within Scappoose adjacent to Area 1. The intent of the porewater collection effort was: (1) to measure the potentiometric surface of the porewater in comparison to the river stage; and (2) to compare porewater parameters (pH, specific conductance, temperature, and DO) to those of surface water. These measurements would indicate if the target location was in a state of “gain” or “loss” with regards to porewater/groundwater. The pilot test had limited success. At most pilot test locations, the PushPoint Sampler plugged with fine-grained sediment before a continuous column of porewater could be established inside the tubing. Several unsuccessful attempts and adjustments to the depth of the sampling screen, filter media (polypropylene ScreenSok, air stone) covering screen, and pumping rate (50 to 200 milliliters per minute [mL/min]) were made in an effort to improve the extraction of the sediment porewater. As a result of these physical challenges, with approval from DEQ, Cascadia suspended efforts to measure the potentiometric difference between porewater and surface water.

While efforts to measure potentiometric differences were unsuccessful, at several pilot test locations, with the PushPoint Sampler inserted 8 to 12 inches below the sediment surface, Cascadia managed to collect enough sediment water to measure water quality parameters. Given the difficulties associated with sediment porewater extraction, it is unclear if the water extracted from the PushPoint Sampler was truly sediment porewater or a combination of porewater and surface water. Either way, the water was pumped from the sampler to the surface and through a flow cell connected to a YSI Multiparameter Meter (YSI). In general, specific conductance (conductivity) and DO levels exhibited noticeable differences between surface water and water extracted from the PushPoint Sampler. However, conductivity was determined to be directly correlated to the number of suspended particulates in a given water column, and therefore was deemed not viable in differentiating a contrast between porewater and surface water. Additionally, due to the inability to maintain a sustained porewater column for the measurement of parameters, DO was also not a viable parameter for comparison of surface water to porewater. Measured temperature differences between surface water and porewater were relatively small compared to the temperature contrasts referenced above in the stilling well and groundwater in MW-25. The lower than anticipated porewater/surface water temperature differential may have resulted from temperature equilibration as porewater was pumped through the surface water column (in tubing). For the

reasons cited above, the porewater quality measurements, including temperature, using the YSI flow cell are considered unreliable. Concurrent with the YSI flow cell measurements, porewater and surface temperature were measured using a thermocouple. The thermocouple was deployed in surface water, approximately 1 foot above the mudline, and 8 inches below the sediment-water interface. The thermocouple indicated that the temperature of surface water was 2 to 7 °F warmer than sediment porewater at all target areas. Based on the apparent effectiveness of the thermocouple, and with approval from DEQ, subsequent porewater/surface water temperature measurements were limited to direct thermocouple readings in sediment and surface water.

### *Full-Scale Implementation*

Between July 18 and 20, 2017, Cascadia returned to the Site to complete the groundwater discharge survey. Using the thermocouple and methods described above, porewater and surface water temperatures were measured at 32 locations in Scappoose Bay and 12 locations in Milton Creek (labeled GWS-11 through GWS-53). Surface water temperature was warmer than porewater by an average of 8 °F in Scappoose Bay and 4 °F in Milton Creek. In general, the greatest temperature contrasts were observed closest to the shoreline within the intertidal zone where the surface sediment substrate predominately consists of fine to medium sand with varying amounts of silt. Review of previous offshore remedial investigations (e.g., boring/sampling logs), indicates that the surface sediment substrate beyond the intertidal zone riverward predominately consists of fine-grained material (e.g., silt with varying amounts of fine, clay and organic debris). The temperature contrasts recorded at each Phase 1 location are illustrated on **Figure 3-6**. Copies of the field forms and photos taken to record observations and temperature measurements collected during the June and July 2017 groundwater discharge survey were provided in the August 15, 2017 Technical Memorandum (Cascadia, 2017b).

#### **3.7.4 Surface Sediment Sheen Mapping – Area 1, July 2017**

At each of the 53 Phase 1 and 2 offshore data gap investigation locations, Cascadia utilized a “poling” technique to disturb surface sediment for the purpose of identifying whether a sheen was produced on the overlying water surface offshore of Area 1 within Scappoose Bay and Milton Creek. The objective of poling was to map areas of sheen occurrence and to differentiate petroleum sheen related to creosote from biogenic sheens attributed to the decomposition of organic material and/or iron/manganese reducing bacteria. Observed sheens were classified as biogenic, slight petroleum, or moderate to heavy petroleum. In accordance with the April 26, 2017 work plan (Cascadia, 2017a), if a sheen was observed, the “Stick Test” was utilized to determine if the sheen was of a biogenic or petroleum nature. The “Jar Shake Test” described in the work plan was abandoned during pilot testing with DEQ concurrence. Sheen observations are documented in the field forms included in the August 15, 2017 Technical Memorandum (Cascadia, 2017b).

Moderate to heavy petroleum sheens were produced in previously identified areas of surficial sediment containing wood debris with creosote. The lateral extent of surface sediment and/or wood debris capable of producing a creosote-related sheen on the overlying water surface when



disturbed (poling) appears to be confined to within close proximity of the former P&T in-water structures (e.g., former transfer table dock). Specifically, moderate to heavy petroleum sheens were only encountered within 10 feet of the former transfer table dock; while sediment poling beyond this distance, towards the channel, did not produce a visible sheen.

Localized/intermittent, slight petroleum sheens were observed near the channel side of the small island located near the confluence of Milton Creek and Scappoose Bay. Additionally, slight petroleum sheens were observed near previously identified creosote seeps within Milton Creek. Target locations and classification of sheen are documented on **Figure 3-7**. Specific field conditions such as location, water depth, temperature, thickness of soft sediment surface, and a qualitative determination of sheen coverage over a specified surface area were recorded on the field forms in the August 15, 2017 Technical Memorandum (Cascadia, 2017b). Many of the July 2017 field forms contain photos of the surface water immediately following sediment agitation.

### 3.7.5 Offshore Toxicity Assessment, September 2017

This section presents the scope and methods for implementing the Phase 3 offshore data gap investigation, which was designed to further assess freely dissolved concentrations of PAHs and TPH in sediment porewater adjacent to and outside offshore areas of creosote NAPL, inclusive of moderate to heavy petroleum sheen, in surface sediment. The results of the Phase 1 and 2 data gap investigations and a review of previously detected concentrations of PAHs in bulk sediment samples guided placement of the Phase 3 *in-situ* PSDs<sup>2</sup>. A summary of total PAHs (i.e., detected concentrations greater than Probable Effects Level) detected in select bulk sediment samples adjacent to Site Area 1 relative to the Phase 3 sampling locations is provided on **Figure 3-8**.

This phase of the offshore toxicity assessment was conducted in general accordance with the Phase 3 Data Gap Investigation Work Plan (Phase 3 Work Plan) (Cascadia, 2017c). Based on DEQ's September 1, 2017 comment letter, field conditions/observations, and subsequent correspondence with DEQ, the following modifications to the Phase 3 Work Plan were implemented:

- Phase 3 porewater sampling location #1 was moved from Milton Creek to the Scappoose Bay location to improve spatial coverage in the offshore area of interest.
- Following additional qualitative assessment of sheen occurrence in surface sediment, Phase 3 sampling location #5 was moved near historical investigation locations SB02, SD067, and SD021 (between the island and peninsula) to assess risk associated with slight to moderate sheens observed during the Phase 2 poling/sheen study completed in July 2017.

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<sup>2</sup> PSD is used in this report to refer to the sampling hardware (either sediment probes or surface water cages) containing the passive sampling media (LDPE). These *in-situ* PSDs are designed to act as a carbon sink so that PAHs sorb to the LDPE and approach equilibrium with dissolved concentrations in sediment porewater or surface water.

- Phase 3 sampling locations #6, #7, #8, #9, #10, #11, and #13 were slightly adjusted to coincide with areas previously characterized (e.g., SB04, SB03, SB08, SB09, SB13, SB27, and PWS-25, respectively).
- Phase 3 sampling location #14 was moved from the former transfer table dock area to coincide with historical investigation location PWS-6.
- Phase 3 sampling location #15 was moved from the former transfer table dock area to the Scappoose Bay location to improve spatial coverage in this offshore area.
- Preparation of one of the triplicate LDPE surface water samples (rep 2), as well as the deeper sediment porewater LDPE sample at Phase 3 sampling location #10 did not follow analytical protocol and their analytical results were omitted from the final laboratory report.
- The upper 30 inches of sediment at each Phase 3 sampling location was to be targeted for bulk sediment examination, field screening, and chemical analysis using clear Teflon® tubes. Due to limited recovery, only the upper 12 inches of sediment were obtained for field screening and chemical analysis at each Phase 3 sampling location, as discussed with DEQ.
- In addition to “volatile” aliphatic and aromatic petroleum hydrocarbons (VPH), select Phase 3 bulk sediment samples<sup>3</sup> were tested for “extractable” aliphatic and aromatic petroleum hydrocarbons (EPH), as requested by DEQ.

On September 5 and 6, 2017, Cascadia in conjunction with personnel with the Food Safety and Environmental Stewardship (FSES) program at Oregon State University (OSU) implemented the Phase 3 offshore data gap investigation with assistance from Cascade Dive Co. of Vancouver, Washington. A total of 15 *in-situ* PSDs were deployed at the above-referenced locations illustrated on **Figure 3-8**. Surface water LDPE passive samplers were deployed at 8 of the 15 Phase 3 sampling locations. Additionally, each Phase 3 sampling location included a separate *in-situ* passive diffusive bag (PDB) sampler<sup>4</sup> for assessing freely dissolved concentrations of TPH.

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<sup>3</sup> DEQ’s request to add EPH analysis was received on September 26, 2017, approximately 21 days after collecting the bulk sediment samples. Due to an error by the laboratory, EPH was not performed on approximately 1/3 of the bulk sediment samples (PWS-01, PWS-02, PWS-12, PWS-13, and PWS-15).

<sup>4</sup> As requested by DEQ, the Phase 3 investigation of sediment porewater also included deployment of PDB samplers in separate adjacent sediment probes (passive samplers) to accumulate dissolved TPH in a controlled manner. Measurements of dissolved TPH concentrations in sediment porewater water were extracted from ASTM Type 1 Deionizer water inside the PDBs. The Equilibrator™ PDBs manufactured by Eon Products, Inc., are designed for deployment into sediment and consist of low-density polyethylene bags filled with relatively de-oxygenated distilled water. When placed in water or sediment containing water, dissolved phase organic compounds diffuse through the wall of the bag in response to the concentration gradient between the porewater in the sediment and the distilled water in the bag.

### Bulk Sediment Collection

At each Phase 3 sampling location, the upper 12 inches of sediment were collected using clear Teflon® sampling tubes for visual examination, field screening, and chemical analysis. Immediately upon retrieval and prior to deploying the PSDs, the Teflon® tubes were cut open and the sediment conditions examined and logged for grain size, debris, odors, visible sheen, and biological activity. Observations were recorded on the field sampling sheets provided in **Appendix C**. A homogenized sample of the upper 12 inches of sediment was placed in laboratory-prepared sampling containers and submitted to Apex Laboratories, LLC (Apex Labs) under chain-of-custody protocol for chemical analytical testing. The sediment samples were submitted for chemical analysis of the following:

- 34 PAHs (measurement of 18 parent PAHs and 16 groups of prominent C<sub>1</sub> to C<sub>4</sub> alky PAH derivatives) by EPA Method 8270D Modified;
- VPH using the Washington Department of Ecology (Ecology) method where volatile aliphatic and aromatic hydrocarbons are collectively quantified within the following equivalent carbon ranges by gas chromatography (GC) using a PID and flame ionization detector (FID) in series;
  - Volatile aliphatics - C<sub>5</sub> through C<sub>6</sub>, C<sub>>6</sub> through C<sub>8</sub>, C<sub>>8</sub> through C<sub>10</sub>, and C<sub>>10</sub> through C<sub>12</sub> ranges; and
  - Volatile aromatics - C<sub>8</sub> through C<sub>10</sub>, C<sub>>10</sub> through C<sub>12</sub>, and C<sub>>12</sub> through C<sub>13</sub> ranges;
- VOCs using GC/MS by EPA Method 5035/8260C;
- EPH using the Ecology method where extractable aliphatic and aromatic hydrocarbons are collectively quantified within the following ranges by GC using an FID;
  - C<sub>8</sub> through C<sub>10</sub>, C<sub>>10</sub> through C<sub>12</sub>, C<sub>>12</sub> through C<sub>16</sub>, C<sub>>16</sub> through C<sub>21</sub>, and C<sub>>21</sub> through C<sub>34</sub> ranges;
- TOC by Standard Method 5310B-Modified; and
- Black Carbon (a.k.a., % soot) in accordance with Environmental Science and Technology (ES&T) American Chemical Society (ACE) publications by Accardi-Dey and Gschwend, 2002 and Gustafsson (et al.), 2004.

Apex Labs subcontracted analytical testing of bulk sediment samples for Black Carbon to Alpha Analytical, Inc. in Mansfield, Maine, and the Ecology VPH/EPH to Analytical Resources, Inc. (ARI) in Tukwila, Washington. As noted above, bulk samples collected on September 6, 2017 (i.e., PWS-090617-1, -2, -12, -13, -15) were not analyzed for EPH because Apex Labs failed to list it on its ARI work order. Cascadia was not aware of the situation nor given an opportunity to review the laboratory work orders until Apex Labs started issuing draft reports in December 2017.

Based on a review of the Apex Labs reports, the remaining field samples were analyzed for all methods with quality assurance/quality control (QA/QC) that met applicable data quality objectives (DQOs). As requested by DEQ, a sample of the certified reference material National Institute of Standards and Technology (NIST) Standard Reference Material (SRM) 2779 Gulf of Mexico Crude Oil was analyzed for PAHs by Apex Labs and included in its final report. In addition to SRM 2779, Apex Labs purchased SRM 1191, SRM 149, and SRM 2260, and analyzed these oil samples select parent and/or alky PAH derivatives. For a particular analyte and/or alkylated group, the performance on the reference material is deemed acceptable if the laboratory result is within 30 percent of the assigned value listed in the Certificate of Analysis for SRM 2779. The results of the SRM PAH analyses are provided the February 14, 2018 Apex Labs report A7K0243, as well as a brief discussion of the results in the Data Quality Review in **Appendix D**.

### *Surface Water and Sediment Porewater Collection*

As described in the Phase 3 Work Plan, the PSDs prepared and provided by FSES consisted of LDPE sheets applied with performance reference compounds (PRCs) housed inside sealed stainless-steel probes. The LDPE average membrane thickness is 75 to 95 micrometers ( $\mu\text{m}$ ), average width of each sheet is 2.7 cm, the average transient polymer cavity size is 10 angstrom ( $\text{\AA}$ ), and each LDPE is nominally 100 cm long (FSES, 2017). The stainless-steel probes consisted of two separate slotted intervals, each containing LDPE sampling media. The slotted intervals were separated by blank sections of the stainless-steel probe so that the slotted interval/LDPE sampling media targeted separate and discrete sediment intervals. Each LDPE sediment probe was manually inserted approximately 32 inches into the sediment, with slotted sampling intervals and media targeting the intervals between 3 and 8 inches bml and 24 and 29 inches bml. Also, FSES prepared and provided stainless steel cages containing LDPE for surface water sampling approximately 12 inches (1 foot) above the mudline at 8 of the 15 Phase 3 sampling locations and included triplicate water cages at PWS-090517-10. The PDBs were prepared and provided by EON Products, Inc. were deployed inside PVC probes manually inserted 12 inches into the sediment with a slotted sampling interval between 4 and 10 inches bml.

The predetermined Phase 3 sampling locations were identified in the field using a high-resolution differential global positioning system (DGPS) with pre-loaded target sample location coordinates using the following horizontal datum: North American Datum of 1983 (NAD83); State Plane Coordinate System; Oregon North Zone; and International Feet. Cascadia and FSES field staff deployed 5 of the 15 passive sampling devices from shore (i.e., PWS-090517-6, PWS-090517-7, PWS-090517-8, PWS-090517-9 and PWS-090517-11). The remaining ten PSDs (PWS-090617-1 through PWS-090517-5, PWS-090517-10, PWS-090617-12 through PWS-090617-15) were deployed from a boat using a diver. Boat and diver operations were conducted by Cascade Dive Company, under subcontract to Cascadia. Each Phase 3 sampling location was established to within 25 feet of the pre-determined location, based on field conditions.

The passive samplers were then left in the sediment and/or overlying water for approximately 21 days and allowed to approach equilibrium. At the time of retrieval on September 26, 2017, the

divers removed the passive samplers and passed them to FSES and Cascadia personnel on the sample vessel for sample handling and transport to the appropriate laboratory for chemical analysis of freely dissolved PAHs and TPH. Specifically, FSES personnel removed the passive LDPE sampling media from the protective housing, rinsed them with water from the Site to remove sediment or biofouling, as necessary, before packaging for transport to the FSES laboratory at OSU. Upon retrieval of the PDBs, Cascadia field staff removed the Equilibrator™ PDB from the PVC casing and immediately punctured the LDPE bag with a discharge straw to fill standard water sampling containers provided by Apex Labs.

Post-deployment preparation of all LDPE samples was performed at the FSES laboratory on October 12, 2017. Batches of samples were extracted as per FSES standard operating procedure (SOP) 406.02 between October 17 and 26, 2017. Chemical analysis of surface water and sediment porewater LDPE PSDs was completed by the OSU FSES Program as described in the following SOPs.

- SOP 407.01 – Calculation of Freely Dissolved Water Concentrations ( $C_{free}$ ) of Organic Compounds Derived from polyethylene (PE) PSDs;
- SOP 418.00 – Determination of Parent and Alkyl Substituted PAHs (a total of 63 PAHs) using Gas Chromatography Tandem Mass Spectrometry (GC-MS/MS);
- SOP 414.00 – Determination of Oxygenated PAHs (OPAHs) (a total of 22 analytes) using GC/MS;
- SOP 416.10 – Determination of Hopane and Cholestane Compounds (a total of 11 analytes) by SIM GC/MS; and
- SOP 427.00 – Determination of Forensic Alkyl PAHs (i.e., 18 parent PAHs and 16 groups of prominent  $C_1$  to  $C_4$  alkyl PAH derivatives [so-called 34 PAHs]) using GC-MS/MS. The primary standard for this method was NIST SRM 1991 Mix Coal Tar/Petroleum Extract in Methylene Chloride.

Problems occurred during the preparation of one of the triplicate surface water samples (rep 2), as well as the deeper sediment porewater sample, at Phase 3 sampling location #10 and subsequently the analytical results for these Phase 3 samples have been omitted from the FSES Final Report (FSES, 2018). According to FSES, the remaining field samples were analyzed for all methods with QA/QC that met applicable DQOs. As requested by DEQ, a sample of the certified reference material NIST SRM 2779 Gulf of Mexico Crude Oil was analyzed for alkyl PAHs by FSES and was included in its Final Report along with measures of instrument precision.

Upon retrieval and transfer of the water from the PDBs into standard water sampling containers, the sediment porewater samples slated for chemical analysis of TPH fractions were submitted to Apex Labs for quantification of aromatic and aliphatic hydrocarbons between equivalent carbon numbers  $C_5$  through  $C_{13}$  using the Ecology VPH test. Apex Labs subcontracted the VPH analysis to ARI, a Washington certified laboratory. Also, an aliquot of the PDB water samples were analyzed for



select VOCs by EPA 8260C using multiple-ion monitoring (MIM) techniques by Apex Labs. MIM techniques were used to search for aromatic and aliphatic hydrocarbons below the VPH method reporting limit of 50 micrograms per liter ( $\mu\text{g/L}$ ).

### 3.7.6 Surface Sediment Sheen Mapping – Area 2, October – November 2018

In October 2017, DEQ staff inspected the Area 2 shoreline and observed creosote-impacted surface sediment near the terminus of the former creosote pipeline and residual pilings associated with a historical dock. According to historical maps and photos, this dock was formerly used to offload creosote from river barges between 1919 and 1959.

In response to the September 2018 DEQ email (DEQ, 2018a) and subsequent telephone conversations, Cascadia prepared a work plan (Cascadia, 2018b) to visually map creosote sheen occurrence along the approximately 900-foot-long portion of the Scappoose Bay Area 2 shown on **Figure 3-9**. The work plan was approved by DEQ on October 11, 2018 (DEQ, 2018b).

Cascadia, with DEQ oversight, completed a low-tide, low-water shoreline inspection on October 22, 2018. Cascadia and DEQ returned to this Site area on November 29, 2018, with a small boat to map offshore sheen occurrence amongst the piling and throughout the footprint of the former creosote offloading dock. The details and findings of these Area 2 shoreline inspections are presented below.

#### *October 2018 Shoreline Inspection*

On October 22, 2018, Cascadia and DEQ visually inspected exposed soil and sediment along approximately 1,000 linear feet of Area 2 shoreline between the riverbank and edge of surface water during low tide for evidence of creosote-related sheen. The low-tide water level on October 22, 2018, at 11 AM was approximately -1.4 feet below the MLLW or 0.65 feet relative to the Columbia River Datum (CRD). Cascadia personnel walked the shoreline and potholed 18 to 24 inches below grade using hand tools at a total of 23 locations shown on **Figure 3-9**. Initially, Cascadia staked out the predetermined locations based on proximity to prior upland investigations (e.g., GB-8, GP-09, and MW-14), historical site features (e.g., former creosote pipeline, oil aboveground storage tank, dock, oil pipe trestle), and general spatial coverage along shoreline within previous composite sediment sample transects (SHI01B, SHI01S, and SHI02B). The exact boring location and the number of borings was adjusted/increased as necessary to define the extent of visible contamination.

Surface sediment conditions generally consisted of silty fine to medium sand with varying amounts of wood debris (combination of dimensional lumber and/or wood fragments). The source of petroleum sheens in surface sediment was determined to be attributed to creosote-treated dimensional lumber and/or wood fragments partially buried within the upper 12 inches of sediment at 11 of the 23 shoreline borings. The vertical extent of creosote contamination did not exceed 12 inches bml and its lateral extent was confined to the intertidal zone (i.e., did not extend to the uplands). The creosote-treated wood debris appears to be associated with deterioration of the former dock and support pilings and is predominately located within the red dashed area shown on



**Figure 3-9.** NAPL blebs independent of wood debris were not observed in the surface sediment. As discussed below, NAPL (inclusive of moderate to heavy petroleum sheen) were not generated by disturbing sediment around the remaining log pilings outside the red dashed area. Highly localized/intermittent areas of creosote contaminated wood debris were observed at shoreline borings #3 and #21, located approximately 150 to 200 feet upriver and downriver of the primary accumulation area, respectively. Sheen observations are documented on the field forms provided in the January 17, 2019 Technical Memorandum (Cascadia, 2019b).

A relatively steep downward slope in sediment bathymetry precluded a full delineation of the offshore extent of creosote-treated wood debris in surface sediment during the October 2018 shoreline inspection.

### *November 2018 Offshore Inspection*

On November 29, 2018, Cascadia and DEQ delineated the lateral extent of sheen occurrence in surface sediment offshore of Area 2. As shown on **Figure 3-9**, a total of 60 offshore locations were investigated for submerged creosote-treated wood debris using the “poling” technique described above in **Section 3.7.4** to disturb surface sediment. Most of the poling occurred between high tide at 10 AM (3.75 feet MLLW or 5.78 feet CRD) and low tide at 4 PM (1.65 feet MLLW and 3.67 feet CRD). The objective of poling was to map areas of sheen occurrence on the overlying surface water and to differentiate creosote-related (petroleum) sheen from biogenic sheens attributed to the decomposition of organic material and/or iron/manganese reducing bacteria. Observed sheens were classified as either “No Sheen or Biogenic” or “Petroleum - Moderate to Heavy Sheen” (indicative of creosote). In the accordance with the work plan, if a sheen was observed, the “Stick Test” was utilized to determine if the sheen was of a biogenic or petroleum nature. As discussed above in **Section 3.7.4**, the “Jar Shake Test” described in the work plan was abandoned during pilot testing with DEQ concurrence.

NAPL, including moderate to heavy petroleum sheens, were noted in 5 of the 60 offshore locations within close proximity of the shoreline borings that encountered creosote contaminated wood debris within the upper 12 inches of sediment. The lateral extent of surface sediment and/or wood debris capable of producing a moderate to heavy petroleum sheens on the overlying water surface when disturbed (poling) appears to cover an approximately 200-foot-long by 50-foot-wide section of the Area 2 shoreline beneath and immediately downriver of the former P&T dock and creosote AST. Specifically, moderate to heavy sheens were only encountered amongst the pilings near the shoreline; while sediment poling beyond 50 feet of the shoreline (even amongst the pilings), did not produce a visible petroleum sheen. Specific field conditions such as location, water depth, thickness of soft sediment surface, and a qualitative determination of sheen coverage over a specified surface area were recorded on the field forms provided in the January 2019 Technical Memorandum (Cascadia, 2019b).

## 4.0 UPDATED SITE SETTING

The supplemental RI data collection efforts have allowed a more detailed evaluation of the Site physical setting. Topographic and bathymetric information for the Site is presented on **Figure 2-1**, and geologic and hydrogeologic information is presented on **Figure 2-2**. Eight detailed cross sections were developed for the locations shown on **Figure 4-1** using stratigraphic data obtained from boring logs. The cross sections are presented on **Figures 4-2** through **4-9**. A contour map showing the elevation at the top of the Basalt Bedrock unit is presented on **Figure 4-10**.

### 4.1 GEOLOGY

Subsurface soil conditions beneath the upland portions of the Site are largely consistent with the description presented earlier in **Section 2.3.1**. Information gathered during the supplemental RI activities allowed for a more detailed understanding of the fill material (i.e., “Fill Zone” unit) and Native Soil units, as well as the underlying Basalt Bedrock.

For the purposes of this report, fill is used as a generic term for imported soil or reworked native soil placed at the Site after initial development in the early 1900s. The thickness of the Fill Zone unit across Area 1 generally ranges from 5 to 10 feet. The fill material is fairly uniform in thickness across most of the upland area, but tends to be thickest along Milton Creek and along the Scappoose Bay shoreline near the Former Operations Area, where the pre-fill land surface sloped toward these surface water features, and in the northwestern portion of the property near the railroad bridge crossing Milton Creek. The fill tends to be thinnest where the Basalt Bedrock elevation is locally high.

The Native Soil unit beneath the Fill Zone unit consists predominantly of silt with varying amounts of fine sand, clay, and organic matter. Silty gravel with varying amounts of sand was encountered immediately above the Basalt Bedrock in localized areas. The thickness of the Native Soil unit above the Basalt Bedrock beneath this portion of the Site varies between approximately 5 and 23 feet. The Native Soil is thickest above dips in the Basalt Bedrock elevation (local troughs), and thinnest where the Basalt Bedrock elevation is locally high, including the northwestern portion of the property near the railroad bridge crossing Milton Creek. The Native Soil was not present in an area along the basalt ridge near Milton Creek. Although not visible at the scale shown on the cross sections, thin layers of fine sand with varying amounts of silt (typically less than 2 inches thick) were observed intermittently within the fine-grained sequences of Native Soil.

The Basalt Bedrock unit was encountered in nearly all RI borings completed with machine drilling equipment (e.g., hollow-stem auger, direct-push, sonic). The contact with the Basalt Bedrock was generally distinct and encountered beneath 6 to 35 feet of soil within the upland portion of Area 1. At offshore locations, the contact with the Basalt Bedrock was encountered beneath 2 to 26 feet of river sediment. The thickness of river sediment in the nearshore area appears to vary depending on the elevation of the underlying Basalt Bedrock. As illustrated by the cross sections, the basalt surface beneath the Site (both upland and offshore) is highly variable with numerous peaks and

valleys over relatively short distances. An updated contour map of the top of the Basalt Bedrock is provided on **Figure 4-10**. Most likely, the irregularity of the basalt topography beneath the Site is related to erosion and not faults within the units (GeoEngineers, 2000).

Varying degrees of weathering and fracturing were encountered in each exploration. Visual examination of core samples obtained from the explorations indicates that the basalt is generally dense with relatively impermeable fractures, which is consistent with prior RI findings.

## 4.2 HYDROGEOLOGY

Hydrogeological conditions beneath the upland portions of the Site are largely consistent with the description in **Section 2.3.2**. Information gathered during the supplemental RI activities allowed for a more detailed understanding of groundwater occurrence and flow within the Fill Zone and Native Soil units, as well as interaction with surface water bodies.

Groundwater elevation contours are plotted on **Figure 4-11** for both high-water and low-water conditions, and the measured groundwater and surface water elevations are presented in **Table 4-1**. Regional groundwater flow in the area of the Site reflects discharge to the Scappoose Bay and Columbia River Systems (including Multnomah Channel). This means that groundwater generally flows toward the river in both the horizontal and vertical directions. The shallow water table beneath the Site exhibits a divergent flow pattern with groundwater beneath its north and west margins flowing towards Milton Creek, and groundwater beneath its south and east margins flowing towards Scappoose Bay. The local, or near-surface, flow regime (shallow groundwater) is present within both the Fill Zone and the Native Soil beneath the Site. RI and supplemental RI monitoring wells were constructed to evaluate shallow groundwater conditions separately within the upper dredge sand fill and the lower native silt. *In-situ* tests (slug tests) conducted as part of the 1996 RI determined that the hydraulic conductivity within the Fill Zone is approximately 1 to 2 orders of magnitude greater than Native Soil hydraulic conductivity. Based on the hydraulic conductivity, wells in the Fill Zone are expected to exhibit a higher level of hydraulic connection with surface water than wells that are screened in Native Soil. These variable levels of hydraulic connection are exhibited by wells MW-25 (Screened within the Fill Zone) and MW-6A (Screened within the Native Soil) during the May – July 2017 Phase 1 data gap investigation. Specifically, groundwater levels in MW-25 exhibit a nearly instantaneous response to changes in river stage, whereas well MW-6A exhibited no significant response to tidal stage and only a low gradual response to seasonal river stage.

The area of Scappoose Bay and Multnomah Channel adjacent to the former P&T site is a regional discharge area for groundwater. Relative shallow groundwater elevations in paired monitoring wells located away from surface waters (interior upland areas) typically exhibit a downward vertical hydraulic gradient from the Fill Zone to the underlying Native Soil. Groundwater elevations in paired monitoring wells located immediately adjacent to the shoreline of Scappoose Bay/Multnomah Channel typically exhibit a slight upward vertical gradient from the Native Soil to the overlying Fill Zone. These observed vertical gradients within the local, or near-surface, flow regime

indicates that shallow groundwater joins with the regional flow system near the Site along the Scappoose Bay/Multnomah Channel shoreline. This flow regime is shown schematically on **Figure 4-12**.

The rates and timing of groundwater discharge to surface water are strongly influenced by seasonal rainfall and fluctuating river stage. These dynamic conditions can result in significant temporal variability in the advective driven impacts to surface water and sediment porewater quality. **Figures 4-13** and **4-14** present the annual hydrographs for the Columbia River in 2012 and 2017, respectively, and identify the sampling periods for porewater and surface water (2017 only).

The July 2017 offshore temperature contrast study was conducted during a period of rapid surface water decline, and much like the heterogenic nature of sediment, its results were highly variable. A comparison of temperature contrasts to grain size descriptions of nearby sediment samples, confirms that shallow groundwater discharges into Scappoose Bay primarily through the sandier bank and sediment stratum generally located along the Site shoreline. Some of the highest temperature contrasts were observed within the poorly sorted beach sand and/or silty sand areas depicted on **Figure 3-6**.

During the late summer and early fall (August, September, and October) when surface water elevations drop and reach seasonally low levels, localized groundwater seeps along the Site's banks have been observed intermittently along the Scappoose Bay and Milton Creek shorelines adjacent to Area 1 (**Figure 4-11**). These groundwater seeps appear to be confined to relatively thin soil layers (2 to 4 inches thick) where the near-surface flow regime is discharging through a lens of sand within the native silt matrix and/or along the Fill Zone/Native Soil contact.

The intermittent groundwater seeps observed along Scappoose Bay within the man-made cove were generally found near the bottom of the shoreline embankment between Area 1 monitoring wells MW-19 and MW-25. The groundwater seeps observed along the banks of Milton Creek were generally found between sediment porewater sample locations PWS-17 and PWS-30. **Figure 3-3** shows the groundwater seep locations identified from the Area 1 shoreline inspection events.

### 4.3 FLUVIAL GEOMORPHOLOGY

The Site is situated along the northwestern shore of Scappoose Bay adjacent to the confluence between Scappoose Bay and the Multnomah Channel of the Willamette River. This lower reach of Scappoose Bay is characterized as a lowland floodplain of the Columbia River estuary (DEA, 2000). The confluence of the Multnomah Channel and the Columbia River is approximately 1.3 miles northeast (downriver) from the Site. Milton Creek is a perennial stream that borders the western Site boundary and discharges to Scappoose Bay at the southwest corner of the Site. The main channel of Scappoose Bay is located just offshore of the former P&T facility (**Figure 2-1**) and borders the Area 1 shoreline. The Area 2 shoreline is located just downstream of Scappoose Bay and borders Multnomah Channel.

A review of bathymetric maps generated adjacent to Area 1 in 2010 and 2017 indicates the main channel of Scappoose Bay is a stable feature adjacent to the Site. Tidal fluctuations of water levels occur daily in Scappoose Bay and Multnomah Channel, in addition to seasonal fluctuations in water levels as a result of runoff events in the watershed. The Site's Scappoose Bay shoreline is routinely inundated above the OHWM (14 feet NAVD88) during high tides when Columbia River surface water elevations are sufficiently high (typically between April and July). During much of the year, mudflats are visible along the Site's shoreline between approximately 5 to 10 feet NAVD88. Depending on shoreline conditions, basalt topography, and channel dimensions, portions of the Site's shoreline experience sediment deposition (e.g., flat, soft bottom cove areas), while riverbank areas closer to the main channel appear to exhibit localized erosion of sediment from large storm events and/or tidal cycles.

The Site's shoreline, including riverbank and mudflats, differs by location. Therefore, the offshore areas exhibiting creosote contamination are described separately below and are termed, the "Cove Area" (on either side of the peninsula), "Area 1 Dock", "Lower Milton Creek", "Upper Milton Creek", and "Area 2 Dock". These offshore areas are illustrated on **Figure 4-15**.

#### 4.3.1 Upper Milton Creek

The sediment profile within Upper Milton Creek consists of 0 to 1 foot of silty organic-rich fluff overlying a 1- to 6-foot hardpan layer of gray stiff clayey-sandy silt with gravel and cobbles. Scouring of the creek channel by seasonal runoff and diurnal tidal cycles appears to limit the accumulation of sediment in this portion of the creek. The Site shoreline with Milton Creek is generally characterized by relatively steep embankment covered with vegetation. Prior to development of the wood treating facility, the upland area of the Site immediately east and northeast of the Upper Milton Creek was part of the Milton Creek floodplain. Between 1929 and 1939, this upland area appears to have been filled and brought to grade with the rest of the Site.

#### 4.3.2 Lower Milton Creek

The Lower Milton Creek in-water area generally covers the portion of Milton Creek downstream of the Railroad Avenue vehicle bridge and the confluence of Milton Creek with Scappoose Bay (riverward of the island). Downstream of the vehicle bridge, the depth to Basalt Bedrock increases and the sediment profile thickens. In the Lower Milton Creek area, the sediment profile consists of 3 to 10 feet of silt with varying amounts of sand and clay overlying Basalt Bedrock.

Riverward of the island and immediately downstream of the mouth of Milton Creek is an approximately 1-acre area of sediment deposition with river bottom elevations between 0 and 5 feet NAVD88. The bottom elevation of the main channel of Scappoose Bay adjacent to this portion of Lower Milton Creek ranges between -7 and -5 feet NAVD88 and is between 50 and 100 feet wide.

### 4.3.3 Cove Area

The Area 1 Scappoose Bay shoreline and in-water area immediately downgradient of the former wood treating facility, inside the island and around the peninsula, is referred to herein as the Cove Area. Prior to development, the Cove Area consisted of a partially vegetated slough (historical aerial photographs were included in the 2000 RI Report). This southwestern portion of the Area 1 shoreline was created between 1948 and 1953 through extensive dredging and filling of historical lowlands.

The elevation of the river bottom within the manmade cove and shallow inlet immediately downriver of the peninsula ranges between approximately 0 and 10 feet NAVD88 within approximately 100 to 300 feet of the shoreline before sloping steeply towards the main channel of Scappoose Bay. The main channel of Scappoose Bay adjacent to the Cove Area widens to approximately 150 feet with bottom elevations between -7 and -5 feet NAVD88.

Since the Cove Area is protected from the erosional effects of large storm and tidal surge, it is a sediment depositional area. In 1960, wood treating plant operations ceased, and presumably dredging, which appears to have led to the deposition and burial of the old operational sediment surface throughout the Cove Area. A sediment deposition rate of 0.2 to 1.4 inches per year (in/yr) is implied based on the presence of 1 to 7 feet of relatively clean fine textured sediment above the old contaminated operational sediment surface. The nature and extent of offshore contamination is discussed in **Section 5.3.2**.

### 4.3.4 Area 1 Dock

The approximately 700-foot section of shoreline and in-water area between the former hog fuel dock and northeastern (downriver) terminus of the former transfer table dock is referred herein as the “Area 1 Dock.” In 2013, the creosote-treated wood decking and lateral bracing was removed from both dock structures and only the creosote-treated timber pilings remain. This portion of the Site’s shoreline is closer to the main channel of Scappoose Bay and is subjected to stronger river current, as evidenced by the coarser sandy sediments encountered within the intertidal zone.

The main channel of Scappoose Bay widens and deepens adjacent to and within the Area 1 Dock. Specifically, the bottom of the main channel ranges between 200 and 250 feet NAVD88 wide and between -10 and -5 feet NAVD88 deep adjacent to Area 1 Dock. Within this offshore area the river bottom slopes steeply downward within 50 to 100 feet of the shoreline. The results of the supplemental RI suggest that this portion of the Site’s shoreline is relatively stable to eroding, generally preventing the deposition of newer clean sediments and the burial of historical contamination.

### 4.3.5 Area 2 Dock

The approximately 600-foot section of Site shoreline near the downriver margins of Area 2 and in-water area at the terminus of the former creosote pipeline and historical offloading dock (circa



1919 to 1959) is referred to herein as the “Area 2 Dock.” This portion of the Site’s shoreline is adjacent to Multnomah Channel and since it was not originally part of the supplemental RI, high resolution bathymetry data are not currently available. Based on the presence of contamination in surface sediment, hard compact nature of the mudflats with relatively steep slopes towards the channel, this portion of the Site’s shoreline appears to be relatively stable to eroding.

The Area 2 Dock boundary is approximately 600 feet long and 150 feet wide (eastward from the riverbank). Its approximately 2-acre dimensions within Multnomah Channel were determined by the outer extent of timber piling associated with the former pipeline and dock structures. According to the FS Tech Memo prepared for the Boise Mill shoreline (AECOM, 2016), the main stem of the Multnomah Channel is 100 to 150 offshore with a bottom elevation of approximately - 15 feet NAVD88 immediately downstream of the Site.

## 5.0 NATURE AND EXTENT OF CONTAMINATION

The 2000 RI Report presented data collected at the Site through 1998. The initial phases of the RI were focused on the upland portions of the Site, with only limited characterization of surface water and surface sediment (i.e., top 4 inches) along its 4,500 linear feet of shoreline of Milton Creek and Scappoose Bay / Multnomah Channel. Since submittal of the 2000 RI Report, an additional 670 samples of soil, groundwater, NAPL, sediment, porewater, and surface water have been collected and analyzed. The supplemental RI activities described in **Section 3.0** were conducted in phases, and the resulting information was used to fill the RI data gaps and address the objectives listed in **Section 1.2**. Unlike the site-wide assessment described in the 2000 RI Report, the supplemental RI findings are focused on the upland portion of Area 1, offshore areas adjacent to Area 1 within Milton Creek and Scappoose Bay, and the offshore area adjacent to Area 2 within Multnomah Channel near the terminus of the former creosote pipeline and residual pilings associated with a historical dock (“Area 2 Dock”).

The development of the nature and extent of contamination discussion presented in this section is based on the field observations and analytical data collected during RI and supplemental RI activities. This discussion is presented by Site media below.

### 5.1 OVERVIEW

The results of the RI demonstrate that the majority of the soil, groundwater, and sediment contamination at the Site is related to the former wood-treatment activities conducted between 1912 and 1960. Creosote has been identified as the primary wood-treating contaminant in soil, groundwater, and sediment samples collected in the vicinity of the former wood-treating facilities (primarily Area 1). Creosote is a TPH mixture of predominantly diesel- and oil-range hydrocarbons and contains substantial amounts of PAHs (about 85% by weight). Consequently, the presence and quantity of TPH and PAHs (or lack thereof) in subsurface soil, groundwater, sediment (bulk and porewater), and surface water collected from the Site and locality were used to evaluate the extent of creosote impacts at the Site.

Based on the results of the supplemental RI, the lateral upland extent of creosote related NAPL extends over a larger portion of Area 1 than had been established in the 2000 RI. Data obtained from conventional characterization techniques (e.g., borings and direct examination of retrieved soil samples at pre-selected depths) suggest that the majority of NAPL beneath upland soil is pooled on top of the basalt surface. Detailed vertical profiling of NAPL architecture using LIF identified much thinner layers of NAPL than were originally believed to be present and indicated that NAPL is generally confined to the fine-grained Native Soil above the basalt surface. Some RI and supplemental RI borings completed near the former wood treating operations did encounter NAPL at the Native Soil/Basalt Bedrock contact, but not consistently enough to support the previous conclusion that significant amounts of creosote NAPL pooled and spread laterally across the basalt surface as was described in the 2000 RI. The majority of creosote NAPL appears to have been

trapped by capillary forces within the overlying Native Soil (fine-grained alluvium) before reaching the Basalt Bedrock.

The lateral and vertical extent of contamination associated with the former wood-treating operations appears to be sufficiently defined beneath the Site and adjacent portions of Scappoose Bay and Milton Creek to assess risk and establish remedial action objectives. Data completeness is further discussed in **Section 8.0**.

## 5.2 SOIL

Results from most upland soil samples collected at the Site were presented in the 2000 RI Report (Section 7.2.1, Figure 21). A limited number of soil samples were collected as part of the supplemental RI (**Table 5-1**). The supplemental RI soil sample results support the conclusions regarding nature and extent of soil impact from the 2000 RI Report. Upland soil at the Site is adequately characterized for the purposes of the RI/FS.

The Fill Zone/Native Soil contact generally represents the original ground surface at the time the wood-treating facility operated. Consequently, creosote-impacted soil in the vicinity of the former wood-treating facilities is generally limited to the Native Soil unit, located beneath 5 to 10 feet of dredge sand fill and gravel (Fill Zone). In explorations completed in close proximity to the former wood-treating plant and former aboveground creosote storage tanks to the west of the plant, varying degrees of creosote impact have been observed throughout the entire thickness of the Native Soil unit (depths ranging between about 5 feet bgs to approximately 23 feet bgs at the Native Soil/Basalt Bedrock contact). In general, creosote-impacted soil decreases in vertical thickness and is encountered at deeper intervals within the Native Soil stratum (i.e., closer to but not necessarily directly at the Native Soil/Basalt Bedrock contact exclusively) as distance increases from the former wood-treating operations.

A summary of the analytical results for soil samples is provided below and in **Table 5-1**.

- Creosote-related hydrocarbons (diesel and oil ranges) were detected in soil samples collected from 19 of 28 explorations completed in Area 1, with a maximum concentration of 6,320 mg/kg (sum of diesel- and oil-range hydrocarbons) in the MW-24 boring.
- Concentrations of total PAHs in soil ranged from not detected to a maximum of 3,410 mg/kg in boring MW-24.

## 5.3 NAPL

Creosote NAPL has been encountered in soil, groundwater, groundwater seeps, and sediment at the Site. The nature of NAPL has been investigated, and the results provided in the 2000 RI Report (2000 RI Report Appendix C, Tables C-17 through C-23) indicate a NAPL composition consistent with recent analytical results for creosote-related constituents from the supplemental RI activities (**Table 5-2**). The extent of NAPL at the Site has been inferred based on field observations of

creosote sheens in soil samples collected during the multiple investigation events conducted during the supplemental RI. The extent is shown on **Figure 5-1**.

The composition of NAPL at the Site is dominated by diesel- and oil-range hydrocarbons (although chromatograms do not match a diesel or oil fingerprint) and PAHs (naphthalene, phenanthrene, 2-methylnaphthalene, and others).

### 5.3.1 Upland

The presence of NAPL has been identified in uplands soil in close proximity to the former operations area (i.e., retorts, pump house, storage tanks) and at distances of up to approximately 300 feet northwest, west, southwest, and south toward Milton Creek and Scappoose Bay. The upland extent of NAPL, although not continuous throughout, has been generally defined within an approximately 4-acre area. The distribution of NAPL beneath the former operations area appears to be a function of subsurface migration from the former creosote storage tanks, plant, and retorts as well as direct releases from other ancillary operations (e.g., the transfer table).

As indicated by TarGOST® logs (SO14, SO15, SO16, SO18, SO20, and SO21) completed within the upland NAPL footprint, potentially mobile creosote is present in the Native Soil at various depths within distinct stratigraphic layers less than 18 inches thick. The total thickness of creosote impacted varies from 1 to 8 feet, and the impacted intervals typically occur at depths greater than 10 feet bgs (below Fill Zone). In general, this vertical layering or profile of NAPL becomes thinner and deeper within the Native Soil with distance from the former operations area at depths greater than 10 feet bgs.

The inferred extent of NAPL indicates that topographical highs on the basalt surface, such as the ridge to the east of the former operations area along the Scappoose Bay shoreline, appear to influence the subsurface distribution of NAPL. The bedrock appears to be a barrier to downward vertical migration of the NAPL, based on the physical properties of creosote samples and *in-situ* hydrogeologic data gathered from RI rock core borings (see **Section 6.0**).

A sheen and/or olfactory evidence of creosote impact were noted in the upper surface of basalt in only 4 of the 45 NAPL delineation borings completed in 2011 (SB10, SB11, MW-24, and MW-25; **Section 3.4.2**). These four borings correspond to Site areas where creosote NAPL was found near the Native Soil/Basalt Bedrock contact. The results of the 2011 NAPL delineation are consistent with the conceptual model presented in the 2000 RI, in that only minor amounts of creosote-related contamination (i.e., dissolved phase) appear to have penetrated and/or migrated through the top of the Basalt Bedrock.

During the 2000 RI, the presence of NAPL was identified in monitoring wells MW 2, MW-3A, and MW-3B. Eight new Area 1 monitoring wells were installed in 2011 (**Section 3.4.2**) to confirm the lateral extent of NAPL inferred from the TarGOST® LIF investigation, direct examination of the subsurface soil samples, and groundwater monitoring of existing wells. Pooled NAPL was not detected in the base of any of the new Area 1 monitoring wells, despite the fact that the wells were

equipped with “DNAPL funnels” set entirely within the upper surface of the basalt, were situated within the former operations area, and were screened across soil intervals containing heavy creosote impact (see **Section 3.4.2**). With the exception of monitoring well MW-3A, NAPL was not observed in any of the Site’s monitoring wells during gauging conducted as part of the supplemental RI. Consistent with the 2000 RI, measured NAPL thicknesses in the base of monitoring well MW-3A ranged from 1.25 to 2.56 feet. Prior measurements of the specific gravity of NAPL collected from monitoring well MW-3A ranged from 1.01 to 1.04. Because the density of creosote NAPL is similar to the density of water, accurate measurements of NAPL thickness in monitoring well MW-3A are problematic and considered qualitative.

### 5.3.2 In-Water

The presence of offshore creosote NAPL differs by source, depth bml, thickness, and fate depending on location. Therefore, the offshore areas defined above in **Section 4.3** are described below separately.

#### *Upper Milton Creek*

Groundwater seepage with a creosote-related sheen has been observed along a 200-foot section of the east bank of the Upper Milton Creek and chemical concentrations in related bank samples indicate contact with NAPL (**Figure 5-1**). However, the Upper Milton Creek in-water area is located over 350 feet west of any known historical wood-treating features and/or operations. Field evidence of NAPL was generally not observed in supplemental RI borings completed between the upland inferred NAPL area and the Upper Milton Creek area. As mentioned above, this portion of the Site was filled between 1929 and 1939. The composition of fill material placed in this portion of the Site between 1920 and 1939 is unknown and could be a source of the metal and wood debris observed in the bank. In later aerial photographs, it is evident that this upland area adjacent to Upper Milton Creek was used for storage of untreated peeled logs.

Currently, the primary sources of contamination to the Upper Milton Creek in-water area are heavy petroleum sheens seeping from a relatively thin (1-foot-thick or less) sand layer situated at an approximate depth of 19 to 20 feet below the top of the bank. Biogenic sheens also seep from the eastern bank of Milton Creek and are intermingled with petroleum sheens. The platy relatively odorless biogenic sheens, which are easily distinguished from the fluid, odoriferous creosote-related petroleum sheens, likely emanate from areas where upland creosote contamination and wood debris is more completely degraded.

It is important to note that NAPL was generally not observed in borings completed directly within the Milton Creek stream bed, and that creosote-impacted soil and groundwater were not encountered in borings along the top of the Milton Creek shoreline. Only TarGOST® boring S002 exhibited a narrow zone of creosote impact between 19 and 20 feet bgs. Measurable NAPL has not been detected in monitoring wells MW-20 and MW-21 installed between the upland inferred NAPL area and Upper Milton Creek.

Contaminated sediments in the channel of Upper Milton Creek primarily occur within the reach of active petroleum seeps.

### *Lower Milton Creek*

Field evidence of NAPL was generally not observed in supplemental RI borings and samples collected within the Lower Milton Creek area. Rather, lesser discrete creosote impacts were encountered in sediment between the surface (e.g., SD-MC-D, PWS-090617-2) and an approximate depth of 5 feet bml (SD009, SD010) downstream of the vehicle bridge near the confluence with Scappoose Bay. Riverward of the island and immediately downstream of the mouth of Milton Creek is a 15-acre area of surface sediment in Scappoose Bay that exhibits light petroleum sheen (e.g., GWS-11, GWS-12, and GW-13) and measurable PAHs in bulk sediment and/or sediment porewater (PWS-13, PWS-22, PWS-23, and PWS-24). The surficial nature of the contamination and its distribution and proximity to the mouth of Milton Creek suggest intermittent discharge from Milton Creek because the sediment impacts are not laterally contiguous.

### *Cove Area*

Immediately upland of the Cove Area, ASTs stored creosote and fuel oil while a hog fuel boiler and pole peeling station operated along the shoreline. Based on historical photographs and information on plant operations and its subsequent demolition, it appears that significant amounts of creosote contaminated hog fuel, tree bark, and dimensional lumber accumulated in the Cove Area. I

The results of the supplemental RI indicate that NAPL has migrated from these upland source areas into approximately 0.8 acre of the Cove Area as shown by the solid red line on **Figure 5-1**. Heavy petroleum sheens are visible in seasonal groundwater seeps along a 300-foot section of bank seepage west of the peninsula. Near-shore Cove Area borings typically encountered 6 to 8 feet of NAPL impacted sediment, with a maximum thickness of 12 feet observed in SB-11. The near-shore presence of moderate to heavy petroleum sheens in surface sediment appears to be related to the NAPL/groundwater seeps, the presence of creosote-treated wood debris, and gas ebullition resulting from biodegradation of organic matter in deeper sediments.

Moderate to heavy petroleum sheens has been detected in subsurface sediment up to 220 feet offshore beneath the Cove Area (borings SB-04 and SB-09). In general, creosote-impacted sediment decreases in thickness and is encountered at deeper intervals within the Cove Area as distance increases from the shoreline. Outside the inferred extent of upland NAPL, the vertical mobilization of sheen via ebullition has not been observed in the Cove Area.

Riverward of the solid red NAPL boundary depicted on **Figure 5-1**, the source of subsurface sediment contamination transitions to creosote contaminated wood debris. This buried layer of creosote wood debris is interpreted to be the old in-water operational surface while the plant was active and during its demolition. Creosote-impacted wood debris ranges from 1 to 7 feet bml beneath much of the Cove Area (e.g., SB-03, SB-04, SB-06, SB-08, SB-09, and TarGOST® borings TGSD26 and TGSD32), and progressively thins and diminishes in magnitude outward from the



shoreline. Vertically, contaminant levels attenuate rapidly within the sediment stratigraphic layers. Sediment within the western portion of the Cove Area is generally unimpacted by upland NAPL migration and/or creosote contaminated wood debris.

Light or slight petroleum sheens have been intermittently observed in the relatively clean, more recently deposited surface sediment beyond the solid NAPL boundary depicted on **Figure 5-1**. Based on the results of bulk sediment and depth-discrete porewater sampling, these slight surficial sheens appear to be attributed to localized particles of creosote-treated wood debris in the surface sediment and do not appear to be attributed to NAPL migration from the underlying sediment. **Figure 5-2** depicts general areas where sheens have been observed in surface sediment at various times during the supplemental RI activities. **Figure 5-3** depicts general areas where sheens have been observed in subsurface sediment during the supplemental RI activities.

### *Area 1 Dock*

Between the former hog fuel dock and northeastern (downriver) terminus of the former transfer table dock (Area 1 Dock), discontinuous, isolated pockets of creosote NAPL have been observed in many locations at or near the sediment surface, as depicted by the red dashed lines on **Figure 5-1**.

The source of sediment contamination in this portion of the Site is creosote contaminated and/or treated wood debris, although differing in character from that described above in the Cove Area. In this portion of the Site, much of the wood debris is finer textured and is described as “pulverized wood” in sediment sampling logs. The pulverized wood is interpreted to be hog fuel (e.g., wood shavings/chips) likely spilled from the hog fuel conveyor and during over-water transfers from ships/barges to the hog fuel hopper and conveyor system. Some of this material appears to have become saturated with creosote and accumulated along the shoreline and in sediment surrounding, and downstream of, the former hog fuel dock. Additionally, some of the contaminated wood debris appears to be related to deterioration of the creosote-treated dock structures (i.e., timber piles, lateral bracing, decking) that existed along this portion of the Area 1 shoreline. The distribution and thickness of the woody debris is highly variable in this portion of the Site, ranging from completely absent to more than 11 feet thick (sediment boring SB-16). The lateral extent of surface sediment and/or wood debris capable of producing a creosote-related sheen on the overlying water surface when disturbed extends approximately 75 feet offshore (i.e., riverward of the OHWM) between the former hog fuel dock and transfer table dock structure.

Within western half of the primary wood dock structure of the former transfer table, thick sequences of contaminated wood debris are intermingled with dimensional lumber, logs, metals ties, and other debris. Heavy sheens are easily generated by disturbing the surface sediment around many of the remaining log pilings. During the DAI, creosote NAPL associated with wood debris was primarily observed in the upper 24 inches of sediment within the central and western portions of the former transfer table dock area. Deposited wood and creosote-related contamination were observed from the surface to approximately 9 feet bml in the far western portion of the former transfer table dock. In general, the thickness of the wood mass decreased to the northeast away from the southwest area

of the former transfer table dock and is not present in significant thickness to the north of hand-auger boring DAI-HA-02 or to the east of location DAI-PH-11 (**Figure 3-3**). The lateral extent of surface sediment creosote contaminated wood debris extends approximately 200 feet offshore (i.e., riverward of the OHWM) within the footprint of the former transfer table dock.

As shown by a solid red outline on **Figure 5-1**, an upland and slightly in-water area of subsurface creosote staining and isolated blebs of NAPL were encountered in the Native Soil (i.e., fine-grained silt only, no sand lenses) beneath the northwest corner of the former transfer table dock. Creosote-impacted soil with residual NAPL decreases in thickness and is encountered at deeper intervals within the Native Soil (i.e., closer to but not necessarily directly at the Native Soil/Basalt Bedrock contact exclusively) as distance increases in all directions from the northwest corner of the former transfer table dock. This corner of the former transfer table dock is covered by recently deposited sand (natural deposition) and there is no visible surface evidence of impacted groundwater seeps from this upland area of NAPL.

### Area 2 Dock

In October 2017, DEQ staff inspected the Area 2 shoreline and observed creosote-impacted surface sediment near the terminus of the former creosote pipeline and residual piling associated with a historical dock (a.k.a., Area 2 Dock). According to historical maps and photos, the Area 2 Dock was formerly used to offload creosote from river barges between 1919 and 1959.

In response to the September 2018 DEQ email and subsequent telephone conversations, creosote sheen occurrence was mapped in surface sediment along the approximately 900-foot-long portion of the Scappoose Bay shoreline shown on **Figure 3-9**. Moderate to heavy petroleum sheens were noted only in borings amongst the pilings near the shoreline that encountered creosote-contaminated wood debris within the upper 12 inches of sediment. Sediment poling beyond 50 feet of the shoreline (even amongst the pilings), did not produce a visible sheen. As shown on **Figure 3-9** and **Figure 5-1**, the lateral extent of creosote contaminated wood debris covers an approximately 200-foot-long by 50-foot-wide section (0.2 acre) of the Area 2 shoreline beneath and immediately downriver of the former P&T dock and creosote AST.

## 5.4 GROUNDWATER

Groundwater sampling results were presented in the 2000 RI Report (Section 7.2.2, Figures 23, 24, and 25), and groundwater samples were also collected in 1999, 2000, 2001, 2003, 2004, 2005, and 2006 (**Section 2.2**). Seep sampling results were presented in the 2000 RI Report (Section 7.2.4, Appendix C Figures C-24 and C-25). This Supplemental RI Report includes discussion of groundwater samples collected in September 2010, August 2011, and February, May, and August 2012 (**Tables 5-3, 5-4, and 5-5**) as representative of current Site conditions.

Residual NAPL continues to be a source for dissolved-phase creosote-related constituents in shallow groundwater beneath the Site. Based on the 2010, 2011, and 2012 groundwater monitoring

results, groundwater beneath Area 1 is adequately characterized for the purposes of the RI/FS. The occurrence of NAPL in groundwater is discussed in **Section 5.3.1**. The extent of PAHs and TPH in groundwater impacted by creosote is presented on **Figures 5-4** and **5-5**, respectively.

Consistent with previous groundwater analytical data, the highest concentrations of PAHs and TPH in groundwater were generally detected in monitoring wells MW 22, MW-2A, and MW-3A, within the inferred NAPL area, followed by detections in wells at the southeastern and northeastern edges (MW-23, MW-24, and MW-25) of the former wood treating operations area. Detections of PAHs were generally lower in wells to the west of, and outside of, the inferred upland NAPL area and in wells at the far eastern edge of Area 1.

A summary of the analytical results for groundwater samples collected for the supplemental RI is provided below.

- Total PAHs were detected in groundwater samples collected within or near the former operations area, with a similar distribution of relative concentrations as TPH (**Figure 5-4**). Total PAHs detected in groundwater ranged in concentration from 0.35 µg/L at well MW-18 to a maximum of approximately 26,800 µg/L at well MW-3A in 2010; NAPL was also detected at MW-3A during the 2010 monitoring event. The maximum Total PAHs in groundwater in 2011/2012 was approximately 22,500 µg/L in well MW-22.
- Petroleum hydrocarbons indicative of creosote were detected in groundwater samples collected within or near the former operations area (**Figure 5-5; Table 5-4**). TPH detections were primarily in the diesel range, presumptively identified.
  - The maximum diesel-range hydrocarbon concentration was detected in well MW-3A at 374 mg/L in 2010; NAPL was also detected at MW-3A and sampled during the 2010 monitoring event. This sample also had elevated BTEX concentrations relative to other sampling events. The maximum diesel-range hydrocarbon concentration in 2011/2012 was 116 mg/L at MW-3A.
  - The maximum concentration of TPH in the oil range was 103 mg/L at MW-3A in 2010; the maximum oil-range hydrocarbon concentration in 2011/2012 was 3.81 mg/L at MW-2A.
- Metals detected in groundwater were arsenic, chromium, copper, lead, and zinc (**Table 5 5**). The distribution of metals detections does not generally correlate with NAPL or the former wood treating operations area.
  - Arsenic was detected in every well sampled during the supplemental RI.
  - Chromium was detected infrequently just above reporting limits in MW-3B and MW-5, and at slightly higher concentrations (maximum of 5.83 µg/L) at MW-2A.

- Copper was detected at MW-5 at a maximum concentration of 18.5 µg/L; the only other detection of copper was just above the reporting limit at MW-4B.
- Lead was detected infrequently in wells MW-3B, MW-5, and MW-9, at a maximum of 3.49 µg/L.
- The maximum zinc detection, 683 µg/L, was at MW-20 in 2011; other detections at MW-20 were below 10 µg/L. Well MW-5, located near the northern property boundary, has had consistent detections above 200 µg/L. All other zinc concentrations were below 200 µg/L, with most below 10 µg/L.

### *Effect of Turbidity on Groundwater PAH Results*

Results from the August 2012 SPME analysis (ASTM Standard Test Method D 7363-11) of groundwater at monitoring wells MW-3A, MW-21, and MW-24 (**Section 3.1.3**) were compared with results for the standard PAH analytical method (EPA Method 8270D SIM) in the same wells for the PAH constituents common to both methods. Analyte concentrations were similar or lower, and detection limits were considerably lower, using the SPME analysis. For samples from MW-3A, results for many analytes were an order of magnitude lower, in some cases as much as three orders of magnitude lower, when using SPME. The PAH concentrations detected using the ASTM SPME analysis method represent dissolved PAHs; therefore, the lower detected concentrations are related to the exclusion of PAH compounds adsorbed to suspended solids and colloids, which are removed from the groundwater samples as part of the extraction process.

The August 2012 groundwater samples from MW-3A were significantly more turbid than samples obtained from MW-21 and MW-24. Monitoring well MW-3A is screened entirely within the clayey silt immediately above the Basalt Bedrock, and the 20-40 sand pack and 0.10-inch slot well screen are not sufficient to filter out suspended solids and colloids during sample collection. Groundwater results from these three wells, including turbidity measurements (in nephelometric turbidity units [NTU]), are presented below for comparison.

Sample ID	Total PAHs (EPA Method 8270 SIM)	Freely Dissolved PAHs (ASTM SPME Method)	Turbidity
MW-3A	16,631 µg/L	7,005 µg/L	67 NTU
MW-21	186 µg/L	146 µg/L	12 NTU
MW-24	3,426 µg/L	3,285 µg/L	9 NTU

The data indicate that the alum flocculation (floc) step used by the ASTM SPME method effectively removed the majority of particulate-bound PAHs in the MW-3A sample. Because significantly less solids were present in samples from MW-21 and MW-24, aqueous PAH levels as measured by SPME versus conventional methodology were more consistent.

## 5.5 SEDIMENT

Sediment sampling results were presented in the 2000 RI Report (Section 9.0, Figure 30) and in the 2006 ERA (Bridgewater Group, Inc., and Kennedy/Jenks Consultants, 2006). This updated supplemental RI Report includes discussion of sediment samples collected in July and October 2011, July and October 2012, October 2013, and September 2017 as representative of current Site conditions. The analytical results for sediment samples are presented in **Table 5-6** and summarized below.

- Petroleum hydrocarbons were detected in sediment samples collected along the Scappoose Bay shoreline. These were primarily diesel-range hydrocarbons with some oil-range hydrocarbon detections. A maximum of 14,000 mg/kg of diesel-range hydrocarbons was detected in sample SB-11 at 4 feet bml; SB-11 was located within the estimated NAPL extent just west of the peninsula (**Figure 3 1**).
- Total PAHs in the 2011 to 2013 surface sediment samples ranged from not detected to a maximum of approximately 4,800 mg/kg in SSED-6 located east of the former hog fuel dock within an area of creosote wood debris. Total PAHs in the 2017 surface sediment samples, all obtained outside inferred NAPL areas, ranged from 1.58 mg/kg (PWS-090517-6) to 53.54 mg/kg (PWS-090517-9). As stated above, the highest relative total PAH concentrations were found within the old buried operational surface and/or within the inferred areas of offshore NAPL.
- As part of the 2017 supplemental RI, surface sediment samples were submitted for VOCs. VOCs were not detected in the Phase 3 bulk sediment samples, except for naphthalene (0.133 mg/kg) in the surface sediment sample obtained at PWS-090517-14.
- As part of the 2017 supplemental RI, surface sediment samples were submitted for VPH/EPH. None of the volatile aliphatic and aromatic hydrocarbons quantified by the Ecology VPH method were detected in the Phase 3 sediment samples (all 15 Phase 3 sampling locations). High molecular weight aliphatics and aromatics ( $C_{16}$ - $C_{21}$  and  $C_{21}$ - $C_{34}$ ) were detected at concentrations ranging between 4.84 mg/kg (PWS-090517-5,  $C_{16}$ - $C_{21}$  Aromatics) and 236 mg/kg (PWS-090517-9,  $C_{16}$ - $C_{21}$  Aromatics) in all 10 of the 2017 surface sediment samples submitted for the Ecology EPH analysis. It is important to note that the laboratory's EPH reporting limits are 6 to 10 times lower than VPH method reporting limits for comparable TPH fractions. Approximately two-thirds of the sediment samples tested for EPH (i.e., 10 of the 15 Phase 3 sampling locations) detected aliphatics and aromatics between  $C_{12}$ - $C_{16}$ . The highest concentrations of aliphatic and aromatic fractions were detected in the surface sediment sample obtained at PWS-090517-9; which also produced the largest total PAHs value and was the only bulk surface sediment sample to contain measurable  $C_{10}$ - $C_{12}$  aliphatics (12.90 mg/kg).

- In the 2011/2012, surface sediment samples analyzed for TOC, concentrations ranged from 520 mg/kg at SB-23 to 150,000 mg/kg at SSED-6; these locations were east of the former hog fuel dock and within 25 feet of each other. The average TOC concentration was approximately 21,000 mg/kg. The average TOC concentration from 0 to 4 inches bml was 28,000 mg/kg, and the average from 8 to 12 inches bml was 16,000 mg/kg. TOC content in the 2017 surface sediment samples ranged from 10,000 mg/kg (PWS-090617-12) to 29,000 mg/kg (PWS-090617-1, -2, and -3), with an average of approximately 22,200 mg/kg across all 15 Phase 3 sampling locations. TOC content varied across the investigated area, and there does not appear to be a discernable pattern of high or low concentrations by locality. In general, samples with higher TOC were observed to contain wood debris, including wood chips, sticks, and roots.
- In the 2012 surface sediment samples analyzed for black carbon, the percentage of black carbon ranged from 0.10 to 0.34 (with the exception of one location at which black carbon was not detected), with an average of 0.18% black carbon. The average black carbon concentration from 0 to 4 inches bml was 0.16%, and the average from 8 to 12 inches bml was 0.19%. Black carbon measurements in the 2017 surface sediment samples ranged from 0.067 to 0.36% (presented as % soot), with an average of 0.17% across all 15 Phase 3 sampling locations. Similar to TOC, black carbon content varied across the investigated area with no discernable pattern of high or low concentrations by locality.

Since the 2000 RI, over three hundred (305) additional sediment samples from the Scappoose Bay and Milton Creek shorelines along Area 1 (including duplicates and reference/background samples) have been analyzed for PAHs, TPH, VPH/EPH, VOCs, TOC, and/or black carbon. Additionally, subsurface information was obtained via the 67 TarGOST® borings and depth-discrete sampling, various sediment sampling events, and multiple shoreline inspections.

PAH concentrations measured in surface sediment during the 2011 to 2017 supplemental RI were generally consistent with the concentrations measured in the historical surface samples, although variations were noted in specific samples collected within close proximity of one another. These variations in sediment bulk chemistry appear to be a function of sediment heterogeneity (e.g., presence of treated wood debris, varying grain size distribution, and varying amounts of organic material) and not attributed to temporal or spatial changes in contaminant mass flux from upland source areas. However, the potential for contaminant concentrations in sediment to be affected by temporal changes in contaminant mass flux from upland source areas cannot be ruled out and should be further evaluated as part of the FS.

As expected, the highest concentrations of PAHs in sediment occurred within the area of the inferred extent of NAPL, although NAPL was not observed in all samples collected within this area. Although TPH was not tested in sediment as frequently as PAHs, the highest TPH detections (primarily diesel-range hydrocarbons) were also observed within the inferred extent of offshore NAPL.



As mentioned above, the current sediment surface outside the inferred NAPL areas is significantly less contaminated than the old buried operational surface. For instance, TPH levels in bulk sediment collected between 3 and 7 feet beneath the Cove Area ranged from 500 to 2,000 mg/kg with total PAHs (including homologues) up to an estimated 800 mg/kg. Over the majority of the Cove Area, sediment contamination is capped by a more recently deposited and relatively clean fine-textured sediment of varying thickness.

## 5.6 SEDIMENT POREWATER

Sediment porewater was not sampled separately as an independent medium as part of the RI (e.g., porewater and sediment were sampled and analyzed together). During the supplemental RI, shallow sediment porewater samples were collected in July and October 2012, and shallow/deep sediment porewater samples were collected in September 2017. The majority of the thirty 2012 porewater samples (PWS-01 through PWS-30) were collected outside inferred NAPL areas. Nine of the 2012 PWS and five of the LSI porewater samples were collected within inferred NAPL areas. The locations of the July and October 2012 sediment porewater sampling location are illustrated on **Figure 5-6**. All fifteen 2017 sediment porewater sampling locations (PWS-0905017-1 through PWS-090617-15) were situated outside inferred NAPL areas. The locations of the September 2017 sediment porewater sampling locations are illustrated on **Figure 5-7**

As mentioned above, the 2012 shallow porewater samples were collected as bulk sediment samples and porewater was extracted in the analytical laboratory (*ex-situ*). The extracted porewater was analyzed for 18 parent PAH compounds and 16 groups of prominent C1 to C4 alkylated PAH homologues (i.e., 34 PAHs) using SPME followed by GC/MS according to ASTM Standard D7363 and procedures developed based on research completed at the University of North Dakota (Hawthorne et al., 2005a/b). The 2012 sediment porewater samples were also analyzed for DOC using SM 5310C.

During the 2017 supplemental RI activities, creosote constituents were measured in shallow (0 to 12 inches bml) and deeper (24 to 29 inches bml) sediment porewater at the Site (*in-situ*) using LDPE PSDs followed by GC-MS/MS or SIM GC/MS for the following parameters:

- Parent and alkyl substituted PAHs (63 compounds) by FSES SOP 418.00;
- 34 PAHs by ASTM D7363 and FSES SOP 427.00;
- Oxygenated PAHs (22 OPAHs) by FSES SOP 414.00; and
- Hopanes/cholestanes by FSES SOP 416.00.

In addition, VPH and select VOCs were analyzed in water samples obtained from *in-situ* PDB PSDs buried between 0 to 12 inches bml adjacent to the LDPE PSDs.

All sediment porewater concentrations reported from the *ex-situ* SPME and *in-situ* LDPE PSD samples, are freely dissolved water concentrations ( $C_{free}$ ), except hopane and cholestanes values which represent instrument concentrations. For *in-situ*  $C_{free}$  calculations, no assumptions were

necessary with regards to the sampling kinetics for any compound because the full kinetic model incorporating PRCs was used when calculating PAH porewater concentrations (Fernandez L.A., C.F. Harvey, and P.M. Gschwend. 2009). For a complete and detailed description of the  $C_{free}$  calculation see FSES SOP 407.01. Copies of the laboratory SOPs are included in **Appendix D**.

The analytical results for porewater samples are presented in **Table 5-7** and summarized below.

## 2012

- Total PAHs (summed 34 PAHs) measured in sediment porewater using the *ex-situ* approach ranged from not detected to a maximum concentration of 1,720  $\mu\text{g/L}$  at PWS-02 near the former transfer table dock. Naphthalene, a key component of PAHs in upland groundwater, was only detected in 4 out of 59 porewater samples; these were located near groundwater seeps in Milton Creek and along Scappoose Bay, and near the former transfer table dock.
- DOC in porewater ranged from not detected to 112 mg/L. The highest concentrations were generally found in samples within or on the margins of the man-made cove, but DOC concentrations were variable throughout the investigation area.

Sediment porewater results for Milton Creek and Scappoose Bay were evaluated using partitioning models developed by EPA to further assess potential risk of PAHs to aquatic invertebrate receptors in and around creosote-impacted Site sediment. The EPA has developed multiple approaches for evaluating risk to invertebrates. These methods involve either using equilibrium partitioning theory to estimate porewater concentrations from bulk sediment concentrations or directly measuring porewater extracted from bulk sediment samples. The 2012 PWS investigation was designed to collect data in support of this assessment. Sediment and porewater results were used to calculate summed Equilibrium Partitioning Sediment Benchmark Toxic Unit ( $\Sigma\text{ESBTU}$ ) values for sediment results, and the summed Interstitial Water Toxic Units ( $\Sigma\text{IWTU}$ ) values for porewater results, in accordance with EPA guidance.

In accordance with EPA guidelines and described in **Appendix G**, the direct measurements of the freely dissolved 34 PAH concentrations in sediment porewater or interstitial water (IW) are used along with their expected final chronic value (FCV) water/lipid partitioning behavior to calculate a hazard quotient, referred to as a toxic unit (TU). The narcosis based TUs are considered additive, and evaluation of the sum of the TUs requires that all 34 PAH analytes be included in the sum ( $\Sigma\text{IWTU}$ ). Calculations of  $\Sigma\text{IWTU}$  have been used on this project as a benchmark for predicting the toxicity of PAHs to benthic invertebrates with a potential for risk when the  $\Sigma\text{IWTU}$  greater than 1.

Calculated  $\Sigma\text{IWTU}$  values are summarized in **Table 5-8** and illustrated on **Figure 5-6**. The 2012 sediment porewater locations with high  $C_{free}$  PAH levels (i.e., IWTU greater than 1) occurred only in the presence of NAPL. This finding indicates that when NAPL is present, it plays a dominant role in the solid-to-water PAH partitioning (Hong et al., 2003). Alternatively, in sediment porewater samples without NAPL, organic carbon seemed to dominate PAH aqueous partitioning. Black carbon (e.g., soot, and other anthropogenic carbon created by pyrogenic processes) is widely

recognized to have stronger affinity for PAHs (i.e., binds more tightly) relative to other forms of organic carbon. The role of black carbon in inhibiting migration of PAHs to porewater and surface water is further discussed in **Section 6.2**.

## 2017

- The total sum of all detected PAHs in sediment porewater using the *in-situ* LDPE PSDs ranged from 0.0055 µg/L (Shallow PWS-090517-3) to 6.780 µg/L (Deep PWS-090617-15). These total PAH values represent the sum of all 63 freely dissolved concentrations (i.e.,  $C_{free}$  Σ63) measured on the LDPE media. In general, higher dissolved PAH concentrations were encountered in the deeper porewater samples (24 to 29 inches bml). Only at sampling locations PWS-090617-2 and PWS-090617-12 were dissolved PAHs detected at markedly higher concentrations in the shallow porewater (3 to 8 inches bml) relative to the deeper sample. Of the 16 prominent alkyl groups, the highest concentrations were reported for the C<sub>3</sub>- and C<sub>4</sub>-naphthalenes.

Because the hydrocarbon narcosis risk model requires the quantitation of 34 PAHs, the results of the FSES forensic alkyl PAH analyses are summarized in **Table 5-7**, rather than the 63 individual analytes.

Only one of the fifteen 2017 sediment porewater locations produced an ΣIWTU greater than 1 (PWS-090617-2) within the biologically active zone (0 to 12 inches bml). This location happens to be in the mouth of Milton Creek and a significant distance downstream from the inferred NAPL area mapped along the east bank of Milton Creek and upstream of the NAPL area mapped in Scappoose Bay. Calculated ΣIWTU values for sediment porewater samples collected in 2017 are summarized in **Table 5-8** and illustrated on **Figure 5-7** (biologically active zone only).

In addition to PAH alkylation group concentration determination, the FSES SOP 427 includes diagnostic ratios between PAHs which can aid in distinguishing between petrogenic (petroleum), pyrogenic (combustion and pyrolytic), and biogenic sources, as well as among multiple pyrogenic sources. As part of evaluating sediment porewater quality in Scappoose Bay upstream and adjacent to the Site, Cascadia reviewed the diagnostic ratios provided by FSES to better differentiate Site-related contamination (i.e., pyrogenic PAHs attributed to creosote) from urban non-point discharges like storm runoff from nearby roadways; fall-out of combustion particles from burning biomass, coal, and petroleum; and incidental discharges or spills of unburned petroleum from boat traffic. Consistent with prior evaluations, the ratio of 4-ringed PAHs fluoranthene/pyrene (Fl/Py) provided the sharpest distinctions and subsequently has been included in the **Table 5-7**.

A comparison of the ratio of select stable PAH isomers (e.g.,  $C_{free}$  fluoranthene and pyrene) in PSW-090617-2 is markedly lower (0.29) than ratios of fluoranthene to pyrene (Fl/Py ratio) typically found in creosote (1.36 to 1.75) (Stouta et al., 2001) (Zemo, 2009). The Fl/Py ratios calculated in the other 2017 porewater sampling locations situated much closer to the Site's creosote source areas, ranged from 0.9 to 1.6. For perspective, the Fl/Py ratio was 1.9 in the  $C_{free}$

groundwater sample obtained from upland monitoring well MW-3A (i.e., source area well containing creosote NAPL). Prior forensic evaluations of Fl/Py ratios to attribute PAH sources within this offshore area have largely relied on bulk sediment data derived by EPA Method 8270. For reference, Fl/Py ratios between 1.2 and 1.6 were noted in bulk sediment samples obtained near creosote seeps or creosote-affected areas. Whereas bulk sediment samples collected near the confluence of Milton Creek and Scappoose Bay have Fl/Py ratios less than 1.2. Fortunately, the resolving power of the Fl/Py ratio to attribute PAH sources in sediment is enhanced by the improved analytical precision of the FSES quantitation of  $C_{free}$  PAHs in sediment porewater. The Fl/Py ratio and other diagnostic ratios (e.g., Pyrogenic Index) provided in Appendix 6 of the FSES report support field observations (i.e., no creosote NAPL noted) that elevated concentrations of the  $C_3$ - and  $C_4$ -naphthalenes in PWS-090617-2 are not Site related.

The spatial distribution of surface and subsurface porewater toxic units, along with the distribution of sheen and bulk sediment PAH concentrations, is shown on **Figure 5-8**.

- The results of VPH, BTEX, and naphthalene analyses for the 15 sediment porewater samples collected in 2017 are presented in **Table 5-9**. None of the volatile aliphatic and aromatic hydrocarbons quantified by the Ecology VPH method were detected in the Phase 3 *in-situ* porewater samples. As mentioned above, the volatiles GC/MS data for each PDB sample analyzed by EPA Method 8260C underwent additional evaluation using MIM. Specifically, MIM techniques were used to search for aliphatic hydrocarbons between  $C_{10}$ - $C_{>12}$  below VPH detection limit (50  $\mu\text{g/L}$ ). According to Apex Labs, the PDB water samples were free of interference and the absence of select VOCs (BTEX and naphthalene) suggests that VPH fractions are not present at significant freely dissolved concentrations in the sediment porewater at the 2017 sampling locations.
- Twenty-one of the thirty 2017 sediment porewater samples contained detectable levels of dissolved OPAHs (**Table 5-10**). The total sum of all detected OPAHs (i.e.,  $\Sigma 22$ ) in the Phase 3 sampling locations ranged from 0.0001  $\mu\text{g/L}$  (Deep PWS-090517-15) to 0.630  $\mu\text{g/L}$  (Shallow PWS-090617-12). All but three of the sediment porewater samples (Shallow PWS-090617-1, Shallow PWS-090617-12, and Deep PWS-090617-12) had relatively few and/or low detections of OPAHs. Of the 22 OPAHs, chromone was detected at the largest concentrations in samples Shallow PWS-090617-1, Shallow PWS-090617-12, and Deep PWS-090617-12.

## 5.7 SURFACE WATER

Cascadia has summarized the results of the following Phase 3 surface water chemical analytical testing:

- 34 PAHs (**Table 5-11**)
- $\Sigma$ SWTU (**Table 5-12**)
- OPAHs (**Table 5-13**)

The corresponding FSES laboratory reports (OSU Final Report, and Appendices 3 and 5) are included in **Appendix D**. The remaining surface water chemical analytical data (e.g., 63 PAHs, hopanes/cholestanes, NIST SRM 2279) have also been included in **Appendix D**; however, they have not been summarized in tables.

### 5.7.1 PAHs

Low levels of freely dissolved PAHs were detected in all eight 2017 surface water samples. Total PAHs measured on the *in-situ* LDPE PSDs after 21 days in surface water ranged from 0.0192  $\mu\text{g/L}$  (Surface Water Site 3) to 0.0797  $\mu\text{g/L}$  (Surface Water 10). These total PAH values represent the sum of all 63 freely dissolved concentrations (i.e.,  $C_{\text{free}} \Sigma 63$ ) measured on the LDPE media. Detected concentrations of select parent PAHs were compared to the surface water SLVs to evaluate potential risk to fish. As shown in **Table 5-11**, all detected PAHs were below their corresponding SLV.

To be consistent with the sediment porewater PAHs data, the 18 parent and 16 alkyl (34 PAHs) results are summarized in **Table 5-11** rather than the 63 individual analytes. Like the sediment porewater data, the highest alkyl PAH reported was  $C_4$ -naphthalene. In general, 34 PAH levels in the 2017 surface water samples were either consistent or slightly higher than detected concentrations in co-located shallow sediment porewater. The two notable exceptions to this data trend are PWS-090617-2 and PWS-090617-12, where detected concentrations of PAHs in shallow porewater are higher than levels measured in the overlying surface water samples.

Like porewater, surface water toxic units relative to the FCVs were calculated and summed ( $\Sigma$ SWTU) as summarized in **Table 5-12** and **Figure 5-7**. As discussed in **Section 10.2**, samples PWS-090917-9, PWS-090517-10, PWS-090617-12, and PWS-090617-13 produced a  $\Sigma$ SWTU greater than 1.

### 5.7.2 OPAHs

Low levels of freely dissolved OPAHs were detected in all but one of the eight Phase 3 surface water samples (**Table 5-13**). The total sum of all detected OPAHs (i.e.,  $\Sigma 22$ ) in the 2017 surface water samples ranged from 0.0001  $\mu\text{g/L}$  (Surface Water Site #2) to 0.438  $\mu\text{g/L}$  (Surface Water Site #10). Of the 22 OPAHs, chromone was detected at the largest concentrations in surface water samples deployed at Phase 3 sampling locations #10, #12, and #13. OPAHs were largely not detected in the sediment porewater.

## 6.0 CONTAMINANT FATE AND TRANSPORT

This section presents a discussion of contaminant fate and transport based on field and laboratory data collected as part of the supplemental RI as presented in **Section 5.0**. Contaminant transport is discussed in Section 11 of the 2000 RI Report. Data collected as part of the supplemental RI generally support conclusions regarding contaminant transport from the 2000 RI Report and further enhances the understanding of Site conditions.

### 6.1 GENERAL

A schematic diagram of contaminant transport at the Site is provided in plan view **Figure 6-1**. This section provides a general overview of the mechanisms for transport of contamination from source areas within the source media (e.g., historical surface soil) and to other media (e.g., surface water).

#### *Operations/Source Area*

- During approximately 40 years of wood-treating operations at the Site from 1919 to 1959, creosote spills and/or releases to upland soil and adjacent portions of Scappoose Bay appear to have occurred.
- Historical dredging and filling activities appear to have altered the Site's shoreline along Scappoose Bay over time. In effect, the upland area increased, and the shoreline appears to have moved 100 to 200 feet south and southwest from the former wood treatment operations.
- The former treatment plant, storage tanks, and product transfer tables appear to have been developed on timber piles and suspended above the historical ground surface because the Site was prone to flooding.
- The wood-treating facilities were dismantled in the 1960s, and the Site's historical ground surface was covered with 5 to 10 feet of clean imported fill in the 1970s.
- Site uses since the 1970s do not appear to have caused significant contamination.

#### *NAPL*

- Creosote, in the form of NAPL, has migrated vertically through the layered fine-grained Native Soil to the shallow water table and spread somewhat laterally through thin sand layers and along the top of basalt beneath approximately 4 acres of the upland as illustrated by the solid red line on **Figure 6-1**.
- The Site's underlying dense Basalt Bedrock appears to be an effective barrier to downward DNAPL migration in those Site areas where creosote impact was observed at the Native Soil/Basalt Bedrock contact.



- Creosote is a multi-component NAPL that contains many hydrocarbons, primarily PAHs, phenolic compounds, and carrier fluids such as diesel. Over the approximately 60 years between plant closure and completion of the RI, subsurface creosote (either as free phase NAPL, sorbed on solids, or dissolved in water) likely underwent compositional changes due to weathering (e.g., loss of more soluble or biodegradable components). Residual Site contamination consists predominantly of creosote-derived PAHs (i.e., no light nonaqueous-phase liquid or evidence of carrier fluids).

### *Groundwater/NAPL Shoreline Seeps*

- Once the creosote reached groundwater, PAHs from the creosote migrated vertically and horizontally with groundwater flow as dissolved-phase constituents; however, diffusive and advective migration has been largely inhibited by limited solubility and the tendency for PAHs to adsorb to soil.
- Dissolved PAHs and NAPL have migrated from the upland former operations area to the southwest bank of Scappoose Bay within the Cove Area, presumably along narrow, thin stratigraphic soil layers, and are visible along a 300-foot section of the riverbank as visible petroleum sheen seeps during late summer when surface water levels are low. This upland derived NAPL source extends approximately 100 feet beneath the offshore Cove Area where sediment contamination is largely capped by more recently deposited and relatively clean sediment.
- Dissolved PAHs and limited amounts of NAPL appear to have migrated from the upland former operations area to the east bank of Upper Milton Creek, presumably along narrow, thin stratigraphic soil layers. Although the supplemental RI did not confirm a direct connection between the former operations area and Milton Creek. In late summer, groundwater seeps with a petroleum sheen are visible along a 200-foot section of the bank. Contaminated sediments in the channel of Upper Milton Creek primarily occur within the reach of active groundwater/NAPL seeps. They appear to be limited to the soft unconsolidated surface sediments and have not been observed in the underlying stiff gray clayey silt.
- Detected concentrations of PAHs and TPH in groundwater monitoring wells located beyond observed areas of direct NAPL seepage along the Area 1 shoreline exceed aquatic water quality standards (**Figures 5-4** and **5-5**). While PAH and TPH data obtained from upland groundwater monitoring wells are not representative of freely dissolved-phase concentrations (i.e., bioavailable fraction) in the groundwater/surface water transition zone, DEQ believes the contamination in groundwater has the potential to discharge to the aquatic environment at concentrations that could cause adverse effects to the environment.

### Sediment/Porewater/Surface Water

- Moderate to heavy petroleum sheens have been encountered in subsurface sediment (>1 foot) beneath approximately 1.9 acres of the Cove Area. Riverward of the red shaded area on **Figure 6-1**, sediment contamination is covered by new relatively clean sediment. Based on the existing RI data, subsurface sediment containing NAPL present in the Cove Area is considered contained by the overlying relatively clean sediment that has been deposited in the Cove Area because operations at the Facility ceased.
- Creosote was also released directly to the surface of Scappoose Bay sediment from historical nearshore and/or overwater operations within the Cove Area, Area 1 Dock, and Area 2 Dock offshore areas. Much of the old in-water operational sediment surface contains wood debris with significant amounts of creosote. Unlike the Cove Area, the old operational sediment surface within the Area 1 and 2 Dock offshore areas has not been covered by new relatively clean sediment. Approximately 2.2 acres of surficial wood-related NAPL are present within Area 1 Dock and approximately 0.3 acre within Area 2 Dock. These areas of significant creosote contaminated wood debris are illustrated by the dashed red lines on **Figure 6-1**.
- Porewater sampling conducted beyond the delineated areas of NAPL indicate that creosote constituents attenuate rapidly in the sediment pore space. The results of depth-discrete porewater sampling were used to evaluate dissolved-phased mass flux from deeper impacted sediment. In general, detected concentrations of dissolved PAHs in “deep” sediment porewater beneath the biologically active zone (i.e., 24 to 29 inches bml) were higher than those measured in the overlying “shallow” sediment and surface water. As summarized in **Table 5-8**, 4 of 15 deep porewater sampling locations exhibited  $\Sigma$ IWTUs greater than 1 (i.e., PWS-090617-1, PWS-090617-2, PWS-090517-5, and PWS-090517-14). However, the overlying sediment exhibited no toxicity ( $\Sigma$ IWTUs < 1) at three of the same four sampling locations (except PWS-090617-2).
- Like sediment porewater, surface water sample with a  $\Sigma$ SWTU greater than 1 are designated as toxic to aquatic receptors, and include samples PWS-9, PWS-10, PWS-12 and PWS-13 (**Table 5-12** and **Figure 5-7**).

## 6.2 GROUNDWATER DISCHARGE TO SEDIMENT AND SURFACE WATER

The Site’s wood-treating operations ceased approximately 60 years ago, and the residual creosote-related contaminants are highly weathered and tightly bound to the soil matrix (i.e., unable to desorb from the soil or organic carbon within the soil matrix). Residual NAPL present in upland Site soil contributes to, and remains a long-term source of, dissolved-phase contamination. Dissolved-phase constituents (mainly PAHs) in groundwater, as well as constituents adsorbed to mobile colloids, migrate with groundwater flow from upland source areas to the surface water bodies. Detected concentrations of PAHs and TPH in groundwater monitoring wells located along the Area 1 shoreline exceed aquatic water quality standards. However, these dissolved-phase

constituents are not expected to reach sediment porewater within the biologically active zone (i.e., upper 12 inches) or surface water at concentration levels equivalent to those in upland monitoring wells. Migration of both dissolved-phase and adsorbed Site-related constituents is mitigated by the affinity of PAHs to adsorb to soil and the limited solubility of PAHs. Furthermore, dissolved PAHs in groundwater entering Scappoose Bay and Milton Creek surface water are subject to significant dilution and are expected to strongly partition onto the natural organic carbon in the soft sediment adjacent to the Site. Specifically, PAHs were detected at much lower concentrations, or were not detected at all in sediment porewater samples obtained outside delineated areas of NAPL. This conclusion is demonstrated by the naphthalene concentrations in groundwater and porewater shown on **Figure 6-2**.

While PAH and TPH data obtained from upland groundwater monitoring wells are not representative of freely dissolved-phase concentrations (i.e., bioavailable fraction) in the groundwater/surface water transition zone, contamination in groundwater has the potential to discharge to the aquatic environment at concentrations that could cause adverse effects to the environment. Therefore, the feasibility study will consider upland or riverbank actions that address contaminated groundwater discharge to the aquatic environment.

### 6.3 NAPL TRANSPORT

The movement of creosote NAPL through the subsurface is complex and highly non-uniform due to the fact that it is acted upon by three forces: (1) gravitational forces (pressure due to gravity), (2) capillary forces (capillary pressure), and (3) hydraulic force (also known as advection or hydrodynamic pressure). In general, capillary forces tend to trap creosote, while gravitational and hydraulic forces tend to mobilize creosote. Creosote NAPL will be mobilized when the vector sum of the gravitational and hydraulic forces exceeds the capillary forces.

NAPL trapping due to capillary forces occurs in two ways: (1) creosote is trapped within the pores at residual saturation; and (2) creosote is trapped as pools (above residual saturation) on top of less permeable layers (due to insufficient NAPL entry pressure to displace water in a fine-grained, low-permeability layer). Consequently, once the surface source is eliminated, NAPL will migrate until a flow equilibrium is reached whereby the mobile creosote is trapped by capillary forces at residual saturation within pores and/or as pools on top of stratigraphic traps (low-permeability, capillary pressure barriers). The volume of NAPL that is mobile at the Site depends on several factors, including: (1) residual saturation trapped by capillary forces, (2) heterogeneity of the fine-grained Native Soil, and (3) site-specific properties of the weathered creosote NAPL. NAPL properties that affect mobility are discussed below.

Based on the physical properties of creosote (i.e., density, high water/NAPL interfacial tension, and high viscosity), Site conditions, and the results of NAPL delineation completed around the former wood-treating facilities (both upland and offshore), the lateral and vertical extent of NAPL appears to be defined and relatively stable. However, evidence of ongoing lateral NAPL migration is evident within the former operations area (via thin sand layers in the Native Soil). Based on the

accumulation of NAPL in MW-3A, it can be inferred that: (1) NAPL in the vicinity of monitoring well MW-3A exceeds the residual saturation limit of the soil and thus is free to migrate; and (2) NAPL transport occurs through these thin, more permeable soil layers under steep hydraulic gradients (i.e., during low-water conditions).

As discussed in Section 5.3.1, NAPL was not identified in supplemental RI monitoring wells installed within or along the edges of the former wood treating operations area (MW-2A, MW-22, MW-23, MW-24, and MW-25) even though the wells are screened across stratigraphic soil layers containing NAPL and equipped with “DNAPL funnels” and collection sumps. This finding demonstrates that the majority of the residual upland NAPL is trapped by capillary forces within the Native Soil macropores and not within the more permeable sand lenses; except for the localized creosote seep areas (discussed below) along the banks of Milton Creek and Scappoose Bay.

### 6.3.1 Vertical Transport

Evidence of NAPL observed near the Native Soil/Basalt Bedrock interface indicates some component of downward vertical migration of NAPL at the Site. However, capillary forces significantly inhibit migration of NAPL, both laterally and vertically. Additionally, the Basalt Bedrock is a barrier to downward vertical migration of the NAPL, based on the physical properties of creosote samples (as described above), *in-situ* hydrogeologic data gathered from RI rock core borings, and limited field observations of NAPL in basalt cores. Vertical migration calculations based on site-specific NAPL density, viscosity, and interfacial tension were presented in the 2000 RI Report, Section 11.3.1; these calculations indicated that vertical migration of creosote into the fractured basalt beneath the Site is not occurring and supports the field observations.

In addition to upland borings, offshore borings completed along Scappoose Bay within the inferred offshore extent of NAPL did not identify appreciable quantities of creosote NAPL at depth within the upper surface of Basalt Bedrock.

### 6.3.2 Lateral Transport

Evidence of NAPL in groundwater seeps along the banks of Milton Creek and Scappoose Bay during low-water conditions demonstrates some lateral NAPL migration beneath the Site. The supplemental RI did not confirm a direct connection between the former operations area and Milton Creek. However, the presence of discontinuous pockets of groundwater/NAPL seepage along 200 feet of Milton Creek’s east embankment indicates that NAPL has spread laterally toward Milton Creek, potentially influenced by a topographic low in the Basalt Bedrock surface. One TarGOST® boring, S002, completed along the top of the east bank of Milton Creek approximately 75 feet north (upriver) of the groundwater/NAPL seepage, detected NAPL near the Native Soil/Basalt Bedrock contact. However, the magnitude of groundwater concentrations at monitoring wells and Geoprobe borings completed between Milton Creek and the former wood treating operations area are not indicative of NAPL. Therefore, investigation results suggest that NAPL has reached Milton Creek along narrow, thin (1 to 2 inches thick) stratigraphic layers within the Native Soil near the contact

with Basalt Bedrock. Sediment impacts in the Upper and Lower Milton Creek stream channel are limited and do not appear to be laterally contiguous.

The supplemental RI did confirm a direct connection between the former wood treating plant and ASTs and Scappoose Bay in the vicinity of the man-made cove and peninsula. Presence of discontinuous pockets of groundwater/NAPL seepage along 300 feet of Scappoose Bay indicates that upland NAPL has spread laterally into approximately 0.4 acre of the Cove Area, as shown by the solid red line on **Figure 6-1**. NAPL was encountered in upland borings completed along the Scappoose Bay shoreline immediately downgradient from the former wood treating plant and ASTs near the Fill Zone/Native Soil contact, indicating that historical releases likely occurred near the original ground surface. Borings completed within the intertidal zone of the man-made cove and western side of the peninsula encountered NAPL near the sediment surface as well as within Native Soil / sediment layers (i.e., macropores of silt and thin sand lenses) to depths of 12 feet below the current mudline. This offshore extent of residual NAPL appears to be a function of lateral spreading within the thin, more permeable soil/sediment layers up to 100 feet offshore beneath the Cove Area (borings SB-10, SB-11, and SB-14). The near-shore presence of moderate to heavy petroleum sheens in surface sediment appears to be related to the NAPL/groundwater seeps, the presence of creosote-treated wood debris, and gas ebullition resulting from biodegradation of organic matter in deeper sediments.

Moderate to heavy petroleum sheens have been detected in subsurface sediment up to 220 feet offshore beneath the Cove Area (borings SB-04 and SB-09). Beyond/riverward the solid red line indicative of upland NAPL, subsurface sediment contamination appears to be related to the former in-water operational surface (buried contaminated wood debris) and is covered by new clean sediment. In general, creosote-impacted sediment decreases in thickness and is encountered at deeper intervals within the Cove Area as distance increases from the shoreline. Beyond the solid red line, the vertical mobilization of sheen via ebullition has not been observed in the Cove Area.

The vast majority of offshore NAPL encountered along the Scappoose Bay shoreline appears to be relatively localized (i.e., discrete oil blebs) and stable (i.e., insufficient creosote mass to migrate further). Most of contaminated sediment beneath the Cove Area is buried by 1 to 7 feet of relatively clean recently deposited sediment. Offshore borings completed within the man-made coves and at the edges of the peninsula (i.e., within the inferred offshore extent of NAPL) did not identify appreciable quantities of creosote NAPL at depth within the upper surface of Basalt Bedrock.

## 6.4 OFFSHORE EXTENT OF CREOSOTE-CONTAMINATED WOOD DEBRIS

Discontinuous, isolated areas of creosote sheen were observed in surface sediment in the intertidal zone along the 700-foot section of Scappoose Bay between the former hog fuel dock and northeastern (downriver) terminus of the former transfer table dock (Area 1 Dock Area). Moderate to heavy petroleum sheens were observed in surface sediment in many areas throughout the footprint of the former transfer table dock, extending several feet beyond the southern limits (riverward) of the former dock structure. The source of these creosote sheens is directly related to



creosote contaminated and/or treated wood debris. The wood debris is generally observed within the upper 1 to 2 feet of sediment beneath and between these historical dock features, as discussed in **Section 5.3.2**. However, thickness and depth of wood waste with creosote was observed as deep as 14 feet bml beneath the far western portion of the former transfer table dock. The accumulation of wood debris in these areas appears to be a function of historical upland and overwater operations, its subsequent demolition, log rafts, deterioration of the remnant dock structures, and material deposition from river currents. In general, the thickness of the wood mass decreases to the northeast away from the southwest area of the former transfer table dock and is not present in significant thickness to the north of hand-auger boring DAI-HA-02 or to the east of location DAI-PH-11 (**Figure 3-3**). Close inspection of exposed surface sediment during periods of low water, low tide between the former hog fuel dock and transfer table dock indicates that the near-shore sediment environment is relatively stable, preventing the net deposition of newer clean sediment and burial of the historical operational surface throughout the Area 1 Dock.

As shown on **Figure 6-3**, the lateral extent of surface sediment and/or wood debris capable of producing a moderate to heavy petroleum sheen on the overlying water surface when disturbed extends approximately 75 feet offshore (i.e., riverward of the OHWM) between the former hog fuel dock and transfer table dock structure. The lateral extent of surface sediment creosote contaminated wood debris extends approximately 200 feet offshore (i.e., riverward of the OHWM) within the footprint of the former transfer table dock.

In addition to the Area 1 Dock shoreline, moderate to heavy petroleum sheens associated with wood debris were identified in the upper 12 inches of sediment over an approximately 200-foot-long by 50-foot-wide section of the Area 2 shoreline beneath and immediately downriver of a former P&T dock and creosote AST. This portion of the Site shoreline is referred to as the Area 2 Dock. The 2018 low-water inspection suggests the Area 2 Dock shoreline is a higher energy environment and that appears to prevent new sediment deposition and burial of this historical operational surface.

## 6.5 AIR TRANSPORT (DUST)

Airborne dust transport is not a likely significant contaminant migration pathway. The original ground surface at the time the former wood-treating facility operated is currently located beneath 5 to 10 feet of non-contaminated dredge sand fill. Consequently, soil contamination related to former wood-treating activities generally is not encountered at depths less than 5 feet below current ground surface (2000 RI Report, Section 7.2.11) and is not exposed to wind erosion.

Gravel roads built atop the clean fill (at current ground surface) reportedly had oil applied to them between 1974 and 1991 for dust suppression. PCBs were detected in surface soil samples collected from former oiled gravel roadbeds at the Site (2000 RI Report, Section 10.0). Potential risk to on-site industrial workers and recreational trespassers from inhalation of airborne particulates from surface soil contaminants was evaluated in the updated HHRA discussed below in **Section 10**.



## 6.6 PRIORITY ACTION AREAS

Using the results from the 2017 and 2018 offshore data gap investigation activities as the primary line of evidence, combined with historical analytical sediment and porewater analytical data obtained during the RI activities, PAAs have been established for the Site. The PAAs are identified as areas in which the concentration of contaminants of concern (COCs) represent an unacceptable risk and require implementation of an active remedy in order to address:

- Areas where contaminant concentrations clearly result in unacceptable risk to human health and/or environment; and
- Areas where creosote NAPL are present in the surface sediment and riverbank seeps.

While Cfree 34 PAHs have been detected outside of the proposed PAAs at concentrations exceeding PRGs (e.g.,  $\Sigma$ IWTU > 1 and  $\Sigma$ SWTU > 1), the elimination of creosote NAPL in surface sediment and riverbank seeps is expected to, over time, allow concentrations of COCs in other matrices and/or less impacted areas outside of the PAAs to naturally attenuate.

### 6.6.1 Upland

Much of the Site's upland area was covered with 5 to 10 feet of imported granular fill in the years after P&T ceased operating the creosote facility. The Fill Zone effectively caps upland creosote contamination and prevents access to the deeper NAPL impacted (hot spot) soils and dissolved-phase constituents in groundwater. Evidence of NAPL in groundwater seeps along the banks of Milton Creek and Scappoose Bay during low-water conditions demonstrates some lateral NAPL migration beneath the Site. Defined riverbank NAPL seeps clearly represent a PAA because of the potential for recontamination of the adjacent in-water PAAs.

Detected concentrations of TPH and PAHs in groundwater monitoring wells located beyond observed areas of direct NAPL seepage along the Area 1 shoreline exceed aquatic water quality standards. While TPH and PAH data obtained from upland groundwater monitoring wells are not representative of freely dissolved-phase concentrations (i.e., bioavailable fraction) in the groundwater/surface water transition zone, DEQ believes the contamination in groundwater has the potential to discharge to the aquatic environment at concentrations that could cause adverse effects to the environment. The upland PAA includes groundwater discharge zones potentially exceeding aquatic standards. The upland PAA is illustrated on **Figure 6-3**.

### 6.6.2 Offshore

The offshore PAAs are characterized by (1) NAPL and moderate to heavy sheens in surface sediment, and/or (2) contaminant concentrations that result in unacceptable ecological risk with high degree of certainty, as discussed in **Section 10.2**. The presence of NAPL is an exceedance of the Oregon narrative water quality standard (340-041-0007[12]), is an unacceptable direct contact risk to human health and ecological receptors, is considered a highly mobile hot spot, and serves as

ongoing source of contamination to sediment, porewater, and surface water. Further, elimination of the ongoing release of creosote NAPL in shoreline seeps and near-shore surface sediment is expected to, over time, allow concentrations of creosote constituents in other matrices (e.g., surface water) to attenuate. Offshore PAAs are included on **Figure 6-3**.

## 7.0 BENEFICIAL WATER USE DETERMINATION

A BWUD was included as Appendix E of the 2000 RI Report. The 2000 BWUD included a detailed discussion of the Site hydrogeological conditions and contaminant distribution and migration. Findings from the 2000 BWUD were updated using current information pertaining to OWRD records for supply wells and surface water rights, Port and City of St. Helens land-use and zoning ordinances, and information regarding available habitat and recreational uses in the vicinity of the Site. Updated information was obtained through desktop review of publicly available records from the OWRD, Port, City of St. Helens, and U.S. Fish and Wildlife Service (USFWS).

DEQ lists general categories of water use in the Guidance for Conducting Beneficial Water Use Determinations at Environmental Cleanup Sites (DEQ, 1998). With respect to groundwater, these general categories can be described as “direct” or “indirect” uses. Direct uses of groundwater include drinking water, irrigation, livestock, and industrial uses. Indirect uses of groundwater are uses involving discharge to surface water and include aquatic habitat, recreation, and aesthetic quality.

### 7.1 GENERAL

The findings of the 2000 BWUD indicated that beneficial water uses were limited to aquatic habitat, recreation, and aesthetic quality. No direct beneficial uses of groundwater occurred at or adjacent to the Site. No on-site surface water uses were identified; however, the Boise Cascade facility downstream of the Site was identified in the 2000 RI as using surface water for facility processes (industrial use). Reasonably likely future beneficial water uses were determined to include industrial, recreational and habitat.

Contaminant distribution and migration were discussed in the 2000 BWUD, and updated discussions are presented in **Section 5** and **Section 6** of this report. Surface water quality data indicate that adverse impacts to surface water from groundwater discharge have not occurred.

Current analytical results, land-use information, and water rights information obtained for this update indicate that the findings of the 2000 BWUD remain applicable to current conditions. The updated information is discussed in the following sections.

### 7.2 LOCALITY OF THE FACILITY

The LOF is defined as the area where a human or ecological receptor contacts or is reasonably likely to contact facility-related hazardous substances (Oregon Administrative Rules 340-122-115[35]). The 2000 BWUD considered the LOF to be delineated by the Site’s property boundary to the north and east, and Milton Creek and Scappoose Bay to the south and west, and limited to the shallow water-bearing zone above the Basalt Bedrock (Section 12.2 of the 2000 RI Report).

For the purposes of this updated BWUD, the LOF has been revised to include in-water areas within Milton Creek west of the Site and Scappoose Bay south-southeast of the Site. The extent of the LOF

was determined using: (1) analytical results for each sampled media (e.g., soil, groundwater, sediment, sediment porewater, and surface water); (2) observations of petroleum sheens or creosote NAPL in media assessed as part of the RI (e.g., soil, groundwater, sediment, sediment porewater, and surface water ); (3) geographic barriers (property and Area 1 boundaries); and (4) physical barriers (Basalt Bedrock, railroad berm north of Area 1). The LOF coincides with exposure units used for the ERA and HHRA (**Section 10.0**). The areal extent of the LOF is shown on **Figure 7-1**, along with reference (background) sample locations that help to define the LOF extent. The LOF is limited to the soil and shallow water-bearing zone above Basalt Bedrock within the outlined area in the upland, and to sediment and surface water in Milton Creek and Scappoose Bay in the outlined offshore area.

### 7.3 CURRENT BENEFICIAL WATER USES

As concluded in the 2000 BWUD, the current indirect beneficial use of shallow groundwater within the LOF is discharge to surface water. No direct use of groundwater occurs within the LOF. Current beneficial uses of surface water within the LOF consist of associated aquatic and terrestrial habitat, recreation, and aesthetic quality.

#### 7.3.1 Groundwater Use

Current beneficial uses of groundwater in the Site vicinity were evaluated by reviewing well logs recorded since the 2000 RI within a radius of approximate 1 mile of the Site. No new beneficial groundwater uses applicable to the Site were identified.

The OWRD database was queried for new water supply well records completed since the submittal of the 2000 RI (April 2000). According to the OWRD database, five domestic wells have been constructed or deepened since 2000 within 1 mile of the Site, none of which are located within the LOF. These wells are all installed with screened intervals at a minimum depth of 100 feet bgs within Basalt Bedrock, well below the shallow water-bearing zone within the LOF. The nearest wells are located approximately 0.5 mile cross-gradient from the Site. Well logs reviewed as part of the BWUD update are included in **Appendix E**, and pertinent information is summarized in the table below.

### Summary of OWRD Well Records

OWRD Record ID	Depth (feet)	Screened Interval Depth(s) (feet)	Use and Type of Work	Distance from Site
COLU52376	280	220 – 280	Domestic; existing well was deepened	0.6 mile west (cross-gradient)
COLU53905	160	100 – 120 140 – 160	Domestic; new well	0.9 mile northwest (upgradient)
COLU54599	160	140 – 160	Domestic; new well	0.9 mile northwest (upgradient)
COLU55360	305	265 - 305	Domestic, new well	0.5 mile northwest (upgradient)
COLU55412	200	160 - 200	Domestic, new well	0.5 mile northwest (upgradient)

### 7.3.2 Surface Water Use

Current beneficial uses of surface water in the Site vicinity were evaluated by reviewing available information on land uses and recreational opportunities, habitat information, and surface water rights within an approximate 1-mile radius of the Site. Surface water in the LOF is currently used for the following purposes:

- Recreation.** Recreational uses include water-based activities, such as kayaking, canoeing, fishing, and boating, near and within the LOF. Current property controls (i.e., fencing) are expected to discourage land-based recreation, such as shoreline fishing and hiking, within the LOF. In addition, the Heavy Industrial land-use designation (**Section 2.1**) limits non-industrial uses within or adjacent to the LOF. A detailed discussion of potential human health impacts is included in the HHRA (**Section 10.1** and **Appendix F**).
- Aesthetic Quality.** Milton Creek and Scappoose Bay provide aesthetic quality for water-based and land-based recreational activities in or near the LOF. Local aesthetics reflect the land-use designation of Heavy Industrial; opportunities for land-based recreation within the LOF are therefore expected to be limited.
- Aquatic and Terrestrial Habitat.** Scappoose Bay is a freshwater tidal estuary that supports populations of aquatic and terrestrial plant and wildlife species. In addition to aquatic habitat, habitats dependent on surface water (riparian and wetland) also are available within the LOF. The USFWS National Wetlands Inventory identifies freshwater forested/shrub and freshwater emergent wetlands within the LOF (USFWS, 2010). A discussion of potential ecological impacts is included in the Supplemental ERA (**Section 10.2** and **Appendix G**).

In addition to the identified surface water uses within the LOF, the Boise Cascade facility located downstream (northeast) of the LOF historically used surface water from Multnomah Channel for industrial purposes (2000 RI Report, Section 12.3) per a Surface Water Registration Statement Pre-1909 Vested Water Right Claim that allowed the use of up to 45 million gallons per day for industrial use (**Appendix E**). Since closure of the mill in 2015 and the purchase of the land by the City of St. Helens, the status of this surface water right is unknown.

#### 7.4 REASONABLY LIKELY FUTURE BENEFICIAL WATER USES

The Port prepared a Strategic Business Plan (SBP) to guide its next 20 years of facilities management and project development (Port, 2012). According to the SBP, land use at the Site will continue to consist of commercial / industrial uses, consistent with the City of St. Helens zoning designation. Water supply at the Site is provided by the City of St. Helens (Port, 2012). Based on the poor yield of the shallow aquifer (less than 0.5 gallon per minute [GeoEngineers, 2000]) and the availability of municipal water supply, future direct beneficial uses of groundwater within the LOF are not expected.

The Heavy Industrial zoning designation may allow for water-intensive land uses (e.g., plant nursery or greenhouses) to occur at the Site or in the immediate vicinity. Additionally, according to a December 2016 EPA Area-Wide Planning Project (Resolution 1765), the 205 acres northeast of the Site will be redeveloped for mixed uses (industrial, retail, and residential) to encourage water-related uses and preserve adequate public space while allowing for private enterprise. Therefore, reasonably likely future beneficial surface water uses may include industrial facility uses and will continue to include recreational uses and aquatic and terrestrial habitat support.



## 8.0 DATA COMPLETENESS EVALUATION

The RI and supplemental RI activities conducted at the Site have generated field data, field observations, and laboratory analytical data toward completion of the RI process for the Site. The data collected are of sufficient quantity and quality to meet RI and supplemental RI objectives, and to support the subsequent FS process.

Over 1,100 samples have been collected at the Site and its immediate vicinity from the following media: soil, surface water, groundwater, sediment, sediment porewater, seep water, and NAPL. Results from approximately 3,000 analytical tests are in the project RI database for the following analyte groups: PAHs, SVOCs, VOCs, petroleum hydrocarbons, metals, herbicides, dioxins/furans, field screening, and wet chemistry. A summary of data collected during the RI and supplemental RI is provided in **Table 8-1**.

EPA's November 1989 Directive 9355.3-01FS2 specifies that available data should be evaluated to determine if: (1) project DQOs have been met, (2) the risks posed by the site have been adequately defined, (3) the need (or lack of need) for remedial action is documented, and (4) the data necessary for development and evaluation of remedial action alternatives have been obtained. These evaluations are each addressed under the subheadings below.

### *DQOs Have Been Met*

The supplemental RI objectives were defined in **Section 1.2** and addressed as follows.

1. Mapping the lateral and vertical extent of NAPL in offshore sediment adjacent to the Site. Additional sediment investigation offshore was required to determine the source(s) of contamination in shallow sediments. The extent of NAPL in offshore sediment has been defined based on extensive sediment sampling and field observations, both within and bounding the estimated NAPL extent shown on **Figure 5-1**.
2. Confirming the vertical and lateral extent of upland NAPL and/or contaminated soil areas potentially contributing to offshore contamination. The extent of upland NAPL has been defined based on installation of additional monitoring wells, TarGOST® borings, direct-push borings, and sonic borings in the upland area, most of which extended to or into the surface of the Basalt Bedrock, as shown on plan view **Figure 5-1** and cross-section **Figures 4-2** through **4-9**.
3. Further assess groundwater conditions beneath Area 1 and the quality of groundwater discharging into the adjacent surface water bodies (Scappoose Bay and Milton Creek). Current groundwater conditions, including NAPL occurrence, were investigated during four quarterly groundwater monitoring events in 2011 and 2012. The quality of groundwater discharge to surface water was investigated through the quarterly monitoring of wells near the shorelines and through analysis of sediment porewater along the shorelines.

4. Further evaluate risk to aquatic receptors near but outside the offshore extent of NAPL. The supplemental RI provided sufficient data to refine the CSM to better account for the nature and extent of offshore contamination, upland NAPL migration, and dissolved-phase contaminant transport and discussed in **Section 5.0** and **Section 6.0**.

#### *Risks Have Been Adequately Defined*

The supplemental HHRA and ERA have been completed using data collected since the 2006 HHRA (Kennedy Jenks Consultants, 2006) and ERA (Bridgewater Group, Inc., and Kennedy/Jenks Consultants, 2006), as described in the respective supplemental documents. Potential risk to both human and ecological receptors has been adequately evaluated using the available data. A summary of the supplemental HHRA and Supplemental ERA results is provided in **Section 10.0**.

#### *Need for Remedial Action Has Been Documented*

The Site will require remedial action to mitigate unacceptable risk. This conclusion is based on the results of the RI and supplemental RI data evaluation, specifically the supplemental HHRA and ERA, and the results of a Hot Spot evaluation (**Section 11.0**). The next steps in the RI/FS process are discussed in **Section 12.0**.

#### *Necessary Data to Assess Remedial Alternatives Have Been Collected*

The RI and supplemental RI data provide sufficient basis to allow evaluation of remedial alternatives, as will be further discussed in the FS. Additional data may be required for remedial design once a remedy has been selected. The next steps in the RI/FS process are discussed in **Section 12.0**.

## 9.0 CONCEPTUAL SITE MODEL

The Site CSM has been updated based on information collected and evaluated during the supplemental RI. The updated CSM is shown schematically on **Figure 9-1**.

Key components of the CSM have been presented in this report as follows:

- **Section 2.4.1** identifies contaminants of potential concern related to the Site, and **Section 2.4.2** summarizes contaminant source (release) areas at the Site.
- **Section 4.0** presents the current understanding of the Site physical setting.
- **Section 5.0** presents the nature and extent of contaminants at the Site based on investigation results, including field observations and laboratory analytical data.
- **Section 6.0** presents a description of pathways of transport of contaminants from source areas within source media and into other media.

The CSM considers potential mechanisms of contaminant transport from source areas to potential and/or hypothetical receptors, both human and ecological. Contaminant transport at the Site has occurred as free-phase NAPL or as dissolved-phase constituents in groundwater. As discussed in **Section 6.0**, NAPL at the Site has migrated from the historical ground surface (release area) to deeper soil and groundwater, and dissolved-phase contaminants have migrated to groundwater seeps and porewater, affecting offshore sediment, porewater, and surface water. In addition, direct overwater release of creosote and creosote-treated wood has released contamination to surface sediment and/or subsurface sediment (former operational sediment surface).

The illustration provided as **Figure 9-1** presents a schematic summary of transport mechanisms at the Site. Potential/hypothetical receptors evaluated in the supplemental HHRA and supplemental ERA are included on the figure.

## 10.0 SUPPLEMENTAL RISK ASSESSMENTS

As part of the supplemental RI Report, previous human health and ecological risk assessments were reevaluated in consideration of new data and DEQ guidance. The supplemental HHRA is provided in **Appendix F**, and the supplemental ERA is provided in **Appendix G**. Each of these risk assessments is summarized in the following sections.

### 10.1 HUMAN HEALTH

An updated supplemental HHRA was prepared for the Site to evaluate the new sediment and groundwater quality data generated during the supplemental RI. The supplemental HHRA also incorporates the results of the 2006 HHRA for soil because no new data for this media were generated during the supplemental RI. The updated supplemental HHRA evaluated potential exposures through direct and/or indirect contact to Site media for five potential receptors: (1) an industrial worker, (2) an excavation worker, (3) a construction worker, (4) a child trespasser; (5) an adult transient trespasser, and (6) an adult and child sport fisher (assuming both general and subsistence consumption of fish). The supplemental HHRA is summarized here.

A summary of the exposure pathways and media considered for the HHRA is presented on **Figure 10-1**.

#### 10.1.1 Data Set and Exposure Units

The groundwater data evaluated in the supplemental HHRA are those generated since 2005, because the 2006 HHRA evaluated groundwater results between 1996 and 2004. All groundwater results between 2005 and 2012 were included in a single exposure unit covering Area 1 of the Site. The groundwater data set includes results for PAHs, petroleum hydrocarbons, BTEX, and selected metals (arsenic, cadmium, chromium, lead, and zinc).

The soil data evaluated in the supplemental HHRA are those collected in 1998, at the request of DEQ, and includes samples covering Areas 1 and 2 of the Site. The surface soil data set analyzed includes the results for PCBs; the subsurface soil data set analyzed includes results for selected VOCs, SVOCs, and metals.

The sediment data evaluated in the supplemental HHRA is comprehensive, at the request of DEQ, and includes the results from all discrete samples located outside of areas of inferred NAPL that were collected in the upper 12 inches of sediment in 1996, 2003 through 2005, and 2010 through 2017. Samples collected from inside the areas of inferred NAPL are presumed to have unacceptable risk and thus were excluded from the analysis. The sediment data sets were segregated into two exposure units, one representing Scappoose Bay and the other representing Milton Creek. Sediment samples were analyzed for PAHs, petroleum hydrocarbons, selected VOCs, selected metals, and dioxins/furans. VOCs in sediment were not quantitatively evaluated in the supplemental HHRA because only one sediment sample outside the areas of inferred NAPL was analyzed for VOCs, and

no VOCs were detected. Metals were not quantitatively evaluated in the supplemental HHRA because all detected metals concentrations in sediment are consistent with the site-specific background levels established during the RI.

### 10.1.2 Risk Assessment Methodologies

The estimated risks for complete exposure pathways were calculated by determining the ratio of the exposure point concentration (EPC) for each COPC to its risk-based screening level, and then multiplying that ratio by  $1 \times 10^{-6}$  for carcinogenic compounds and by 1 for noncarcinogenic compounds. Cumulative risks were estimated by summing the individual risks for each compound in each exposure pathway, and then by summing the risks from all complete exposure pathways for each receptor to estimate a total risk.

Exposure point concentrations were developed through the use of ProUCL software (version 5.0) (EPA, 2013) to evaluate the reasonable maximum exposure (RME) as well as the central tendency exposure (CTE). The RME EPC is the 90% upper confidence limit (UCL) of the mean detected concentrations for each data set, though in some cases ProUCL recommended a higher confidence level to ensure adequate confidence in the UCL. The CTE EPC is the arithmetic mean of the detected concentrations for each data set. In cases where the data set was small, or where the compound was detected only a few times, the maximum concentration was used as the RME EPC, and the minimum concentration was used as the CTE EPC. In cases where there was only a single detection, the detected concentration was used to evaluate both the RME and CTE.

Risk-based screening levels used in the supplemental HHRA come from five sources: (1) Risk-Based Concentrations (RBCs) published by DEQ in May 2018; (2) DEQ SLVs published in 2007 (and modified using current subsistence fish consumption rates); (3) site-specific RBCs developed for the recreational trespasser using the DEQ HHRA Guidance (DEQ, 2010b); (4) site-specific TPH RBCs developed to evaluate exposure to petroleum hydrocarbons in sediment, and (5) site-specific exposure assumptions used to develop preliminary remediation goals (PRGs) for the adjacent Armstrong site. The RBCs, SLVs, and PRGs used in the updated supplemental HHRA are provided as appendices to that document and can be found in **Appendix F**.

### 10.1.3 Risk Assessment Results and Uncertainty Analysis

The results of the quantitative evaluation for each receptor are summarized below. These results include the evaluation prepared for the supplemental HHRA and the results for soil that were presented in the 2006 HHRA.

- Industrial workers – No unacceptable risks were estimated for direct exposure to buried creosote-impacted soil, or from indirect exposure to creosote constituents (TPH and PAHs) in soil through inhalation pathways of indoor or outdoor air. Unacceptable risk to industrial workers potentially exists from direct contact with residual PCBs in surface soil (i.e., gravel roadbed samples SS-08, SS-10, SS-19, and SS-24). Detected concentrations of naphthalene in

groundwater monitoring wells MW-3A and MW-22 indicate unacceptable risk to industrial workers inside buildings overlying NAPL (e.g., vapor intrusion to indoor air).

- Excavation/construction workers – No unacceptable risks were estimated for direct exposure to soil, or for indirect exposure to contaminants in soil from inhalation outside the inferred upland NAPL area, with the exception of an exceedance of risk calculated due to the localized high concentration of arsenic in one deep soil sample (MW-10) collected historically. The potential risks from exposure to groundwater in an excavation were not quantified because the COPCs are semi-volatiles and DEQ does not recommend a quantitative assessment of dermal exposures to SVOCs because their dermal permeability coefficients are outside of the effective predictive domain used to model this exposure factor. Instead, a qualitative discussion is provided in the uncertainty section and concludes that:
  - It is reasonable to assume there are unacceptable risks or hazards from dermal contact with groundwater where NAPL is present.
  - It is not possible to accurately quantify the magnitude of the risk from dermal contact with water containing appreciable levels of PAHs (e.g., >100 µg/L) or other semi-volatile compounds (such as weathered creosote related TPH > 1 mg/L) in areas where NAPL is not present.
  - Thus, it is reasonable to consider that an administrative or engineering control should be applied to Area 1 excavation workers to control future exposures to groundwater with NAPL. Administrative and engineering controls have already been established for Area 2, and similar controls could easily be applied to Area 1 of the Site.
- Potentially complete current and reasonably likely future exposure pathways to contamination in the offshore area include direct contact with sediment and consuming fish that accumulated site-related contamination. These exposure pathways are discussed below:
  - Direct Contact with Sediment – People on the Site may directly contact beach sediment. At this Site, four different exposure scenarios were evaluated: adult anglers contacting sediment while fishing, child anglers, child trespasser, and adult transients trespassing on the Site. No unacceptable risks were estimated for direct exposures by anglers and trespassers to sediments outside of NAPL areas.
  - Fish Consumption – Screening values protective of people consuming fish that have accumulated site-related chemicals were derived for both water and sediment. Of the limited number of sediment samples analyzed for dioxins and furans, there was found to be unacceptable risk for the sport fisher from the consumption of fish exposed to site-related dioxins and furans in the Scappoose Bay area; however, exceedances were mostly limited to detected concentrations in the sample collected within the offshore



PAA. Freely dissolved concentrations of PAHs in sediment porewater and surface water beyond the offshore PAA indicate a low level of concern for bioaccumulation of cPAHs into fish tissue consumed by humans. However, detected concentrations of PAHs in some bulk sediment samples obtained out the PAA exceed bioaccumulation sediment screening values.

#### 10.1.4 Conclusions from Human Health Risk Assessment

Based on the results of the updated supplemental HHRA, the following conclusions can be drawn:

- The estimated risk levels were below the target risk level of 1 for noncarcinogenic compounds for all receptors and exposure pathways outside the inferred NAPL areas, with the exception of exceedances based on isolated detections of PCBs and/or arsenic from historical (1998) soil samples.
- The estimated risk levels were below the target individual risk level of  $1 \times 10^{-6}$  and the cumulative risk level of  $1 \times 10^{-5}$  for carcinogenic compounds for all receptors and exposure pathways outside the inferred NAPL areas, with the exception of an exceedance of risk from subsistence fish consumption based on one sample collected within the offshore PAA.
- The risks from dermal exposure to PAHs and TPH in groundwater were not quantified but are assumed to be unacceptable in locations where NAPL is present. Because it is not possible to accurately quantify the magnitude of potential risks from dermal contact with water containing appreciable levels of PAHs or other semi-volatile compounds in areas where NAPL is not present, it is reasonable to consider use of administrative or engineering controls for Area 1 groundwater similar to those currently in place for Area 2 groundwater.
- Areas of creosote NAPL in surface sediment represent unacceptable risk from contact by anglers and transients. Based on available data, it appears there is acceptable risk associated with current and likely future exposure pathways to chemical constituents in sediment outside of the NAPL areas.
- Directly measured surface water concentrations of PAHs indicate a low level of concern for bioaccumulation of creosote-related constituents in fish tissue consumed by humans.
- Detected concentrations of total PCBs in 5 of 24 discrete surface soil samples (gravel roadbed material) exceed direct contact RBCs for industrial workers. The 1970s practice of applying used oil to gravel roadways for dust control is the alleged source of PCBs.
- Subsurface soil (3 to 6 feet bgs) was evaluated for risks to the on-site excavation and construction worker from direct exposure to subsurface soils impacted by select VOCs, PAHs, and metals. For purposes of the exposure assessment, subsurface soil is from 3 feet to the depth of the shallow groundwater underlying the Site (approximately 6 feet bgs). The only risk exceedance was for arsenic exposure based on the RME scenario, which was

elevated due to a single sample (MW-10-5.5). The RME calculated excluding this outlier showed no risk exceedance. No exceedances were calculated in the central tendency exposure (CTE) scenario.

## 10.2 ECOLOGICAL

The collection of additional PAH data for sediment and porewater with direct exposure pathways to ecological receptors and the progress that has been made in recent years in the science of evaluating the potential for adverse effects to these receptors has necessitated a supplement to the ERA process that has been in progress at the Site since 2003. The updated supplemental ERA is presented in **Appendix G** of this report, which is summarized here.

The updated supplemental ERA focuses on application of new methods and research in evaluating the recently collected 34 PAH data from the aquatic habitats of the Site (Scappoose Bay and Milton Creek) as additional lines of evidence (LOE) to the overall assessment of ecological risk at this Site. Therefore, the scope of this updated supplemental ERA is limited to new data (collected since 2005) and exposure pathways and receptors associated with the sampled media (sediment, porewater, surface water, and groundwater).

A summary of the exposure pathways and media considered for the ERA is presented on **Figure 10-2**.

### 10.2.1 Data Set and Exposure Units

The data included in this supplemental ERA are limited to analytical results for sediment, porewater samples from the upper 1 foot of sediment (0 to 12 inches bml), and surface water outside delineated areas of inferred NAPL presence where unacceptable risk to ecological receptors is presumed to occur. Receptors addressed in this supplemental ERA are benthic invertebrates that may be exposed to dissolved-phase PAHs in the interstitial water of the Site sediments and fish (resident and anadromous) exposed through direct contact with these waters (released to surface water) and through bioaccumulation. This supplemental ERA also includes an examination of analytical results from groundwater, pre DEQ's request, to determine potential risks to aquatic receptors from dissolved phase constituents after discharge of groundwater to Scappoose Bay. Other receptors identified on **Figure 10-2** were previously addressed in the 2006 ERA and no revision to that assessment is needed for these receptors. For the purposes of this assessment, the Site was segregated into two ecological exposure areas: the Milton Creek exposure area and the Scappoose Bay exposure area.

The basis of this supplemental ERA is sediment data collected in July 2011, July 2012, October 2012, and September 2017. (Note that no samples from October 2011 or the DAI were evaluated in the Supplemental ERA because none of the samples were collected from the upper 1 foot of sediment outside of the inferred NAPL areas.) The July 2012 samples represent high-water conditions of the Columbia River, and the September 2017 and October 2012 samples represent declining and/or low-water conditions. These bulk sediment samples were analyzed for PAH and

TPH, as summarized in **Section 3.4** and **Section 3.5**. Most of the 2011 samples were only analyzed for the 16 priority PAHs (plus 1- and 2-methylnaphthalene), although some samples were analyzed for the full suite of 34 PAH analytes (18 parent PAHs and 16 groups of alkylated PAHs). All of the 2012 and 2017 sediment samples were analyzed for the 34 PAH analytes. All of these samples (2011, 2012, and 2017) were analyzed for TOC. The 2012 and 2017 samples were also analyzed for black carbon. The 2017 sediment samples were analyzed for VPH/EPH.

Sediment samples collected in 2012 (both rounds) were centrifuged to extract porewater for PAH analysis in accordance with the SPME methodology. The 2017 sediment porewater and surface water LDPE PSDs were left at the Site over a 21-day period, which generally corresponds to a chronic exposure scenario for aquatic organisms (**Appendix D**). These surface water and porewater samples were analyzed for the full suite of PAH analytes as well as VPH.

### 10.2.2 Risk Assessment Methodologies

Multiple LOE were used to identify probable ecological toxicity or impacts to aquatic receptors including: (1) the presence of NAPL and/or moderate to heavy petroleum sheen within the upper 12 inches of sediment and/or surface water; (2) sediment toxicity by comparing total PAHs and TPH in surface sediment to screening level values (e.g., threshold/probable effects concentrations; TEC/PEC); (3) porewater toxicity by comparing the  $C_{\text{free}}$  34 PAHs in surface sediment to FCVs and summing the individual ratios to determine if the resulting TU ( $\Sigma\text{IWTU}$ ) is greater than 1; (4) surface water toxicity by comparing detected  $C_{\text{free}}$  34 PAHs in surface water PSDs suspended 1 foot above the mudline to FCVs ( $\Sigma\text{SWTU}$ ) and SLVs based on toxic responses to individual chemical constituents; and (5) other porewater and surface water toxicity indicators (e.g., OPAHs, total of 63  $C_{\text{free}}$  PAHs, hopanes and cholestanes).

Results from these approaches were used to produce primary and secondary possible indicators of aquatic ecological risk:

#### Primary

- Observations of moderate to heavy petroleum sheen in surface sediment (1 foot bml).
- Surface water concentrations representing a summed surface water toxic unit ( $\Sigma\text{SWTU}$ )  $\geq 1$  based on the direct measurement of 34 PAHs.
- Surface sediment porewater concentrations representing a summed interstitial water toxic unit ( $\Sigma\text{IWTU}$ )  $\geq 1$  based on the direct measurement of 34 PAHs.

#### Secondary

- Bulk sediment total 34 PAH concentrations  $\geq$  probable effect concentration (PEC) of 22.8 mg/kg.
- Significant concentrations of total TPH in bulk sediment relative to fraction specific SLVs.

- Bulk sediment total 34 PAH concentrations >10 mg/kg, representing the mid-point between the threshold effect concentration (TEC) of 1.6 mg/kg and the PEC of 22.8 mg/kg.
- Total TPH concentrations greater than fraction specific SLVs.
- Porewater concentrations in surface sediment representing 1/2 of a TU.
- Relative magnitude of  $C_{\text{free}}$  63 PAHs > 0.5 µg/L (not risk based).
- Relative magnitude of  $C_{\text{free}}$  total OPAHs concentrations > 0.5 µg/L (not risk based).

Previous sampling (2012 and earlier) included:

- Bulk sediment chemistry of PAHs, total organic carbon, and black carbon. Some samples were analyzed for the complete 34 PAH parent and alkylated compounds, and others were only analyzed for 18 parent compounds.
- Porewater  $C_{\text{free}}$  PAH concentrations were determined *ex-situ* using laboratory SPME. In the laboratory, SPME fibers were exposed to porewater taken from centrifuged sediment samples. Porewater concentrations are estimated using established chemical partitioning relationships for PAHs. Samples were collected during high water (July) and low water (October) conditions and were co-located with bulk sediment samples analyzed for 34 PAHs. Detection limits were elevated, particularly for the high molecular weight PAHs, and therefore TUs for low molecular weight PAHs were examined as a separate line of evidence. The 2017 *in-situ* methodology for the analysis of  $C_{\text{free}}$  achieved adequate detection limits to evaluate TUs for all PAHs.
- Groundwater samples from the upland area were analyzed for concentrations of PAHs and TPH.

The 2017 sediment porewater and surface water characterization provided time-integrated samples over a 21-day period that generally corresponds to a chronic exposure for aquatic organisms. The quantitation of chemicals in sediment porewater using the LDPE passive samplers developed by the FSES program at OSU appears to be significantly more robust and precise than the 2012 *ex-situ* measurements of freely dissolved PAHs in sediment porewater. The 2017 supplemental RI activities were instrumental in DEQ's January 15, 2019 LOE discussion and presented below.

### *NAPL/Sheen*

Presence of creosote NAPL and moderate-to-heavy petroleum sheen presents unacceptable risk to ecological receptors where it is observed in surface sediment and surface water. The offshore areas exhibiting moderate to heavy petroleum sheens in surface sediment is illustrated on **Figure 5-2**.

## Sediment Toxicity

### Total PAHs

Bulk sediment was either analyzed for 18 parent compounds, or for 34 PAHs, consisting of 18 parent compound and 16 groups of alkylated homologues. DEQ requested the comparison of the total 34 PAHs to Total PAH criteria (TEC and PEC) to estimate toxicity. This approach incorporates toxicity related to the larger range of environmentally relevant PAHs as an alternative to relying on comparisons to the sediment TPH fraction SLVs as a primary LOE (EPA, 2012). According to DEQ, samples where the sum of 34 PAHs in bulk sediment are greater than the TEC of 1.7 mg/kg may be toxic, and samples above the PEC of 22.8 mg/kg have a higher probability of toxicity.

Risk to fish from bioaccumulation was based on comparisons of sediment PAH concentrations (as the 90% UCLs) to PAH-specific screening levels from the DEQ guidance for bioaccumulative chemicals in sediment (DEQ, 2007a). These, however, are limited to only two PAHs—fluoranthene and pyrene. EPCs for this evaluation were based on all available sediment datasets including both recent datasets (2011, 2012, and 2017) as well as the historical (1996 to 2005) data for the two exposure areas (0- to 12-inch sampling interval only).

### TPH

Bulk sediment was analyzed for VPH, and a subset of samples were analyzed for EPH. It is important to note that laboratories report the results in equivalent carbons. The equivalent carbon number is related to the boiling point of a chemical or its retention time in a boiling point gas chromatographic column.

## Porewater Toxicity

### 34-PAH $C_{free}$ and TUs

The 2017 *in-situ* sampling methodology improves the relevancy of measured dissolved water concentrations by time-integrating exposure concentrations representative of site-specific environmental factors that control the bioavailable free dissolved concentrations. This improves the confidence in risk estimates of chronic exposure and toxicity. Directly measuring the  $C_{free}$  in surface sediment and surface water appropriately integrates site-specific factors such as diffusion, advection, bioturbation, and resuspension in addition to particle-bound and colloid-bound partitioning. This is an improvement on the 2012 *ex-situ* methodology that measured  $C_{free}$  in sediments in the laboratory, separate of the site-specific environment.

The  $C_{free}$  34 PAHs were compared individually to their FCV. The ratio of the measured concentration to the chronic values of each PAH is a TU, which shows site concentrations relative to acceptable levels for each PAH. The sum of individual PAH specific TUs are totaled to calculate the  $\Sigma$ IWTU for each sample. Samples are designated toxic where  $\Sigma$ IWTU is equal to or greater than ( $\geq$ ) 1 (see **Figures 5-6 and 5-7**). This analysis can be applied to both surface sediment porewater and surface water to estimate toxicity to aquatic life.

### VPH and Select Constituents

The volatile fraction of TPH and select constituents (benzene, toluene, ethylbenzene, total xylenes, and naphthalene) were sampled in surface sediment using PBDs to evaluate any risk associated with TPH fractions not captured by the PAH analysis.

### Surface Water Toxicity

Surface water samples were collected as part of the Phase 3 offshore data gap investigation. The same LDPE PSDs were used in surface water and installed in eight Scappoose Bay locations offshore of Area 1 beyond delineated areas of NAPL in surface sediment, inclusive of moderate to heavy petroleum sheens. The risk drivers in the surface water samples were similar to those in porewater, with samples collected within the LOF boundary exhibiting greater concentrations than upstream and downstream locations.

### Other Porewater and Surface Water Toxicity Indicators

#### OPAHs

OPAHs may achieve greater dissolved concentrations than parent hydrocarbons due to their greater polarity. This can result in metabolite concentrations as high as one to two orders of magnitude greater than hydrocarbon-only concentrations under baseline conditions (Stenson et al., 2016). Toxicity of metabolites has been found to be comparable to the parent compounds and may induce synergetic effects that may result in greater effects than additivity (Jonker et al., 2016).

#### Total of 63 $C_{free}$ PAHs

In addition to the 34 PAHs, porewater and surface water samples were analyzed for 63 PAHs by GC/MS/MS, providing  $C_{free}$  for a specific group of individual PAHs. These data provide concentrations for a wider range of parent and alkyl substituted PAHs. However, these individual PAHs are a subset of the 34 PAH homologue groups described above.

The potential for risk to fish from direct exposure to porewater and/or affected, near-bottom surface water was evaluated based on the concentrations of freely dissolved PAHs calculated from the measured surface water concentrations in 2017. The SLVs used to evaluate detected concentrations of PAHs in the surface water samples were fish-specific, when possible; however, several of the SLVs were based on Tier II secondary chronic values presented by Suter and Tsao (1996) and EPA regional screening levels for surface water.

#### Hopanes and Cholestanes

Concentrations of hopanes and cholestanes were measured in porewater and surface water as biomarkers for petroleum. These were presented as instrument concentrations and were not freely dissolved concentrations.



### *Groundwater Toxicity Indicators*

Historical (2010 to 2012) groundwater data from nearshore monitoring wells were used to assess the potential risk to aquatic receptors following discharge of upland groundwater to surface water. Concentrations of select PAHs and TPH were compared to surface water SLVs as a conservative estimate of risk.

#### PAHs

As with porewater and surface water, concentrations of PAHs in groundwater were converted to TUs using FCV values. Groundwater was only analyzed for either 14 or 16 PAHs; the sum of TUs ( $\Sigma$ GWTUs) calculated from these individual PAHs may be biased low as a result.  $\Sigma$ GWTUs greater than 1 indicate the potential for toxicity to benthic organisms.

Concentrations of select individual PAHs in nearshore groundwater samples were also screened against DEQ Level II SLVs for surface water as an evaluation of potential risk after upland groundwater migration to Scappoose Bay

#### TPH

Concentrations of diesel- and gasoline-range hydrocarbons were compared to Freshwater Ecotox Aquatic Habitat Goal Levels from San Francisco Bay Regional Water Quality Control Board (SFBRWQCB, 2019). As described above, this approach was used as a conservative analysis of potential risk to Scappoose Bay from upland groundwater migration.

### 10.2.3 Risk Assessment Results and Uncertainty Analysis

#### *NAPL/Sheen*

Observations of NAPL and moderate to heavy petroleum sheen in surface sediment represent unacceptable ecological risk based on this indicator alone. Sample locations and areas with observations of moderate to heavy petroleum sheen in surface sediment on **Figure 5-2**.

#### *Sediment Toxicity*

##### Total PAHs

All surface samples locations had total PAH bulk chemistry concentrations above TECs, and nine samples located well beyond delineated offshore areas of moderate to heavy petroleum sheen had total PAHs levels above the PEC, including PWS-05, PWS-06, PWS-08, SB-09, PWS-090517-9, PWS-13, PWS-090617-13, PWS-16, and PWS-25.

##### TPH

The highest detections of TPH fractions in sediment included the EPH ranges  $C_{>21} - C_{>34}$  aliphatics and aromatics, followed by  $C_{>16} - C_{21}$ , and then  $C_{>12} - C_{16}$ . Locations PWS-090517-9 and PW-090517-10 had the highest detections of sediment TPH.

Sediment concentrations were compared to criteria developed as a part of the Portland Harbor Superfund Site ecological risk assessment. No VPH ranges were detected; however, the detection limits of the VPH analysis were elevated above criteria. EPH fraction concentrations were detected above criteria at all sample locations for the  $C_{>16} - C_{21}$  and the  $C_{>21} - C_{34}$  aromatics, with the highest magnitude exceedance at PWS-090517-9 (236 mg/kg). Aliphatic fractions  $C_{>16} - C_{21}$  and  $C_{>21} - C_{34}$  were detected at a maximum of 71.7 mg/kg and 191 mg/kg, respectively; criteria are above the solubility limit.

### *Porewater Toxicity*

#### 34-PAH $C_{free}$ and TUs

As mentioned above, the 2017 *in-situ* shallow sediment porewater data carries a higher degree of confidence than the 2012 *ex-situ* shallow sediment porewater data in estimating toxicity aquatic life. Therefore, the following summary focuses on the shallow sediment porewater data only. A summation of the 34 PAH specific toxic units ( $\Sigma$ IWTU) using full detection limits for non-detected analytes is presented in **Table 5-8**. The 2017 porewater data demonstrate an overall lack of potential narcosis risk to benthic organisms outside of delineated offshore NAPL areas. Specifically, the  $\Sigma$ IWTU exceeded 1 in only 1 of the 15 Phase 3 locations (i.e., PWS-2) based on porewater measurements obtained within the biologically active zone (i.e., upper 12 inches of sediment). The  $\Sigma$ IWTU > 1 risk prediction is primarily driven by the alkyl PAHs grouped as  $C_3$ -naphthalene and  $C_4$ -naphthalene.

It is important to note, that while most parent PAHs (and many of their perdeuterated analogs) are available as pure standards, few alkyl PAHs are available, so their response must be estimated rather than measured in many cases. The calibration and quantitation of the more highly alkylated PAHs is increasingly complicated by the fact that a single group can have multiple (even hundreds of  $C_3$ - and  $C_4$ -alkyl PAHs) alkylated isomers that are listed as a single PAH in the total 34 PAH list. Care must be taken to avoid including non-target compounds in the integration of a group of alkyl PAHs. For example, dibenzothiophene elutes at the end of the  $C_4$ -naphthalene cluster and frequently has a higher concentration than the total  $C_4$ -naphthalene group. Since both dibenzothiophene and  $C_4$ -naphthalenes have  $m/z$  184 as their molecular ion, care must be taken not to include the peak area of dibenzothiophene in the  $C_4$ -naphthalene peak area. Similarly, the deuterated internal standard, fluorene-d10, elutes in the middle of the  $C_3$ -naphthalene cluster and has an approximately 15% ion at  $m/z$  170, which is the same mass as monitored to determine the  $C_3$ -naphthalene compounds. This interfering peak from fluorene-d10 was substantially larger than the total alkyl  $C_3$ -naphthalene peaks, and therefore, care is needed to remove its peak area to avoid grossly overestimating the alkyl  $C_3$ -naphthalene concentrations (Hawthorne, et al., 2005a/b). OSU FSES was asked to provide non-background corrected 34 PAHs. Given the above-mentioned concerns with co-eluting non-target compounds, the background corrected 34 PAH data were used in the ecological risk assessment.

The results of the 2017 shallow sediment  $\Sigma$ IWTU calculations based on the LDPE 34 PAHs analyses are illustrated on **Figure 5-7**. The spatial distribution of surface sediment  $\Sigma$ IWTU, along with the distribution of sheen and bulk sediment total PAHs, is shown on **Figure 5-8**. Toxicity predicted in the 2017 sediment porewater locations are generally consistent with the 2012 sediment porewater results, where available.

Based on data reported by McDonough et al. (2010),  $\Sigma$ IWTU values from direct porewater measurement are likely conservative predictors of potential narcotic risk. These authors used laboratory toxicity test results to determine the optimal benchmark value of  $\Sigma$ IWTU for both sensitivity (the ability to predict toxic sediment) and specificity (the ability to discriminate between nontoxic and toxic sediments). For direct porewater measurements, the optimal  $\Sigma$ IWTU value was 7.0, which also had a sensitivity of 95% or greater and a specificity of 94%. Nonetheless, given the uncertainty associated with quantifying the alkyl PAHs, porewater within the upper 12 inches sediment is considered unacceptable where the total  $\Sigma$ IWTU  $\geq 1$ .

#### VPH and Select VOCs

None of the volatile aliphatic and aromatic hydrocarbons quantified by the Ecology VPH method were detected in the 2017 shallow sediment porewater. According to Apex Labs, the PDB water samples were free of interference and the absence of select VOCs (BTEX and naphthalene) suggests that VPH fractions are not present at significant freely dissolved concentrations in the sediment porewater at the 2017 PSD/PDB sampling locations.

#### Surface Water Toxicity

Like porewater, surface water samples with a  $\Sigma$ SWTU  $\geq 1$  are considered unacceptable, and include sample PWS-090917-9, PWS-090517-10, PWS-090617-12, and PWS-090617-13 (**Table 5-12**). PAHs driving surface water  $\Sigma$ SWTU  $> 1$  include the same alkyl PAHs to those driving risk in porewater (mainly C<sub>4</sub>-naphthalene).

For potential risk to fish in Scappoose Bay from direct exposure to dissolved PAHs, it was found that none of the surface water PAHs exceeded their corresponding SLVs, indicating that no unacceptable risk exists to fish for these cases. However, it should be noted that SLVs were found only for the 18 priority PAHs (including 1- and 2-methylnaphthalene) typically evaluated in environmental samples; therefore (with the exception of C<sub>1</sub>-naphthalene, for which 1-methylnaphthalene was used as a surrogate), risk to fish could not be evaluated for the alkylated PAHs, benzo(e)pyrene, and perylene (the latter two, and six of the alkylated PAH analytes, were not detected in the porewater samples).

#### Other Porewater and Surface Water Toxicity Indicators

##### OPAHs

Detections of OPAHs in porewater and surface water vary at the Site. Although several individual OPAHs were detected, chromone at surface water locations PWS-090517-10, PWS-090617-12, and

PWS-09061713. Sediment porewater samples PWS-090617-1 and PWS-090617-12 had similar chromone concentrations to surface water at approximately 0.5 µg/L.

#### Total of 63 $C_{free}$ PAHs

The highest concentrations of the sum of the 63 freely dissolved PAHs was detected at porewater location PWS-090617-1 at 5 µg/L and PWS-090617-2 at 1.3 µg/L.

#### Hopanes and Cholestanes

The results are presented in Appendix B of the Phase 3 Offshore Data Gap Progress Report (Cascadia, 2018a). The highest concentrations were found at surface water location PWS-090517-9, and porewater locations PWS-090517-14 and PWS-090617-15.

#### Groundwater Toxicity Indicators

##### PAHs

Concentrations of PAHs in the upland nearshore groundwater were screened against DEQ Level II SLVs. Monitoring wells MW-5, MW-7, and MW-18 had no exceedances; all other monitoring wells had one or more exceedance. Exceedances in one or more sample were found for all PAHs with a DEQ Level II SLV (acenaphthene, anthracene, benzo[a]anthracene, benzo[a]pyrene, fluoranthene, fluorene, naphthalene, and phenanthrene). Nearshore monitoring wells with ΣGWTUs greater than 1 in one or more sample included MW-3A, MW-3B, MW-6A, MW-10, MW-19, and MW-25. Total PAHs and ΣGWTUs in groundwater are shown on **Figure 5-4**.

As mentioned in **Section 10.2.2**, this approach of analyzing potential risk to benthic organisms from groundwater is highly conservative, as there is no exposure at the source, and it does not account for any changes in concentration as water migrates from upland to Scappoose Bay.

##### TPH

Concentrations of gasoline- and diesel-range hydrocarbons in upland groundwater samples were compared to Freshwater Ecotox Aquatic Habitat Goal Levels (HGLs), as shown on **Figure 5-5**. There were exceedances of diesel-range hydrocarbon HGLs in one or more groundwater sample from nearshore monitoring wells MW-3A, MW-3B, MW-6A, MW-10, MW-19, and MW-25. There were exceedances of gasoline-range hydrocarbon HGLs in one or more sample from nearshore monitoring wells MW-3A, MW-3B, and MW-6A; all other monitoring wells had no exceedances detected in samples. No HGLs exist for oil-range hydrocarbons. As discussed above, screening groundwater analytical results against surface water screening levels is a conservative approach that includes a large degree of uncertainty, as there is no direct exposure and does not account for any mitigating factors that may be occurring as water migrates to Scappoose Bay.

#### 10.2.4 Conclusions from Ecological Risk Assessment

Based on the Supplemental ERA, the following conclusions can be drawn:

- Presence of creosote NAPL and moderate-heavy petroleum sheen present unacceptable risk to ecological receptors where it is observed in surface sediment porewater and surface water. The offshore areas exhibiting moderate to heavy petroleum sheen in surface sediment are illustrated on **Figure 6-3**.
- Issues with the 2012 measurement of freely dissolved PAHs in sediment porewater centered around elevated detection limits, particularly high molecular weight PAHs, and a perceived low bias for detecting select low molecular weight PAHs (e.g., naphthalene and its alkylated isomers). This uncertainty to confidently assess porewater toxicity led DEQ to consider other lines of evidence. Subsequently, in 2017, *in-situ* passive samplers were deployed within offshore areas where prior efforts to assess porewater toxicity and habitat impairment posed by Site-related contamination had been inconclusive. Compared to whole sediment and *ex-situ* porewater sampling and analysis, the 2017 quantitation of  $C_{free}$  34 PAHs in sediment porewater and surface water using a time-integrated passive sampling approach appears to better quantify the potential risk to aquatic organisms when considering the heterogeneous conditions and assessing the chronic exposure of aquatic organisms.
- The 2017 porewater data demonstrate the low or nonexistent potential narcosis risk to benthic organisms outside of delineated offshore NAPL areas. Specifically, only 1 of the 15 sediment porewater sampling locations obtained within the biologically active zone (i.e., upper 12 inches of sediment) produced a  $\Sigma IWTU \geq 1$ , PWS-090617-2. It is important to note that the 2017 PWS-090617-2 sediment porewater sample was obtained in Milton Creek near the confluence with Scappoose Bay. The diagnostic ratios of select stable PAH isomers (such as the ratio of Fl/Py) in PWS-090617-2 relative to samples obtained within the inferred creosote NAPL areas are consistent with field observations (i.e., no creosote sheen or odor noted at PWS-090617-2) and suggest that the elevated concentrations of the alkylated homologues  $C_3$ - and  $C_4$ -naphthalene at passive sampling site PWS-090617-2 may not be Site related. Nonetheless, this offshore area is part of the LOF because Site-related constituents detected in Upper Milton Creek could migrate and settle out within this depositional sediment area.
- Similar to sediment porewater, surface water samples with a  $\Sigma SWTU \geq 1$  are considered unacceptable. Four of the eight 2017 surface water passive sampling sites (PWS-090917-9, PWS-090517-10, PWS-090617-12, and PWS-090617-13) resulted in a  $\Sigma SWTU$  slightly above 1.
- The quantitation of chemicals in sediment porewater and surface water using the passive samplers developed by the FSES program at OSU is significantly more robust and precise than bulk sediment analysis of PAHs and TPH. After reviewing the 2017 LDPE PDS data, there appears to be little to no correlation of total PAHs detected in bulk sediment samples to freely dissolved concentrations in porewater and overlying surface water. Extraction and

analysis of bulk sediment samples combine both the  $C_{\text{free}}$  fraction and the contaminant fraction that is bound to particulate materials and carbon in the matrix that is sampled. The standard screening benchmarks used to evaluate the potential toxicity of PAHs in bulk sediment (e.g., TEC, PEC, TPH SLVs) appear to overestimate the toxicity of creosote-derived PAH to benthic invertebrates.

- A comparison of the 2017 surface water concentrations of  $C_{\text{free}}$  PAHs to published SLVs for individual PAHs, where available, indicates that risk to fish outside of delineated offshore NAPL areas is negligible from direct exposure to surface water. A comparison of the 2017 sediment concentrations of  $C_{\text{free}}$  PAHs to published SLVs for the bioaccumulation of individual PAHs (fluoranthene or pyrene) also indicated negligible risk outside of delineated offshore NAPL areas. As described above, the assessment of narcosis risk was conducted as a separate evaluation.
- A screening of analytical results from monitoring wells along Scappoose Bay indicate dissolved phase constituents may pose a risk to aquatic receptors from discharge of upland groundwater to surface water based on exceedances of select SLVs for PAHs and TPH and  $\Sigma\text{GWTU}$  values greater than 1. There is still large degree of uncertainty associated with this pathway, and further evaluation is needed as part of the feasibility study and/or remedial design.



## 11.0 HOT SPOTS AND PRIORITY ACTION AREAS

As required by DEQ Environmental Cleanup Rules, a “hot spot” evaluation was performed in accordance with the DEQ “Guidance for Identification of Hot Spots” (DEQ, 1998). The definition of hot spots depends upon the medium that is contaminated. Generally, for water, a hot spot exists if contamination results in a significant adverse effect on the beneficial use of that resource, and if restoration or protection of the beneficial use can occur within a reasonable amount of time. For media other than water, a hot spot exists if the site presents an unacceptable risk and if the contamination is highly concentrated, highly mobile, or cannot be reliably contained.

Using the results from the 2017 and 2018 offshore data gap investigation activities as the primary line of evidence, combined with historical analytical sediment and porewater analytical data obtained during the RI activities, PAAs have been established for the Site. The PAAs were identified as areas in which the concentration of COCs represent an unacceptable risk and require implementation of an active remedy. While  $C_{free}$  34 PAHs have been detected outside of the proposed PAAs at concentrations exceeding PRGs (e.g.,  $\Sigma IWTU > 1$  and  $\Sigma SWTU > 1$ ), the elimination of creosote NAPL in surface sediment and riverbank seeps is expected to, over time, allow concentrations of COCs in other matrices or less impacted areas outside of the PAAs to naturally attenuate.

### 11.1 NAPL

The hot spot guidance generally assumes that the presence of NAPL will produce “highly concentrated” and “not reliably containable” hot spots. Creosote NAPL is present in the subsurface soil and groundwater beneath the former wood treatment operations area and represents a hot spot. Downward contaminant migration is not a current transport of concern, based on the expected increasing hydraulic head with depth and the presence of very dense Basalt Bedrock beneath the Site. Historically, creosote NAPL at the Site has migrated from the former operational ground surface (release area) to deeper soil and groundwater, affecting riverbanks, near-shore sediment, porewater, and surface water adjacent to Area 1. The presence of NAPL in riverbank seeps and surface sediment is an unacceptable direct contact risk to human health and ecological receptors, is considered a highly mobile hot spot, and serves as an ongoing source of contamination to sediment, porewater, and surface water. In summary, the presence of NAPL is an unacceptable risk and is considered a hot spot in all media where the NAPL is accessible and not reliably contained, including subsurface sediment if exposed.

In upland areas, subsurface NAPL was typically encountered within thin discontinuous lenses and layers present in the native fine-grained stratum (Native Soil) at various depths above the basalt surface. In general, Basalt Bedrock acts as a barrier to downward vertical migration of the NAPL (**Section 6.3.1**). The results of the RI soil sampling, groundwater quality monitoring, and sediment investigations indicate that the lateral mobility of NAPL within these media is limited, except for the

intermittent groundwater with creosote sheen seepage observed along the banks of Milton Creek and Scappoose Bay (**Section 6.3.2**).

Historical wood treatment operations are believed to be the primary reason for creosote NAPL to be present in offshore sediment versus advective contaminant transport from upland areas. As illustrated by the solid red outline on **Figure 5-1**, approximately 4.3 acres of Native Soil and offshore sediment contains residual creosote NAPL beneath and immediately downgradient of the former operations area. Beyond the solid red outline of inferred creosote DNAPL, contaminated sediment beneath the Cove Area is buried by 1 to 7 feet of relatively clean recently deposited sediment.

According to DEQ, the elimination of creosote NAPL in surface sediment along the Site's shoreline and riverbanks is paramount to success of the aquatic remedy (DEQ, 2019a). The upland and in-water extent of NAPL (i.e., hot spots) and the PAAs are illustrated on **Figure 6-3**.

The Cove Area with surface sediment NAPL (hot spot) generally includes the following:

- Hot Spot Area – ~0.8 acre;
- Hot Spot Depth – mudline to 1 foot bml (biologically active zone); and
- Hot Spot Volume – ~1,300 cubic yards.

The Cove Area riverbank exhibiting NAPL seeps (hot spot) generally includes the following:

- Hot Spot Length – ~300 feet; and
- Hot Spot Depth/Thickness – mobile NAPL exists within relatively thin (1-foot-thick or less) sand layers intermittently situated between depths of 11 and 25 feet bgs.

The Cove Area with NAPL in subsurface sediment<sup>5</sup> generally includes the following:

- Subsurface Sediment Area – ~1.9 acre;
- Subsurface Sediment Depth – Varies; >1 foot bml up to 12 feet bml (an average thickness of 4 feet was used in the volume calculation); and
- Subsurface Sediment Volume – ~12,500 cubic yards

The Upper Milton Creek riverbank exhibiting NAPL seeps (hot spot) generally includes the following:

- Hot Spot Length – ~200 feet; and
- Hot Spot Thickness/Depth – mobile NAPL exists within a relatively thin (1-foot-thick or less) sand layer situated at an approximate depth of 19 feet bgs.

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<sup>5</sup> Considered a hot spot if not reliably contained/containable

Discontinuous pockets of surficial wood related creosote NAPL have been observed within the Area 1 Dock offshore area as shown by the dashed red lines on **Figure 6-3**. The lateral extent of surface sediment and/or wood debris capable of producing a creosote-related sheen on the overlying water surface when disturbed extends approximately 75 feet offshore (i.e., riverward of the OHWM) between the former hog fuel dock and transfer table dock structure, and approximately 200 feet offshore (i.e., riverward of the OHWM) within the footprint of the former transfer table dock.

The portion of Area 1 Dock with wood related creosote NAPL in surface sediment (hot spot) generally includes the following:

- Surface Sediment Area – ~2.2 acres;
- Surface Sediment Depth – mudline to 1 foot bml (biologically active zone); and
- Surface Sediment Volume – ~3,600 cubic yards.

The portion of Area 1 Dock with NAPL in subsurface sediment<sup>6</sup> (hot spot) generally includes the following:

- Subsurface Sediment Area – ~2.2 acres;
- Subsurface Sediment Depth – Varies, >1 foot bml up to 14 feet bml (an average thickness of 5 feet was used in the volume calculation); and
- Subsurface Sediment Volume – ~18,100 cubic yards.

Discontinuous pockets of surficial wood related creosote NAPL have been observed within the Area 2 Dock offshore area as shown by the dashed red line on **Figure 6-3**.

The Area 2 Dock with wood related creosote NAPL in surface sediment (hot spot) generally includes the following:

- Hot Spot Area – ~0.3 acre;
- Hot Spot Depth – mudline to 1 foot bml (biologically active zone); and
- Hot Spot Volume – ~560 cubic yards.

## 11.2 SOIL/SEDIMENT

The DEQ cleanup rules define hot spots in “media other than water” (including soil and sediment) as:

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<sup>6</sup> NAPL in the subsurface sediment is considered a hot spot if not reliably contained/containable.

*OAR 340-122-0115(32)(b): For media other than groundwater or surface water (e.g., contaminated soil, debris, sediments, and sludges; drummed waste; 'pools' of DNAPL submerged beneath groundwater or in fractured bedrock; and NAPL floating on groundwater), if hazardous substances present a risk to human health or the environment exceeding the acceptable risk level, the extent to which the hazardous substances:*

*Are present in concentrations exceeding risk-based concentrations corresponding to:*

*100 times the acceptable risk level for human exposure to each individual carcinogen;*

*10 times the acceptable risk level for human exposure to each individual non-carcinogen;*

*10 times the acceptable risk level for individual or populations of ecological receptors to each individual hazardous substance;*

*Are reasonably like to migrate to such an extent that the conditions specified in subsection (a)1 or paragraphs (b)(A) or (b)(C) would be created; or*

*Area not reliably containable, as determined in the FS.*

No contaminant concentration in soil outside of the inferred NAPL areas resulted in a human health risk level corresponding to soil hot spots. In particular, none of the carcinogenic COCs had a concentration in soil causing an excess cancer risk greater than  $1 \times 10^{-4}$ . None of the non-carcinogenic COCs have a concentration in soil causing a Hazard Quotient greater than 10. NAPL in subsurface soil represent unacceptable risk to construction/excavation workers. NAPL in riverbank seeps and surface sediment represent unacceptable risk to human health (e.g., anglers and transients) and ecological (benthic and fish) receptors. Outside of offshore areas with NAPL, concentrations of dissolved-phase constituents above human health and ecological criteria are the most certain line of evidence used to assess toxicity.

Contaminated subsurface soil present on the Site is easily contained. The Site's topography is relatively flat and PCB-impacted roadbed material is easily contained. Contaminated riverbank and surface sediment along the Site's shoreline are prone to erosion and are not currently reliably contained. Therefore, the FS will consider technologies that would reliably contain these areas.

Soil contamination leaching potential is addressed through the assessment of groundwater contamination and the associated identification of the groundwater hot spot as discussed below in **Section 11.3**.

## 11.3 WATER

The DEQ cleanup rules define hot spots in groundwater (includes sediment porewater) and surface water as:

*OAR 340-122-0115(32)(a): For groundwater or surface water, hazardous substances having a significant adverse effect on beneficial uses of water or waters to which the hazardous substances would be reasonably like to migrate and for which treatment is reasonably likely to restore or protect such beneficial uses within a reasonable time, as determined in a feasibility study.*

As noted in **Section 7.3.1**, the beneficial use of shallow groundwater beneath the Site is limited to discharge to Milton Creek and Scappoose Bay. The current and reasonably likely future beneficial surface water uses within the Site's LOF include aquatic habitat, recreation, and aesthetic quality. The risk assessments concluded that direct contact with creosote NAPL in groundwater (e.g., excavation water, riverbank groundwater seeps) and sediment porewater represents unacceptable risk to human and ecological receptors. Based on available data, the risk to human and ecological receptors from exposure to chemical constituents in groundwater discharge is low outside of the inferred NAPL areas. However, contaminated groundwater with the potential to discharge to the near-shore aquatic environment remains a data gap that needs to be further evaluated in either the FS or remedial design.

The presence of NAPL in riverbank seeps and surface sediment is an unacceptable direct contact risk to human health and ecological receptors, is considered a highly mobile hot spot, and serves as an ongoing source of contamination to sediment, porewater, and surface water. Dissolved-phase creosote constituents in porewater and surface water that cause unacceptable risk to benthos and fish are also potential hot spots. Therefore, the upland PAA includes groundwater discharge zones potentially exceeding aquatic standards. It is anticipated that removal or containment of contamination in the PAAs will allow the lesser impacted offshore areas to recover (e.g.,  $\Sigma$ SWTU > 1 in surface water).

## 12.0 CONCLUSIONS

EPA's November 1989 Directive 9355.3-01FS2 specifies that available data should be evaluated to determine if: (1) DQOs have been met, (2) the risks posed by the site have been adequately defined, (3) the need (or lack of need) for remedial action is documented, and (4) the data necessary for development and evaluation of remedial action alternatives have been obtained. As documented in **Section 8.0**, each of these criteria has been met. These criteria are each addressed under the subheadings below.

1. DQOs have been met: The supplemental RI DQOs were defined in **Section 1.2**, and each has been met through field observations, investigation, analysis, and data evaluation. Each of these is addressed in more detail below.
2. Risks have been adequately defined: Potential risk to both human and ecological receptors have been adequately evaluated using the available data.
3. Need for Remedial Action has been documented: The Site will require remedial action to mitigate unacceptable risk.
4. Necessary data to assess remedial alternatives have been collected: The RI and supplemental RI data provide sufficient basis to allow evaluation of remedial alternatives, as will be further discussed in the FS. Additional data may be required for remedial design once a remedy has been selected.

Supplemental RI objectives have been met and, the results from the supplemental RI are summarized below.

1. The lateral and vertical extent of NAPL in offshore sediment adjacent to the Site has been defined. Upland NAPL near the former operations area extends a maximum of approximately 100 feet offshore (riverward of OHWM) beneath 0.8 acre of Scappoose Bay (solid red line beneath the Cove Area). Moderate and heavy petroleum sheens have been observed in subsurface sediment up to 220 feet from the shoreline near the former operations area beneath 1.9 acres of Scappoose Bay (orange shading beyond the Cove Area in-water PAA). The supplemental RI work revealed that wood debris in surface sediment along 700 feet of the Area 1 shoreline is a source of NAPL beneath the former hog fuel dock and transfer table dock structures (referred to as the Area 1 Dock) and extends approximately 75 feet offshore. The creosote contaminated wood debris beneath the former transfer table dock extends approximately 200 feet offshore (riverward of OHWM). In addition, moderate to heavy petroleum sheens have been identified in surface sediment along a 50- by 200-foot portion of the Area 2 shoreline beneath a former creosote offloading dock structure (referred to as the Area 2 Dock). The estimated extent of offshore NAPL in surface sediment is illustrated on multiple figures.



2. The vertical and lateral extent of upland NAPL and/or contaminated soil areas potentially contributing to offshore contamination has been defined. The area of upland NAPL is similar to the area presented in the 2000 RI Report, with some expansion of the inferred area based on installation of additional monitoring wells and various investigation techniques, most of which extended to or into the surface of the Basalt Bedrock. The estimated extent of upland NAPL is shown on **Figure 5-1**, and NAPL observations are presented on cross-section **Figures 4-2** through **4-9**.
3. Based on the physical properties of creosote (i.e., density, high water/NAPL interfacial tension, and high viscosity), Site conditions, and the results of NAPL delineation completed around the former wood-treating facilities (both upland and offshore), the lateral and vertical extent of NAPL appears to be defined and relatively stable, except for the localized creosote seep areas identified in the various report figures along the banks of Milton Creek and Scappoose Bay. As documented in DEQ's January 15, 2019 RI Summary, the highest goal of the in-water remedial action should be to eliminate the presence of NAPL and petroleum sheen in surface sediment, seeps, and surface water. The elimination of the ongoing release of creosote constituents is expected to, over time, allow concentrations of creosote constituents in other matrices to attenuate.
4. Current groundwater conditions beneath Area 1, NAPL occurrence, and the quality of groundwater discharging from Area 1 uplands to the adjacent surface water bodies (Scappoose Bay and Milton Creek) have been investigated. Four quarterly groundwater monitoring events in 2011 and 2012 and analysis of sediment porewater along the shorelines indicate the presence of PAHs in upland groundwater; however, PAHs were detected at much lower concentrations in sediment porewater and surface water samples. Although upland groundwater discharges to sediment porewater and surface water within Milton Creek and Scappoose Bay, the risk to human health and ecological receptors from dissolved-phase constituents transported via groundwater appears to be low outside the observed areas of direct NAPL seepage.
5. The CSM has been refined to better account for offshore sediment contamination (particularly NAPL along the Site's shorelines), as well as upland NAPL migration and dissolved-phase contaminant transport. Upland NAPL has migrated, to a limited extent, via sand lenses and seeps to offshore sediment; however, overwater operations, including deposition of treated wood waste, are also a source of NAPL in surface sediment. The shoreline and offshore extent of creosote NAPL and petroleum sheens have been adequately defined for the FS. The upland and offshore PAAs have been identified as shown on **Figure 6-3**. The updated CSM is summarized in **Section 9.0** and is shown schematically on **Figure 6-1** and **Figure 9-1**.
6. The updated supplemental HHRA indicates low potential risk to human receptors other than direct contact with NAPL and Area 1 groundwater by excavation workers and direct contact with NAPL by shoreline anglers/transients. Detected concentrations of total PCBs in

5 of 24 discrete surface soil samples (gravel roadbed material) exceed direct contact RBCs for industrial workers. The updated supplemental HHRA is summarized in **Section 10.1**, and the updated supplemental HHRA report is provided in **Appendix F**.

7. The updated supplemental ERA indicates that the presence of creosote NAPL (inclusive of moderate to heavy petroleum sheen) present unacceptable ecological risk to benthic invertebrates and fish where it is observed in surface sediment (**Figure 5-2**). Beyond the delineated NAPL areas, concentrations of freely dissolved-phase constituents above ecological criteria represent the most certain line of evidence used for assessing risk to ecological receptors. In general, the 2017 surface sediment porewater sampling indicates that dissolved-phase constituents in deeper sediment and/or upland groundwater do not adversely impact benthic invertebrates outside the prior remedial action areas. Specifically, only one of the fifteen 2017 *in-situ* surface sediment porewater PSDs deployed outside the inferred NAPL areas indicates unacceptable risk to benthic invertebrates (PWS-090617-2 in Lower Milton Creek), although the source of this contamination is uncertain. Surface water PAH toxic units indicate there may be unacceptable risk to fish near the priority remedial areas. The updated ERA is summarized in **Section 10.2**, and the updated supplemental ERA report is provided in **Appendix G**.
8. The hot spot evaluation indicates that groundwater and sediment within the delineated extent of NAPL, and NAPL-affected groundwater seeps, are hot spots in accordance with DEQ guidance. Presence of NAPL is a violation of the Oregon narrative water quality standard (340-041-007(12)), is an unacceptable direct contact risk to human health and ecological receptors, is considered a highly mobile hot spot, and serves as an ongoing source of contamination to sediment, porewater, and surface water. Dissolved-phase creosote constituents in porewater and surface water that cause unacceptable risk to benthos and fish are also potential hot spots. The hot spot evaluation and discussion of upland and in-water PAAs is provided in **Section 11.0**.

Subsequent to DEQ approval of the Supplemental RI Report, the Port will begin development of the Site FS to address media impacted by upland and offshore NAPL. The RI and supplemental RI data provide sufficient basis to allow development and evaluation of remedial alternatives, as will be further discussed in the FS. Additional data may be required for remedial design once a remedy has been selected.

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