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REVISED AGENCY REVIEW DRAFT REMEDIAL INVESTIGATION REPORT

BLAKELY HARBOR PARK SITE BAINBRIDGE ISLAND, WASHINGTON

Prepared for:

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For submittal to:

Washington State Department of Ecology
Olympia, Washington

Ecology Facility Site ID Project No.: 14770

Project Number: PNG0900

October 2025

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October 17, 2025

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ACRONYMS AND ABBREVIATIONS

°F	degrees Fahrenheit
µg/kg	micrograms per kilogram
ACM	asbestos-containing material
AESI	Associated Earth Sciences, Inc
Anchor	Anchor Environmental, LLC
AO	Agreed Order
ARARs	applicable or relevant and appropriate requirements
aRPD	apparent redox potential discontinuity
AVS	acid volatile sulfide
BBP	butyl benzyl phthalate
bgs	below ground surface
BI Parks	Bainbridge Island Metropolitan Parks and Recreation District
bml	below mudline
cm	centimeters
COC	chemical of concern
COPC	chemical of potential concern
cPAH	carcinogenic polycyclic aromatic hydrocarbon
CSL	Contaminant Screening Level
CSM	conceptual site model
CUL	cleanup level
DAHP	Washington State Department of Archaeology and Historic Preservation
DCAP	draft cleanup action plan
DF	detection frequency
DPS	distinct population segment
DQOs	data quality objectives
DRO	diesel range organics
DVR	data validation report
dw	dry weight
EC50	effective concentration
Ecology	Washington State Department of Ecology

EF	exceedance factor
EHD	Environmental Health Disparities
EJ	environmental justice
ELCR	excess lifetime cancer risk
EPA	United States Environmental Protection Agency
ERIS	Environmental Risk Information Services
ESA	Endangered Species Act
FOE	frequency of exceedance
FS	feasibility study
ft	feet/foot
Geosyntec	Geosyntec Consultants, Inc.
GPS	global positioning system
HI	hazard index
HPAH	high molecular weight polycyclic aromatic hydrocarbon
IDW	inverse-distance weighting
in	inches
Integral	Integral Consulting Inc.
LCS/LCSD	laboratory control sample/laboratory control sample duplicate
Lidar	light detection and ranging
LMW	low molecular weight
LPAH	low molecular weight polycyclic aromatic hydrocarbon
MDL	method detection limit
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
mi	miles
Mill	former Port Blakely Mill Company
MLLW	mean lower low water
MS/MSD	matrix spike/matrix spike duplicate
MTCA	Model Toxics Control Act
NAVD88	North American Vertical Datum of 1988
NB	natural background

ng/kg	nanograms per kilogram
NOEC	no observable effects concentration
OC	organic carbon
PAHs	polycyclic aromatic hydrocarbons
POC	point of compliance
Port Blakely	Port Blakely Tree Farms
PQL	practical quantitation limit
PV	plan view
QA	quality assurance
QAPP	Quality Assurance Project Plan
QC	quality control
RCW	Revised Code of Washington
RI	remedial investigation
RMF	relative mobility factor
SAP	Sampling and Analysis Plan
SCO	Sediment Cleanup Objective
Shannon & Wilson	Shannon & Wilson, Inc.
SIM	selected ion monitoring
SL	screening level
SM/ML	silty sand/sandy silt
SMS	Sediment Management Standards
SPI	sediment profile imaging
SSG	sand, silt, and gravel
State waters	Waters of the State of Washington
SVOCs	semi-volatile organic compounds
SWACs	spatially weighted average concentrations
TCDD	2,3,7,8-tetrachlorodibenzo-p-dioxin
TCLP	toxicity characteristic leachate procedure
TEE	Terrestrial Ecological Evaluation
TEF	toxicity equivalency factor
TEQ	toxic equivalence quotient

TOC	total organic carbon
TPH	total petroleum hydrocarbons
TVS	total volatile solids
U&A	Usual and Accustomed
UCL	upper concentration limit
USGS	United States Geological Survey
WA DNR	Washington Department of Natural Resources
WAC	Washington Administrative Code
WDFW	Washington Department of Fish and Wildlife
Work Plan Addendum	RI/FS Work Plan/Sampling Analysis Plan Addendum
Work Plan	RI/FS Work Plan

1. INTRODUCTION

On June 24, 2020, the Washington State Department of Ecology (Ecology) entered into an Agreed Order (AO) with Port Blakely Tree Farms (Port Blakely) (AO No. DE 16944; Ecology and Port Blakely Tree Farms, 2020) to conduct a remedial investigation and feasibility study (RI/FS) and prepare a draft cleanup action plan (DCAP) at the Blakely Harbor Park Site located on Bainbridge Island, Washington. The AO identifies Port Blakely and Bainbridge Island Metro Park & Recreation District (BI Parks) as potentially liable persons. The RI/FS is being conducted in accordance with the AO, pursuant to the Model Toxics Control Act (MTCA) Revised Code of Washington (RCW) Chapter 70A.305 (MTCA Statute), Washington Administrative Code (WAC) Chapter 173-340 (MTCA Regulations), and Sediment Management Standards (SMS) Regulations Chapter 173-204 WAC.

MTCA WAC Section 173-340-200 defines "site" as any site or area where a hazardous substance, other than a consumer product in consumer use, has been deposited, stored, disposed of, or placed, or otherwise come to be located. This site will be defined as the extent of contamination caused by release of hazardous substances from historical operations associated with the former Port Blakely mill (Mill), which became operational in 1863 and ceased operations in 1923. The overall purpose of the Blakely Harbor RI is to characterize the nature and extent of contamination at the site. The area investigated during this RI is called the Study Area.

In July 2021, Ecology provided conditional approval of the *RI/FS Work Plan* (Work Plan) prepared by Geosyntec Consultants, Inc. (Geosyntec) on behalf of Port Blakely. Geosyntec completed the Phase 1 field investigation in September of 2021,[1] and Ecology approved the final Work Plan in January 2022 (Geosyntec, 2022). An *RI/FS Work Plan/Sampling Analysis Plan* (SAP) *Addendum* (Work Plan Addendum) was submitted in April 2023 (Geosyntec, 2023a) to fill data gaps identified in soil, groundwater, and sediment media after Ecology requested further site characterization following review of the Phase 1 data results. Results of Phase 2 investigations were summarized in a technical memorandum submitted to Ecology in August 2023 (Geosyntec, 2023b). A Field Change Request was submitted in November 2023 (Geosyntec, 2023c) to fill data gaps identified in soil and sediment media after review of the Phase 2 data results collected in 2022. Data collection in association with the Field Change Request was conducted in December 2023. Results of the 2021, 2022, and 2023 investigations are presented herein.

1.1 Project Organization

The RI/FS is being conducted by Geosyntec on behalf of Port Blakely. Ecology is providing regulatory oversight of the RI/FS activities. In accordance with the AO, the designated Project Coordinators and their contact information are provided in Table 1-1.

The Project Coordinator for Ecology is Rachel McDermott. She is responsible for the regulatory oversight of all RI/FS activities, including review and approval of this RI Report and all other AO

[1] Bathymetry and sediment profile imaging (SPI) and plan view (PV) surveys were completed in 2020 (Geosyntec, 2020a and 2020b, respectively); the bathymetry report is provided as Appendix B and the SPI report as Appendix F.

deliverables. The Project Coordinator for Ecology is also responsible for ensuring implementation of the AO for the site and coordination with the Suquamish Tribe.

Port Blakely's Project Coordinator is Cindy Bartlett of Geosyntec. She is responsible for overall project management, implementation of the AO, and oversight of RI/FS activities. The Project Coordinator role is to provide technical consulting and coordination of all efforts, including on the following tasks: project planning and scheduling; project deliverables; data collection and analysis; and coordination with the Ecology Project Coordinator and Port Blakely representatives. Port Blakely's Technical Advisor is Anne Fitzpatrick of Geosyntec. She is responsible for technical oversight of RI/FS activities.

Port Blakely is a signatory of the AO and has agreed to complete the RI/FS and DCAP in accordance with the AO. The representative for Port Blakely is Mike Warjone, President of United States Forestry.

1.2 Report Organization

The remainder of this report is organized into the following sections:

- Section 2, Site Background, describes the site location, historical uses of the site, including Native American uses, industrial land development, current land use and ownership, and reasonably anticipated future uses.
- Section 3, Physical and Environmental Setting, describes the site physical conditions including topography and bathymetry, the regional geology, and site hydrogeological conditions based on RI field studies and regional information.
- Section 4, Field Investigation, summarizes previous environmental investigations conducted at the site and describes the scope of field investigations conducted in support of the RI, including physical surveys and analytical sampling for chemicals of potential concern (COPCs). This Section also describes any modifications/deviations to the approach outlined in the Work Plan Addendum.
- Section 5, Site Screening Levels, COPCs, and chemicals of concern (COCs), presents the methodology to refine the preliminary screening levels (SLs) and site COCs. Background concentrations are discussed in this section.
- Section 6, Nature and Extent of Contamination, describes the distribution of COPCs in site environmental media. It also provides estimated extent of wood waste and a summary of sediment toxicity bioassay results.
- Section 7, Conceptual Site Model and Risk Evaluation, provides a synthesis of the collective information about the site to identify potential sources of contamination, evaluate the mechanisms of fate and transport, assess potential exposure pathways and related risks, and summarize the areas and media to be further evaluated.
- Section 8, Proposed Cleanup Standards, summarizes proposed cleanup levels and points of compliance.

- Section 9, RI Conclusions, summarizes the RI Report.
- Section 10, References, provides a list of reference materials cited in the RI Report.

Tables and figures are located at the end of the text, followed by appendices.

2. SITE BACKGROUND

This section provides detail regarding the site location, a description of the site history, including a description of pre-industrial history and historical Mill operations, a description of current land use of the site and nearby properties, and a description of anticipated future site use.

2.1 Site Location

The site is located on the southeast side of Bainbridge Island, Washington (Figure 2-1), at Northeast Blakely Avenue and 3-T Road.[2] The upland portion of the site is located within Blakely Harbor Park, a public park owned and managed by BI Parks. The site is a marine embayment located in the westernmost portion of Blakely Harbor, which includes approximately 26 acres of vacant and forested upland area, a 7.5-acre former Mill Pond, 7,500 linear feet (ft) of shoreline, and approximately 74 acres of marine harbor including wetland areas inundated during high tidal cycles (intertidal) or permanently submerged (subtidal). This total Study Area is about 100 acres (Figure 2-1).

The Blakely Harbor Park property is bounded to the west by Northeast Country Club Road and to the north by Northeast Blakely Avenue and private property. Blakely Harbor Park is bounded to the south by private residential property located along Northeast Country Club Road. The western portion of the harbor, including the former Mill Pond, is owned by BI Parks and private property owners; the eastern portion of the harbor and beyond is owned by the State of Washington and managed by Washington State Department of Natural Resources (WA DNR). A temporary pedestrian bridge was installed by BI Parks in 2020 across the narrow inlet between the former Mill Pond and the Inner Harbor. This temporary bridge connects the southern and northern shorelines of the harbor for park users (Figure 2-2). The Facility/Site ID is 60939, and the Ecology Cleanup Site ID is 14770. Figure 2-2 shows the tax parcel lot lines.

2.2 Pre-Industrial Harbor History and Cultural Resources

Human occupation within the Pacific Northwest and Western Washington began at least 10,000 years ago. The oldest archaeological evidence of this occupation are large projectile points, with the Clovis point being the most widely recognized. The sparse archaeological record up to about 5,000 years ago may be, in part, due to geological events that may have submerged or buried any archaeological sites. However, a relatively common site-type observed in the Puget Sound, called an “Olcott” site, originates from the Middle Holocene period (8,000 to 5,000 years ago). Olcott sites typically contain utilitarian cobble tools and Cascade-style leaf-shaped projectile points located near small streams on upland terraces. During the later Holocene, archaeological sites became more frequent and widespread, often indicating a greater reliance on marine and littoral resources based on the presence of shell middens.

[2] The site address in the AO is Blakely Avenue and 3-T Road Bainbridge Island, Washington 98110. The figures in this document show “Northeast” in front of most roads because that is what is used on the Tax Lot Parcel layer provided by Kitsap County.

Beginning about 2,000 years ago, large village sites became more frequent in riverine and littoral settings, with surrounding specialized seasonal camps associated with larger villages. These winter village sites are associated with the quintessential Northwest cultural traits and account for the highest frequency of known precontact site types in the region. An example would be a winter village/occupation site located at West Point, roughly 5.5 miles (mi) northeast of Blakely Harbor, which includes a large shell midden (Larson and Lewarch, 1995).

The Study Area lies within the traditional territory of the Suquamish people and their ancestors, who occupied much of the Kitsap Peninsula and the western shores of Puget Sound. The Suquamish lived in autonomous villages but were widely affiliated with neighboring peoples through language, intermarriage, trade, and material culture. A winter village is known to have been located on the south shore of Blakely Harbor (Suquamish Tribe, 2021). Three ethnographic place names have also been recorded for the Blakely Harbor vicinity: Tuts3xolo'sEb is a miry area at the upper end of Blakley Harbor meaning "clayey ground;" Kwalqs was the name of the promontory at the north end of the Blakely Harbor; and Sba'badid was the name of the seastack outside Blakely Harbor now holding a navigation light (Waterman et al., 2001). Seasonal camps existed along the shoreline of Blakely Harbor and likely at least one village existed in this area as well. Although not along the shore, a spring Suquamish village was also recorded on the south side of Restoration Point by George Vancouver in May 1792.

Ethnographic and archaeological evidence demonstrates that the Suquamish Tribe inhabited the area in and around Blakely Harbor and utilized its natural resources (including fish and shellfish) for thousands of years. Blakely Harbor and the surrounding area have been and continue to be significant natural and cultural resources for the Suquamish Tribe.

The Study Area, in its entirety, falls within the boundaries of the historical lumber Mill and milltown, recorded as archaeological site 45KP110 by Dennis Lewarch of Larson Anthropological Archaeological Services Limited. The archaeological site was first recorded with the State of Washington in 1995, although its eligibility for listing in the National Register of Historic Places (NRHP) was not determined at that time. The archeological site is currently listed in the Washington Information System for Architectural and Archaeological Records Data (WISAARD) as "potentially eligible" (Lewarch, 1995). According to the 1995 archeological site record, site 45KP110 is the former Mill and milltown of Port Blakely dating between 1863 and 1920, although Mill operations ceased in 1923. When the archeological site was recorded in 1995, foundations, ornamental plants, abandoned roadbeds, and pilings associated with the old wharves were observed (Lewarch, 1995). The archeological site record also notes that all but two of the buildings were burned or torn down when the Mill closed. The locations of the former buildings and structures are well documented on the Sanborn Fire Insurance map from 1893.

A field visit conducted September 10, 2020, by Jacobs Solutions Inc. archaeologist Matthew Sterner confirmed the presence of building remnants associated with the Mill, including foundations, structural depressions, and pilings. While most of the archeological site is obscured by vegetation, historical materials such as glass and ceramic fragments, bricks, structural wood beams, slag, and structural remnants are common across the archeological site. Similar remnants were recorded in a 1992 survey (Carlsson, 1992). Some of these materials have been presumably

collected or handled by residents or other park users and purposefully stacked along existing cut logs at the eastern end of the site; this suggests the possibility that materials associated with the "archeological site's period of significance" may be present.

The 2019 upland and intertidal sampling activities were observed in the field by a representative of the Washington State Department of Archaeology and Historic Preservation (DAHP) for the possible presence of cultural artifacts during sampling. No archaeological artifacts were found during the field activities conducted for the RIs, which are further discussed in Section 4. Additional details regarding the archaeological site history and cultural relevance are provided in the *Archaeological Monitoring at Blakely Harbor Park Site Report* (Appendix A).

2.3 Mill History and Historical Land Use

The site's industrial development and operation began in 1863; operations peaked in the early 1900s and ended in 1923. Descriptions of the Mill's historical ownership, the harbor's industrial timeline, and the Mill's historical facilities are presented below.

2.3.1 Industrial Property Ownership History

In 1863, Captain William Renton purchased land around Blakely Harbor and established a sawmill (the Mill), doing business as the Port Blakely Mill Company. During the 60 years of the Mill's operation and the years since the Mill shut down, the Mill was owned by entities bearing the name "Port Blakely," including but not limited to Port Blakely Mill Company (California), Port Blakely Mill Company (Washington), Blakely Mill Corporation, and Port Blakely Tree Farms Limited Partnership. Port Blakely Tree Farms Limited Partnership transferred ownership to BI Parks in two transactions, one involving an assignment of a purchase option by the Bainbridge Island Land Trust to BI Parks in December 1999 and the other in November 2001.

2.3.2 Historical Operations and Past Land Use

The former Mill, once considered the world's largest sawmill under one roof, began operations in 1863 and operated until 1923, sometimes under lease to third parties (Price, 1989). The Mill was torn down in 1924. The original sawmill was situated east-west on a spit that separated a pond used for log storage (former Mill Pond) from the natural harbor to the east (Figure 2-3). Between 1863 and 1880, the Mill complex was gradually expanded to the east along the northern shore of the harbor to include a planked-loading dock, the 75-room Bainbridge Hotel, a Masonic Hall, a school, and living and dining quarters for the sawmill laborers (Carlsson, 1992; Environmental Risk Information Services [ERIS], 2019a). In 1880, the Hall Brothers Shipbuilding Company (a separate entity) relocated to Blakely Harbor, approximately a quarter mile east of the Mill. Rail tracks were built along the shoreline to connect the two entities (Port Blakely Mill Company, 2019). In 1882, the Mill was producing 140,000 board-ft of lumber per day and 40 million board-ft per year.

In February 1888, the original Mill burned down, but it was subsequently rebuilt with increased capacity in August of that same year. Heading northeast from the Mill, a boardwalk was set partly on a pier and partly on dry land and lined with residential housing. As the Mill continued to increase operations, a railroad slip for barges was built in 1898 at the lumber yard on the south

side of the harbor. Finished lumber could then be loaded directly into rail cars, which were barged to the main railroad line in Seattle. A year later in 1899, a telegraph crossarm factory was built near the railroad barge slip (Price, 1989; Port Blakely Mill Company, 2019). In 1903, Hall Brothers Shipbuilding relocated their operations north to Eagle Harbor to expand their shipbuilding capacity.

At the height of operations in 1904, the Mill complex included a machine shop, a blacksmith shop, an oil house, a foundry, steam dry kilns, a planing mill, and warehouse facilities, as well as an expansive wharf extending east into the harbor, used for loading/unloading materials onto ships (Price, 1989; Port Blakely Mill Company, 2019; Figure 2-3). In April 1907, an overheated journal box set fire to and burned down approximately half of the Mill, including a portion of the wharf (Carlsson, 1992). Construction of a smaller replacement Mill began the same year and was not completed until 1909. In 1916, Port Blakely Mill Company leased the Mill to the Dominion Mill Company, which operated the Mill until it closed in 1923 (Port Blakely Mill Company, 2019). Between 1923 and 1929, the Mill was gradually decommissioned and demolished. After the Mill was dismantled in 1924, the harbor served as a ferry dock between 1924 and 1937, log storage area between 1942 and 1958, and mooring dock for the United States Army Transportation Corps (USATC) in 1943–1944. The property remained owned by the Port Blakely Mill Company until 1999. BI Parks acquired portions of the site in 1999 and 2001.

2.3.3 Potential Sources of Contamination

Historical sources of contamination at the site include potential spills and releases to soils and groundwater from Mill operations, including those formerly occurring in the machine shop, powerhouse, blacksmith shop, oil house, hog fuel/refuse burner, foundry, steam dry kilns, planing mill, and warehouse facilities. Overwater activities that might have resulted in spills and releases included Mill operations such as debarking, rafting logs, and loading and unloading materials onto ships at the wharf. Potential releases during these nearshore activities might then be transported to sediment or from soil and/or groundwater to sediment or surface water via seeps.

In addition, the Mill burned down and was rebuilt twice during the period of operations. The fires occurred in 1888 and 1907, and both upland and overwater structures were destroyed in the fires. Remnants of burnt wood and byproducts of the fires could accumulate in soil and sediment and constitute a secondary source of contamination for the adjacent media. Construction debris, including brick mounds in the upland area and remnants of Mill buildings, may also serve as sources of contamination and wood debris throughout the upland area.

Wood waste is a term used by Ecology to discuss different types of wood, including but not limited to sawdust, wood scraps, bark/ chips from logs, whole logs, and dimensional lumber. Wood waste from industrial processes such as log rafting and milling differs from the wood naturally found in the environment that is described as wood debris. As used in this RI, the term “wood waste” is used to describe wood from the former Mill and log rafting that is present in the marine environment.

2.4 Current and Future Land Ownership and Uses

Current and potential future land uses of the site and surrounding Study Area are described below.

2.4.1 Shoreline Parcel Ownership and Zoning

The majority of the upland portion of the site, the former Mill Pond, and portions of the Inner Harbor area are currently owned and operated by BI Parks (31 acres). This portion of the site is located on Kitsap County Parcel No. 022402-3-032-2000, which is referred to by the Kitsap County Assessor's office as Parcel A. The legal description for Parcel A includes Government Lots 3 (former Mill site), 4 (former Mill Pond), and 5 (western and southern shoreline), collectively shown on Figure 2-4 as the "BI Parks Tax Lot Property Boundary."

The Study Area also includes subtidal areas extending east from the Blakely Harbor shoreline. The Inner Harbor includes intertidal and submerged land[3] owned by BI Parks and private property owners; the Outer Harbor includes submerged lands managed by the WA DNR (State waters). The subtidal areas of the site are visible in the aerial imagery presented on Figure 2-2.

2.4.2 Current Site Use

The upland portion of the Study Area is a public park (Blakely Harbor Park), which includes approximately 0.5 mi of walking trails for recreational day use. A temporary pedestrian footbridge was installed in 2020 to traverse a narrow inlet through the isthmus connecting the north and south sections of the park. This inlet connects the former Mill Pond to Blakely Harbor and is subject to tidal influence. Blakely Harbor Park contains remnants of the former Mill structures, including the former powerhouse, pontoon wall used to close off the former Mill Pond, slag piles along the northern shoreline, scattered brick piles and building debris now covered with vegetation, and partially eroded wharf pilings. The park is used by the Suquamish Tribe as discussed in Section 2.4.4 and is frequented by recreational users for passive recreation, such as picnicking, kayaking, trail walking, and wildlife viewing. The primary access points to the park are the small parking lot in the northeast corner of the park, near the intersection of Northeast Blakely Avenue and Northeast Halls Hill Road, and the harbor via small watercraft (Figure 2-2).

The portion of the Study Area located in the subtidal zone, east of the park boundary, consists of multiple parcels of private residential property along the southern shoreline on Northeast Country Club Road. These private properties extend approximately 300 ft from the southern shoreline into Blakely Harbor. Private ownerships along the northern shoreline extend less than 150 ft in the harbor. State waters, which are managed by WA DNR, begin approximately 200 ft from the Blakely Harbor Park shoreline and extend east to make up the rest of Blakely Harbor (Figure 2-4). The subtidal area is primarily used for recreation, including boating, kayaking, and swimming, and for anchoring boats in the mid-harbor.

2.4.3 Surrounding Land Use

The land surrounding the Study Area is a mix of residential and vacant and heavily forested properties. Adjacent current land uses are summarized below:

[3] Submerged lands refer to land located under waters and under tidal influence that are navigable.

- North—Northeast Blakely Avenue and residential properties are directly adjacent to the site, followed by approximately a quarter mile of vacant and heavily forested land, followed by Port Blakely Cemetery.
- South—Residential properties along the shoreline, followed by Northeast Country Club Road, followed by vacant and heavily vegetated land, and then residential development.
- West—Northeast Country Club Road, followed by approximately a third of a mile of vacant and heavily forested land.
- East—Blakely Harbor and the residential properties that line its southern and northern shores.

2.4.4 Tribal Use

The Suquamish and other Tribes have identified the site as lying within their adjudicated usual and accustomed (U&A) fishing area. As a part of the 1855 Treaty of Point Elliot, the United States and the Suquamish and other Tribes agreed that the Tribes would cede certain portions of their aboriginal lands while reserving the right to use and occupy their U&A lands and waters. Under the 1989 State/Tribal Centennial Accord and the 2012 State/Tribal Relations Act (Chapter 122, Laws of 2012), Ecology maintains a government-to-government relationship with Tribes that is committed to the principals of government-to-government consultation and cooperation with Tribes to protect, preserve, and enhance Washington's environment, and promote the wise management of land, air, and water for the benefit of current and future generations. Ecology also works with Tribes and DAHP to ensure that ground-disturbing activities under the agency's purview are compliant with federal, state historical, and archeological preservation laws.

An aboriginal right retained under the Treaty of Point Elliot includes the immemorial custom and practice to hunt, fish, and gather within the U&A area; these customs and practices were the basis of the Suquamish Tribe's source of food and culture in the past. Treaty-reserved resources include, but are not limited to, fishery resources situated within the Suquamish Tribe's U&A fishing area. The Suquamish Tribe U&A area extends well beyond Port Madison Indian Reservation, and their fishing places include: marine waters of Puget Sound from the northern tip of Vashon Island to the Fraser River in Canada, including Haro and Rosario Straits; and the streams draining into the western side of Puget Sound and also Hood Canal. The U&A area of the Suquamish Tribe also extends west into Jefferson County and south into Mason County. The Port Madison Reservation comprises 7,657 acres and is located in proximity to the City of Poulsbo, approximately 10 mi north of the site and across the Agate Passage.

The Suquamish Tribe has taken a leadership position in the efforts to protect, restore, and enhance the marine waters of Puget Sound to ensure protection of the Suquamish Tribe's treaty and cultural resources. The Suquamish Tribe has historically harvested and consumed fish and shellfish from waters in and around Bainbridge Island and has indicated its intent to do so in the future.

2.4.5 Anticipated Future Use

In addition to the expression of tribal treaty rights, the portion of the Study Area that is Blakely Harbor Park is expected to remain a public park. The other portions of the Study Area; including the submerged lands managed by the WA DNR and the residential private properties, are expected to remain as such.

3. PHYSICAL AND ENVIRONMENTAL SETTING

This section describes site characteristics, including site geology, site hydrogeology, natural resources, climate and climate change vulnerability, and a vulnerable population screening.

3.1 Study Area Geology

The general description of Bainbridge Island's regional geology and hydrogeology included in this report is based on information provided by the United States Geological Survey (USGS) (2005 and 2011). Site-specific geology and hydrogeology conditions are based on information gathered during historical environmental investigations conducted at or near the site (Shannon & Wilson, Inc. [Shannon & Wilson], 1991, 1992a, and 1992b; Anchor Environmental, LLC [Anchor], 2009; GeoEngineers, 2019; Leidos and NewFields, 2019) and during remedial investigation activities conducted by Geosyntec.

3.1.1 Regional Geology

Bainbridge Island lies within the Salish Lowland Physiographic province (USGS, 2005). The northern and central portions of Bainbridge Island are primarily underlain by Pleistocene glacial deposits, namely the Vashon Till. The southern end of Bainbridge Island, including Blakely Harbor, is underlain by the Blakely Harbor Formation, which consists of Miocene Age volcanic-lithic sandstone, siltstone, conglomerate, and peat deposits. Blakely Harbor is situated within the Seattle Fault zone, a broad zone of shallow east-west thrust faults that runs from Seattle through the southern half of Bainbridge Island.

Two geotechnical investigations provide information about the local geology around Blakely Harbor (Associated Earth Sciences, Inc. [AESI], 2000, 2001). Exploratory borings advanced approximately 0.25 mi east of the site, along Halls Hill Road, showed a mixture of clayey silt with gravel (native topsoil interpreted to be weathered or reworked from the Blakely Harbor Formation) and sandy gravel fill material from the surface to 3 ft below ground surface (bgs) (AESI, 2001). The surface material is underlain by bedrock (conglomerate, sandstone, and mudstone) deposits that extended to at least 27.5 ft bgs. Test pits from another geotechnical investigation, approximately 0.4 mi west of the site, showed 0.5 to 1 ft of organic-rich sandy silt topsoil underlain by a weathered Blakely Harbor Formation to the depth of exploration[4] (between 5 and 6 ft bgs) (AESI, 2000).

3.1.2 Site Geology and Topography

The upland portion of the Study Area is relatively flat, with elevations ranging from about -4.3 to 9.7 ft (North American Vertical Datum of 1988 [NAVD88])[5] in the northwest corner of the site. The intertidal shoreline area at the site can be characterized by relatively flat and low-angle slopes,

[4] The term exploration refers to drilling or test pits for collection of subsurface soil samples.
[5] Converted from ft above mean sea level to ft NAVD88 based on data from National Oceanic and Atmospheric Association (NOAA) tide station ID 9447130 in Seattle, Washington.

gently sloping towards Blakely Harbor as detailed in the *Bathymetric and Light Detection and Ranging (Lidar) Survey Report* provided in Appendix B.

The interpretation of the site geology presented below is based on borings logs for the RI. Historical exploration logs from AESI (2000, 2001), Shannon & Wilson (1992b), and Anchor (2009) were used for informative purposes but are not displayed on the cross-sections since depth and elevation controls were tied into the same datum. The locations of historical and RI site explorations are displayed on Figure 3-1. Field sampling results are discussed in more detail in Section 4.

Subsurface investigations have identified three distinct units, consisting of seven subunits, based on their depositional characteristics (see Figures 3-2 and 3-3a through 3-3d for exploration locations and cross-sections):

- **Fill Material (Fill Unit)**: Anthropogenic fill material, likely a result of erosional processes and development of the Mill. The surficial subunit of fill material generally consists of surficial topsoil and sand and the thickness ranged from approximately 3 to 15 ft. The fill material includes the lithological subunits of sand fill, wood debris, other debris fill, and sand, silt, and gravel (SSG) fill, defined below:
  - *Sand fill* is characterized by surficial topsoil and sand. Sand fill was observed primarily in the upper 2 ft of upland borings and intertidal sediment cores SC-03, SC-10, SC-11, SC-17, and SC-52 (Appendix D).
  - *Wood fill* is characterized by natural wood (twigs, bark), and wood waste such as sawdust, dimensional lumber, and wood chips. Wood was observed in both soil borings and sediment cores throughout the site, although it was primarily observed in the north/northeast section of the site in areas where historical structures were located. Wood was typically encountered below the surficial sand Fill Unit and above the native unit and is described on the cross-sections (Figures 3-3a through 3-3d) as debris or fill with wood. The nature and extent of wood is discussed further in Section 6.2 and is depicted on Figures 7-7a through 7-8f.
  - *Other debris fill* is characterized by building and wood including slag, bricks, and glass. Debris fill was primarily observed in the former Mill area.
  - *SSG fill* is characterized as fill material with varying percentages of sand, silt, and gravel. SSG fill was observed at various depths across the site.
- **Recent Deposition (SM/ML):** Recent deposition is characterized as a silty sand/sandy silt (SM/ML) with no fill material (i.e., no wood or debris were observed within the unit). SM/ML was observed in two upland borings (SB/GW-27 and SB/GW-29) and in sediment cores as the recent depositional unit above the native contact. The thickness ranged from 1.5 to 2 ft in the upland borings and 1.9 to 2.2 ft in sediment cores.
- **Native Alluvial Deposits (Native A and Native B, collectively Native Deposits)**: The native contact was observed in the majority of borings, except for those that were too shallow or hit refusal before the native contact. The maximum depths or thicknesses of

the native units were not determined. The native alluvial deposits are characterized by two lithological subunits, Native A and Native B, described below:

- Native A is characterized by a greenish-gray gravelly silt and/or sand with no shell material. Native A was observed as deep as 20 ft bgs.
- Native B is characterized by a greenish-gray gravelly silt and/or sand/gravelly sand with silt and shell material present. Native B was typically observed below Native A. Native B was observed as deep as 20.5 ft bgs.

A sandstone (bedrock) was encountered in two shallow borings (HA-31 and HA-32) at approximately 1.4 and 1.7 ft bgs. An outcropping of the sandstone is visible to the west of HA-31 and is interpreted to be part of the Blakely Formation.

The current understanding of subsurface geological conditions at the site are depicted in cross-sections provided on Figures 3-3a through 3-3d. Key observations of each cross-section are described below:

- Cross-Section A-A' (Figure 3-3a) is aligned generally west-southwest to east-northeast and transects the deepest section of the former Mill Pond and former structures of the Mill. The maximum depth of borings in this cross-section were 20 ft bgs (approximately -5 ft elevation). Wood waste was observed in the majority of borings. The fill-native interface, where encountered, was generally found at an elevation of approximately 0 ft. Groundwater monitoring well GW-27 is screened across the native unit.
- Cross-Section B-B' (Figure 3-3b) is aligned generally south-southwest to north-northeast and transects the east side of the former Mill Pond, the temporary pedestrian bridge, and former Mill structures. The borings' depth in this cross-section was a maximum of 20.5 ft bgs (approximately 0 ft elevation). Wood waste was encountered in the borings within the historical Mill area. The fill-native interface, where encountered, was generally found between -5 ft and 5 ft elevation. Groundwater well GW-24 is screened across the Fill Unit where wood waste was observed.
- Cross-Section C-C' (Figure 3-2c) is aligned generally east to west and transects the park to the west, the former Mill Pond and former Mill, and then extending into Blakely Harbor. The deepest boring was completed to a depth of 17 ft bgs (approximately -5 ft elevation). The fill-native interface in the upland borings, where encountered, was generally found between -5 ft and 5 ft elevation, with a thick unit of wood material above the native interface in the area of the former Mill structures. Moving east into Blakely Harbor, the topographic/bathymetric surface dips, and sediment cores show a top unit of SM/ML, with a native contact encountered in one core at an elevation of approximately -33 ft.
- Cross-Section D-D' (Figure 3-2d) is aligned generally west-southwest to east-northeast, north of and parallel to A-A'. Cross-section D-D' transects the deepest section of the former Mill Pond and former structures of the Mill. The deepest boring was completed to a depth of 20 ft bgs. Wood waste was observed in the majority of

borings. The fill-native interface was generally found between -5 ft and 5 ft elevation. Groundwater monitoring wells GW-26 and GW-27 are screened across the native unit.

3.1.3 Study Area Geologic Conditions

Soil types within the Study Area generally consisted of brown, gravelly, silty, well-graded sand with intermittent debris fill material, including historical wood waste. Test pits and subsurface cores in shoreline sediment and soil indicated the presence of considerable amounts (up to 100%) of inorganic (e.g., red brick and glass fragments) and historical wood waste including dimensional lumber, piling stubs, sawdust, and logs in the upper 8 ft (Anchor, 2009; Shannon & Wilson, 1992a). Native gray sands and gravels (Native A and Native B) with no historical wood waste or inorganic debris were encountered below fill material typically around elevations of 4 to -10 ft (depths between 4 and 8 ft bgs, extending to total depths of 20 ft bgs). Native B was also encountered to a depth of 11 ft below mudline (bml) (approximately -38 ft elevation) in Blakely Harbor.

Percent fines (i.e., the sum of silt and clay grain size fractions) in Blakely Harbor surface sediment varies between 7% and 67% (Anchor, 2009; GeoEngineers, 2019; Leidos and NewFields, 2019). Percent fines were highest in the former Mill Pond sediment (higher than 40%) and lowest along the southern portion of the Study Area in subtidal sediment (lower than 20%). Total organic carbon (TOC) in intertidal and subtidal surface sediment collected from Blakely Harbor ranged from 0.45% and 22%. The TOC range found in Blakely Harbor also exceeds the average TOC in Puget Sound, which is approximately 2% (these results are discussed and presented in Section 6). The highest TOC concentrations were identified in the former Mill Pond and in the intertidal area along the western shoreline of Blakely Harbor. TOC concentrations generally decreased with increasing distance from the shoreline and were lowest in the Outer Harbor and along the eastern and southern portions of the Study Area. Summary statistics for grain size and TOC data are also presented in Section 6.

During an initial site visit, slag debris were observed as black, aggregate chunk piles along the shoreline near the former foundry, machine shop, and blacksmith shop (Figure 2-3). Shannon & Wilson also noted scattered slag-like debris in the former Mill Pond (Shannon & Wilson, 1992a), but these prior observations were not confirmed during the RI field work (additional discussion in Section 4.2.1.5). A more comprehensive slag survey was conducted for the RI and is discussed in Section 4. In addition, subsurface RI explorations identified slag in the upper 1 to 2 ft of borings located in the uplands near historical Mill structures. The deepest observed slag was encountered at 6 ft bgs on the hillside to the north of the historical Mill structures (SB-23). Boring logs are provided in Appendix C.

3.2 Site Hydrogeology

Site-specific hydrogeology conditions are based on information gathered during historical environmental investigations conducted at or near the site (Shannon & Wilson, 1991, 1992a, 1992b; AESI, 2000, 2001; Anchor, 2009; GeoEngineers, 2019; Leidos and NewFields, 2019) and during RI field investigations conducted by Geosyntec.

Study Area groundwater flow observations have been described in two previous studies, and additional information was gathered during RI investigations. Groundwater was characterized

during RI investigations through the installation and monitoring of temporary and permanent groundwater monitoring wells and during shoreline seep surveys. The locations of historical and RI Study Area explorations are shown in Figure 3-1. Groundwater monitoring well construction logs are provided in Appendix C, and field observations are discussed in Appendix D. This section describes the water-bearing unit and summarizes groundwater elevations and flow directions, tidal exchange, and surface water quality.

3.2.1 Single Water-Bearing Unit

The available information indicates that the saturated portions of the combined Fill Unit and Native Deposits form a single water-bearing unit within the depth of exploration. While the Fill and Native Deposits contain variable percentages of silt, no continuous and laterally extensive layer of silt (aquitard) has been observed to indicate there are vertically distinct water-bearing zones within the combined unconsolidated deposits.

3.2.2 Groundwater Elevations and Flow Directions

Study Area groundwater is encountered at shallow depths ranging from approximately 3.7 ft bgs to 8.5 ft bgs. Based on one year of quarterly monitoring in the four monitoring wells, groundwater levels seem to fluctuate seasonally by approximately 1 to 3 ft, with elevations highest in the spring and relatively consistent throughout remainder of the year. Groundwater elevations measured in temporary wells ranged between 6.9 and 10.6 ft bgs and were within the ranges measured in monitoring wells in autumn 2022 (3 to 12 ft bgs).

Groundwater in the shallow water-bearing zone flows from the park upland to the south towards Blakely Harbor (Figures 3-4a through Figures 3-4d). Groundwater seep observations along the shoreline provide evidence of shallow groundwater discharging into Blakely Harbor (Anchor, 2009). However, variability in subsurface lithology due to local wetlands, streams, ditches, and fill can influence the local shallow groundwater flow direction. Likewise, sudden rises in the water table following heavy rains or due to tidal influences can cause temporary and local changes to the groundwater flow regime.

3.2.3 Tidal Exchange

Blakely Harbor has two tidal cycles per day ranging from a maximum low tide elevation of about -2.5 ft mean lower low water (MLLW) to a high-water elevation of about +12.5 ft MLLW throughout the year. Tidal fluctuations and tidal exchange, along with harbor geometry, are mechanisms that can strongly affect harbor circulation, sediment transport, and groundwater chemistry and flow at coastal sites. The zone of nearshore groundwater that mixes with marine water is termed the transitional zone.

The extents to which tidal fluctuations and tidal exchange affect groundwater conditions in Blakely Harbor have not been quantified, as there have been no tidal studies within the Study Area. However, groundwater flow observations have been described in two previous studies (Shannon & Wilson, 1992a; Anchor, 2009) and additional information was gathered during RI investigations by Geosyntec. Saltwater intrusion was confirmed along the shoreline through field parameter (electrical conductivity) monitoring during the 1992 test pit excavations (Shannon & Wilson,

1992a). Anchor (2009) documented intertidal groundwater seeps that discharged saline water from the transitional zone during low tide conditions to Blakely Harbor. Groundwater quality field parameters (e.g., electrical conductivity, salinity, and others) were collected during groundwater monitoring in the Study Area in 2022–2023, and these field parameters are discussed in Section 4.2.

3.2.4 Surface Water Quality

Surface waters in Blakely Harbor are classified as Category 2 by Ecology; defined as waters of concern for bacteria based on one exceedance of water quality standards in November 2001 (Ecology, 2020). Surface water from Blakely Harbor was subsequently sampled and analyzed in 2007, 2008, and 2009 for bacteria, and no exceedances occurred. However, Blakely Harbor surface water remains classified as a Category 2 water body, as the most recent data were deemed insufficient to indicate that this water body meets water quality standards. Average salinity in the harbor is expected to be above 25 parts per thousand.[6]

3.3 Natural Resources

The Study Area includes upland, shoreline (riparian zones), and aquatic habitats, with their associated flora and fauna. The shoreline includes features of the upland ecology (soil or sediment substrate, plants, and debris distribution); therefore, the upland and shoreline habitats are discussed jointly. A description of these habitats is included below.

The Washington Department of Fish and Wildlife (WDFW) has indicated that Blakely Harbor hosts estuarine and marine habitats that provide spawning and foraging grounds for a variety of fish species including Endangered Species Act (ESA)-listed Puget Sound Chinook and Steelhead (WDFW, 2020). Sensitive and endangered species and their habitats are also discussed below.

3.3.1 Upland and Shoreline Habitats

The upland and shoreline areas of the Study Area occupy approximately 26.5 acres,[7] mostly within Blakely Harbor Park. Upland and shoreline habitats include areas of frequent public use (by park visitors) within the park and lesser-frequented areas (e.g., wetland patches of aquatic plants, evergreen trees; and invasive or volunteer blackberries). The areas of frequent public use within Blakely Harbor Park include restrooms (portable restrooms and a permanent structure), boardwalks, picnic and beach facilities, decks, the temporary footbridge, small wildlife viewing structures, wildlife habitat restoration structures, interpretive displays and picnic areas, a gravel parking area, and a launch for human-powered boats.

[6] The sea water of Puget Sound is estimated to be approximately 28.5 parts per thousand (University of Washington, 2017). A surface conditions report by Ecology in 2011 measured salinity at nearby Manchester Basin at 28.7 and Whidbey Island at 28.5 parts per thousand.
[7] As measured to mean higher high water (MHHW).

The National Wetland inventory and the Kitsap County System registry[8] identify the upland and shoreline habitats as WA DNR surveyed or potential wetlands. These wetland areas are shown in Figure 3-5 and include the following:

- Freshwater Forested/Shrub Wetland or Palustrine Forested Seasonally Flooded (PFOC) Wetland in the South Upland. The Palustrine System includes nontidal wetlands dominated by trees, shrubs, persistent emergent mosses or lichens, and such wetlands that occur in tidal areas where salinity due to ocean-derived salts is below 0.5 part per trillion. The forested class includes areas with wood vegetation that is 6 meters tall or taller. The seasonally flooded regime includes areas where surface water is present for extended periods in the growing season with a variable water table after flooding ceases.
- Estuarine and Marine Wetland or Estuarine Aquatic Bed Unconsolidated Shore Regularly Flooded (E2AB/USN) in part of the North Upland. The Estuarine System consists of deepwater tidal habitats and adjacent tidal wetlands that are usually semi enclosed by land but have open, partly obstructed, or sporadic access to marine surface water bodies. The substrate in these habitats is flooded and exposed by tides, including the associated splash zone. The aquatic bed unconsolidated shore class includes wetlands dominated by plants that grow principally on or below the surface of the water with unconsolidated substrates with less than 75% areal cover of stones, boulders, or bedrock and less than 30% areal cover of vegetation. The regularly flooded regime includes landforms such as beaches, bars, and flats that are exposed at least once daily by tidal flood.

Additional details on the shoreline types are discussed in Section 4.2.1.3.

3.3.2 Aquatic Habitats

The in-water areas of the Study Area occupy approximately 74.1 acres within the Blakely Harbor marine embayment. Depths within the Study Area range from 0–40 ft MLLW.

Habitat survey data from Ecology's online Coastal Atlas of Washington display patchy salt marsh along the shoreline of the former Mill Pond, patchy kelp along portions of the northern harbor and east of the site, and patchy to continuous eelgrass along the southern shoreline both within and outside the Blakely Harbor Park Site (Ecology, 2020). The United States Fish and Wildlife

[8] The Kitsap County parcel search geographic information system (GIS) was used to identify wetland areas; the web portal was accessed on March 11, 2024, at the following link: https://psearch.kitsap.gov/psearch/index.html

Service's National Wetland Inventory and the National Wetland inventory[9] and the Kitsap County System registry[10] identify the marine embayment habitats (Figure 3-5) and include the following:

- Estuarine and Marine Wetland or Estuarine Aquatic Bed Unconsolidated Shore Regularly Flooded (E2AB/USN) in the former Mill Pond and part of the Inner Harbor. This system was described in Section 3.3.1.
- Estuarine Unconsolidated Bottom Subtidal (E1UBL) in the Outer Harbor and part of the Inner Harbor. The Estuarine System consists of deepwater tidal habitats and adjacent tidal wetlands that are usually semi-enclosed by land but have open, partly obstructed, or sporadic access to marine surface water bodies. The substrate in these habitats is continuously covered with tidal water (i.e., located below extreme low water). The unconsolidated bed class includes wetlands and deepwater habitats with at least 25% cover of particles smaller than stones (less than 6-7 centimeters [cm]) and a vegetative cover less than 30%. The subtidal regime includes substrate continuously covered by tidal salt water.

Eelgrass surveys conducted in 2013, 2015, and 2016, indicated that about 90% of the eelgrass along Bainbridge Island shorelines grows at an elevation between 0 and -15 ft MLLW, with a median depth of approximately -5 ft MLLW (WA DNR, 2017). The median depth refers to all eelgrass along the shorelines of Bainbridge Island, including both *Zostera japonica* (common in the study area) and *Zostera marina*. Approximately two thirds of the eelgrass around Bainbridge Island was classified as subtidal, growing at water depths greater than -1 m MLLW. In Blakely Harbor, both *Zostera marina* and *Zostera japonica* eelgrass species were documented in the nearshore subtidal areas along the southern Blakely Harbor shoreline. Eelgrass was absent from the Inner Harbor and northern shorelines of Blakely Harbor (WA DNR, 2017).

Eelgrass meadows and kelp forests contribute to a diverse and productive aquatic habitat and provide habitat for marine species, including endangered species like salmon. In addition to ecological benefits, kelp and eelgrass have important cultural value to Northwest Tribal Nations, playing a prominent role in traditional fishing, hunting, and food preparation and storage. The extent of eelgrass and kelp along the Study Area shoreline retrieved from the Washington State Coastal Atlas[11] is reported in Figure 3-5.

[9]The Wetlands Mapper is the primary public interface to the wetlands geospatial dataset that spatially integrates National Wetland Inventory data with additional natural resource information and political boundaries; the web portal was accessed on March 11, 2024, at the following link: https://fwsprimary.wim.usgs.gov/wetlands/apps/wetlands-mapper/.

[10] The Kitsap County parcel search GIS was used to identify wetland areas; the web portal was accessed on March 11, 2024, at the following link: https://psearch.kitsap.gov/psearch/index.html.

[11] The Washington State Coastal Atlas provides geographically linked information to support informed management of Washington's marine shorelines. This database is used by Ecology, WA DNR, WDFW, and other agencies. Data depicted in Figure 3-5 were retrieved on March 5, 2025.

3.3.3 Sensitive and Endangered Species and Habitat

The potential presence of ESA-listed species is discussed below based on preferred habitats available within the Study Area. A wildlife study prepared for a nearby forested area by BI Parks reports the lack of ESA-listed species' preferred habitat in upland areas (Ecological Land Service, 2021).[12] The WDFW Priority Habitats and Species (PHS) website identifies the potential presence of priority habitats and species areas in aquatic environments in the vicinity of the Study Area, including spawning and foraging grounds for two ESA-listed fish species (WDFW, 2020).[13] The WDFW online map service[14] was queried to identify forage fish spawning areas within the site. Site shoreline areas for smelt spawning are depicted on Figure 3-5.

The species mapped for western Washington as threatened include the marbled murrelet (*Brachyramphus marmoratus*), the streaked horned lark (*Eremophila alpestris strigata*), the yellow-billed cuckoo (*Coccyzus americanus*), and the bull trout (*Salvelinus confluentus*). The two fish species considered potentially foraging and spawning within the Blakely Harbor embayment are the Puget Sound Chinook Salmon and the Puget Sound Steelhead (*Oncorhynchus mykiss*). A detailed description of habitat for each ESA-listed species is provided in the subsections below.

3.3.3.1 Marbled Murrelet

Marbled murrelet habitat generally consists of greater than 500 acres of low-elevation forests with at least 30% late-successional or old-growth forest components within 40 mi of the coastal shoreline (United States Fish and Wildlife Service 1997, Federal Register 1992). Old-growth forests provide important nesting habitat for murrelets because they have developed the broad, horizontal-branching structure necessary for nest platforms. Marbled murrelets feed in ocean waters as well as within inland bays and fjords. There is no suitable habitat available for this species within the Study Area.

3.3.3.2 Streaked Horned Lark

Streaked horned larks are found in western Washington where they occupy open landscapes such as prairie-oak habitats, sandy islands, wet prairies, oak savannahs, grasslands found at airports, coastal spits, and coastal dune communities. They can also occur within moderately to heavily grazed pastures, gravel roads or shoulders of lightly traveled roads. It is unknown whether this species is present within the Study Area.

3.3.3.3 Yellow-billed Cuckoo

Suitable breeding habitat for the yellow-billed cuckoo is defined as patches of mature willow and cottonwood riparian vegetation that are greater than 50 acres in size. Yellow-billed cuckoos are found in a variety of vegetation types during migration, including coastal scrub, secondary growth

[12] This study was for a trail being constructed on Bainbridge Island, 6 mi north of the Site.
[13] This study includes habitat in streams and wetlands habitat in Bainbridge Island.
[14] The WDFW online map service is tool to visualize the database including sand lance, smelt, herring spawning areas, herring pre-spawner holding areas, and the forage fish spawning survey beaches in Washington State. Data depicted in Figure 3-5 were retrieved on March 5, 2025.

woodland, hedgerows, humid lowland forests, and forest edges. It is unknown whether this species is present within the Study Area.

3.3.3.4 Bull Trout (Salvelinus confluentus)

The Coastal-Puget Sound distinct population segment (DPS) Bull Trout was listed in 1999 (United States Department of the Interior, 1999). The designated ESA critical habitat for the bull trout includes freshwater, estuarine, nearshore, and offshore marine areas. Typical bull trout timing for spawning is from August through November (McPhail and Murray, 1979; Pratt, 1992). Sub-adult and adult bull trout feed mostly on fish in marine/estuarine areas of northern Puget Sound (e.g., smelt, herring, and juvenile salmonids). It is unknown whether this species is present within the Study Area.

3.3.3.5 Puget Sound Chinook Salmon

The evolutionarily significant unit (ESU) of Chinook salmon includes all naturally spawned populations from rivers and streams flowing into Puget Sound. Adult Chinook salmon are opportunistic pelagic feeders and are found in Puget Sound during their migration to and from the open ocean and their upriver spawning grounds. Designated ESA critical habitat for Chinook salmon in and around the Study Area includes freshwater, estuarine, nearshore, and offshore marine areas. It is unknown if adult Chinook salmon are present within the Study Area at any time of year.

3.3.3.6 Puget Sound Steelhead (Oncorhynchus mykiss)

The Puget Sound steelhead's designated ESA critical habitat includes freshwater, estuarine, nearshore, and offshore marine areas. The Puget Sound DPS of steelhead includes all naturally spawned anadromous winter-run and summer-run populations. Winter-run and summer-run population histories are defined based on the timing of adult returns to their natal spawning streams and by their degree of sexual development at the time they enter freshwater (National Marine Fisheries Service, 2005a). Juvenile steelhead out-migrate from freshwater and enter marine waters. In general, the majority of steelhead appear to migrate directly to the open ocean and do not rear extensively in the estuarine or coastal environments (Burgner et al., 1992). Therefore, juvenile steelhead would not be expected to be present in the Study Area, but it is unknown. It is also unknown if adult steelhead are present in the Study Area throughout the year.

3.3.3.7 Southern Resident Killer Whale

The Southern Resident killer whale is federally listed as a threatened species (National Marine Fisheries Service, 2005b). The Southern Resident killer whale group has been established as a DPS and a stock under the Marine Mammal Protection Act (MMPA) of 1972; this group contains pods or groups. Three family groups of whales—J, K, and L—spend several months of the summer and fall each year in Puget Sound. Killer whales usually prefer marine habitats with deep waters. The marine embayment at the site is characterized by bathymetry ranging from 0 to -50 ft MLLW. It is unknown if the Southern Resident killer whale frequents the Study Area; however, video evidence suggests its historical presence in the area.

3.4 Climate and Climate Change vulnerability

The Puget Sound basin has a maritime climate with temperate winters and summers. Substantial winter snowfall occurs at high elevations, but snow rarely falls in the lowlands. Storms lasting longer than one day mostly occur in the late fall and winter and are controlled by large-scale synoptic weather systems. Bainbridge Island is located in a temperate rainforest, and the climate is mild.

Average temperatures in Bainbridge Island range from a low of 40 degrees Fahrenheit (°F) in winter to around 75°F during summer months; the lowest and highest temperatures in the past 20 years were 36°F in February and 76°F in July and August, respectively.[15] Average precipitation throughout the year is approximately 44 inches (in) of rain and 4 in of snow.

The northwest United States is vulnerable to climatic stressors, including warming air temperatures and variable precipitation patterns, which will likely result in altered snowpack, stream flows, and water availability (Snover et al., 2013; Mote et al., 2014). Stressors will result in potential inundation, erosion, and modification of the overall shoreline profiles. Bainbridge Island contains 53.3 mi of shoreline, 82% of which is currently in residential, recreational, commercial, or industrial use. Areas most susceptible to inundation are the uplifted beach terraces on the southern third of the island and the majority of the bays and coves on the island (Huppert et al., 2009), which includes the Study Area. Wave action is expected to be mild on Bainbridge Island because of the limited magnitude of energy. Bluff erosion can, however, occur after heavy rains, and erosion rates average between 2 and 6 in per year, depending on beach profile, substrate, and slope angle, as well as the presence or absence of human-built protective structures such as bulkheads (Herrera Environmental Consultants, 2011).

3.5 Indian Tribes, Vulnerable Populations, and Overburdened Communities

The MTCA Cleanup Regulations require determination of whether the population threatened by a contaminated site includes a likely vulnerable population or overburdened community during a remedial investigation for the limited purposes of site prioritization (WAC 173-340-340, 173-340-350 through 173-340-390). The MTCA Cleanup Regulations define the terms "vulnerable population" and "overburdened community" to mean the same as under the Healthy Environmental for All (HEAL) Act, Chapter 70A.02 RCW (WAC 173-340-2007). The Implementation Memorandum No. 25 provides guidance to identifying likely vulnerable populations and overburdened communities under MTCA (Ecology, 2024).

The presence of vulnerable populations at the site was assessed using the Environmental Health Disparities (EHD) Index from the EHD Map maintained by the Washington State Department of Health (2022) and the Environmental Justice (EJ) Screening and Mapping Tool (United States Environmental Protection Agency [EPA], 2024). According to Ecology guidance, a potentially

[15] Data available here: Bainbridge Island climate: Average Temperature by month, Bainbridge Island water temperature (climate-data.org).

exposed population is defined as a vulnerable population or overburdened community when located in a census tract that

- ranks 9 or 10 on the EHD Index, or
- is at or above the Washington State 80th percentile of the Demographic Index or the Supplemental Demographic Index from the EPA EJScreen tool.

3.5.1 Environmental Health Disparities

The EHD map shows an assigned environmental health disparity index for a community based on census tracts with population ranging between 2,000 and 8,000. The EHD Index utilizes a 1 to 10 ranking scale, with 1 being low risk and 10 being high risk for EHD.

The Study Area is under the 091000-census tract and has an overall EHD ranking of 1, indicating the population within the Study Area is not considered at risk of environmental health disparity. The EHD ranking is calculated based on 19 indicators that are grouped in four categories listed below:

- Environmental exposures, which considers exposure to particulates (PM2.5), diesel emissions, and ozone concentration; proximity to heavy traffic roadways and toxic release from facilities (RSEI model); this category was ranked low (3) for the Study Area.
- Environmental effects, which is assessed based on risk of exposure to lead from housing, proximity to hazardous waste treatment, storage, and disposal facilities, Superfund sites, risk management plan facilities and wastewater discharge. This category was ranked medium (5) for the Study Area, likely due to the proximity to the Wyckoff/Eagle Harbor Superfund Site.
- Presence of sensitive populations, which is evaluated based on factors like incidence of death from cardiovascular disease and low birth weight. This category was ranked low (2) for the Study Area.
- Socioeconomic factors, which are evaluated based on the prevalence of limited English-speaking communities, high school diplomas, percent of population living below federal poverty level, unemployment, and race distribution. This category was also ranked low (1) for the Study Area.

A screenshot of the EHD map for the Study Area is included in Appendix E.

3.5.2 Environmental Justice Screening

The EPA EJScreen tool was used to generate a report of EJ indices and socioeconomic indicators for an area of about 506 acres including the Study Area and a buffer area extending 0.2 mi from the site; the detailed report is included as Appendix E. There are 13 EJ indices that aim to

characterize pollution and proximity of potential pollution sources within the Study Area.[16] Socioeconomic indicators inform on the demographic and economic status of communities within the Study Area.[17] The Demographic Index (low income and people of color) for the Study Area is within the 10th percentile for the state and 12th percentile for the nation. The Supplemental Demographic Index (low income, unemployment, lack of English proficiency, less than high school education, and low life expectancy) for the Study Area is within the 8th percentile for the state and 7th percentile for the nation.

The screening performed according to Ecology's guidance indicates that the potentially exposed population within the Study Area does not include a likely vulnerable population or overburdened community.

3.6 Tribal Communities

The EHD Index screening does not consider disproportionate site-related health risks to tribal communities exercising treaty rights within usual and accustomed harvest areas. Given significantly higher seafood consumption rates and longer exposure durations and frequencies, tribal community members, including children, face higher health risks than the general public through the consumption of seafood. For example, Suquamish tribal consumption rates are documented as some of the highest among Salish Sea tribal communities.

These tribal exposure parameters will typically drive the process of establishing site-specific risk-based sediment clean up levels. In such cases, SMS guidance provides an approach (Option 1) that allows risk-based clean up levels for exposure via seafood consumption to default to natural or regional background concentrations.

In consultation with the Suquamish Tribe and Ecology, an Option 1 approach was used at the Blakely Harbor Site for the RI. Sediment cleanup levels set at natural background are assumed to be protective of tribal members as a population potentially exposed to disproportionate risks.

[16] EJ indices include concentrations of air particulate matter, ozone, and diesel particulate matter; air toxic cancer risk and respiratory hazard index, toxic release air, traffic proximity, lead paint, superfund proximity, Risk Management Program facilities, hazardous waste proximity, presence of underground storage tanks, and wastewater discharges.

[17] Socioeconomic indicators evaluated by the EPA EJ Screening and Mapping tool include demographic and supplemental demographic indices, race and income information, unemployment rates, limited English-speaking households, less than high school education, population under age 5 and over age 64.

4. FIELD INVESTIGATION

This section summarizes previous investigations and the subsequent RI activities. Appendices referenced in this section provide additional detail.

4.1 Summary of Previous Environmental Investigations

Several previous investigations were conducted at the Blakely Harbor Study Area from 1990 through 2019. These studies are listed in the Study Area history and timeline of activities (Table 4-1) and summarized in Section 2.4 of the Work Plan (Geosyntec, 2022). In brief, investigations prior to 2019 included the following:

- Shannon & Wilson in 1991 and 1992 (soil, sediment, groundwater)
- Anchor in 2008 (sediment, shoreline samples, seeps)
- GeoEngineers and Leidos and NewFields in 2019 for Ecology (soil and sediment)

Historical sampling locations are shown in Figure 4-1 and details regarding sampling rationale for these investigations are included in their respective reports and briefly summarized below.

4.1.1 Shannon & Wilson Inc. (1991, 1992)

Over the course of two years, Shannon & Wilson collected 10 sediment samples, 17 surface soil samples, nine groundwater samples, and one surface water sample as part of a phased Environmental Site Assessment on behalf of Port Blakely (Shannon & Wilson, 1991, 1992a, 1992b). This work was performed by Port Blakely to satisfy property transfer requirements to BI Parks at the time of the sale. The field investigation included limited sampling of the former Mill Pond and Blakely Harbor sediments (near surface) and backhoe test pits advanced in the upland area to estimate the extent of wood waste. Groundwater was collected from temporary well points. A total of 10 soil samples, 19 sediment samples, and 10 water/seep samples were collected. Samples were analyzed for total petroleum hydrocarbons (TPH) and metals, and some soil samples from test pits were analyzed by toxicity characteristic leachate procedure (TCLP) for metals. The test pits provided visual documentation of subsurface conditions and the extent of wood waste from former Mill operations. TPH concentrations were below the method detection limit of 50 milligrams per kilogram (mg/kg), total metals concentrations were below the state and federal regulations at that time, and TCLP metals concentrations were below criteria for designation as characteristic dangerous waste.

These data were not included in the RI dataset because of data quality concerns[18] but were retained as a line of evidence in our conceptual understanding of Study Area conditions.

[18] Quality of data collected during the Shannon & Wilson investigations was not considered acceptable due to the age of the data (more than 20 years old) and the use of obsolete analytical methods resulting in elevated method detection limits.

4.1.2 Anchor Environmental LLC (2009)

In 2008, Anchor collected sediment and seep samples and conducted diver probing for the City of Bainbridge Island, Washington, as part of an investigation of potential shoreline restoration options (Anchor, 2009). The scope of work included 11 sediment piston-core locations, three seep samples, sediment composite sampling from three test pits, and three diver probing surveys to estimate the extent of wood waste. Sediment samples were collected from the nearshore intertidal and shallow subtidal areas of Blakely Harbor and the former Mill Pond. Limited subsurface sediment samples were also collected from three test pits adjacent to the historical Mill structures. A combination of hand-probing, steel probe soundings (using rebar), hand-driven piston cores at low tide, and test pits were used to collect samples. Three diver swim-along transects were completed using hand-probing tools to visually estimate the extent of wood waste perpendicular to the shore. Sediment samples were analyzed for an array of parameters (depending on the location), including grain size, total solids, total volatile solids (TVS), TOC, total ammonia and sulfides, metals, semi-volatile organic compounds (SVOCs), volatile organic compounds (VOCs), TPH, polychlorinated biphenyls (PCBs), pesticides, and dioxins/furans. Water samples were also analyzed[19] for tributyltin (TBT).

Results of sediment chemical analysis indicated potential impacts from metals, polycyclic aromatic hydrocarbons (PAHs) and wood waste in the vicinity of historical Mill structures. A slight oily sheen was observed in surface sediment sample BH-02 (Figure 4-1). Anchor completed a data validation review and considered all data usable for decision-making.

The Study Area shoreline was inspected at low tide for groundwater discharge seeps, and three predominant seeps were observed. Seep samples were collected at these locations using a stainless-steel well point with a 1-ft-long screen interval inserted into the sediment at approximately 1 ft below the sediment surface. Discrete samples were collected using a peristaltic pump with low-flow methods and were analyzed for ammonia and sulfides. The area around the seeps was visually inspected and found the presence of *Beggiatoa sp*, a white, filamentous bacteria attached to wood surfaces at seep BH-22 (Figure 4-1).

These data were not included in the RI dataset because of data quality concerns[20] but were retained as a line of evidence in our conceptual understanding of site conditions.

4.1.3 Ecology 2019 (GeoEngineers and Leidos and NewFields)

In 2019, on behalf of Ecology, GeoEngineers collected six intertidal surface sediment samples and five soil samples. Surface sediment samples were collected during low tide from 0 to 0.3 ft bml (0 to 10 cm) using hand sampling methods. Soil samples were collected from a depth of 0 to 1 ft bgs and below vegetative layers. All samples were located in the vicinity of the historical wharf and

[19] Water samples were collected from a composite sample of sediment and debris material to evaluate potential restoration, reuse, or disposal options, and samples were analyzed accordingly to the Dredge Material Management Program (DMMP).

[20] Quality of data collected during the Anchor investigation was not considered acceptable for use in the RI due to the age of the data (more than 15 years old) and the use of obsolete analytical methods resulting in elevated method detection limits.

former Mill operations (GeoEngineers, 2019). Chemical analyses included metals, SVOCs (including PAHs), dioxins/furans, and conventionals (grain size, TOC, ammonia, sulfides). EcoChem, Inc. of Seattle, Washington, completed the data validation.

As part of the same 2019 study for Ecology, Leidos and NewFields collected an additional 40 surface sediment and five duplicate samples from the former Mill Pond, intertidal nearshore locations, and subtidal Outer Harbor areas of Blakely Harbor (Leidos and NewFields, 2019). These samples were analyzed for the same constituents as the samples collected by GeoEngineers. Leidos completed the Stage 2b data validation for all SMS chemical data and completed Stage 4 validation for the dioxins/furans data. Leidos considered all data usable for decision-making, but quality assurance/quality control (QA/QC) qualifiers were applied to some of the data because of laboratory method blank contamination and low recoveries. Potential impacts to sediment were identified in areas of historical Mill operations and included presence of wood waste,[21] metals, PAHs, phenols, and dioxins/furans.

The Leidos and NewFields report included the following recommendations: (1) collect additional data to fill spatial data gaps; (2) perform marine biological testing to determine biological effects; (3) test archived samples for dioxins/furans;[22] and (4) perform additional extract cleanup or use higher resolution analytical methods (e.g., selective ion monitoring [SIM]) for future SVOC analysis.

The data collected during the GeoEngineers and NewFields investigations were considered acceptable for use in the RI and are included in the RI dataset.

4.1.4 Dioxin/Furan 2020 Results of Ecology Archived Samples

In 2020, two soil samples and 18 sediment samples from the archived (frozen) 2019 field efforts were selected for dioxin/furan testing with permission from Ecology. These data underwent Stage 4 data validation by the Geosyntec chemistry group, and the data were found to be useable to support project objectives. However, some J-qualifiers were applied to the results because of hold time and QC issues. Since these samples were analyzed at a later date, these dioxin/furan results were not included in the GeoEngineers or Leidos reports.

Total dioxin/furan concentrations for the two soil samples were 8.6 and 79 nanograms per kilogram (ng/kg) toxic equivalence quotient (TEQ). The higher concentration (S-5-0-1) exceeded the MTCA Method B direct contact level (13 ng/kg TEQ dioxins/furans) by a factor of 6.1. This sample was located in the vicinity of the former Mill operations. Total dioxin/furan sediment concentrations ranged from 0.27 to 14.9 ng/kg TEQ, with higher concentrations located closer to shore. Three sediment samples exceeded the Puget Sound natural background 90/90 upper tolerance limit (UTL) value (4 ng/kg).

[21] Wood waste as referred to in this document consist of wood material that has been identified and characterized as described in the Standard Operating Procedure #107 of the Work Plan (Geosyntec, 2022).
[22] Additional testing of archived samples was initiated by Port Blakely in consultation with Ecology. Testing was initiated in June/July 2020, and results are provided in Appendix F.

The dioxin/furan data were validated and provided to Ecology in November 2020; Ecology approved them for use in the RI.

4.2 Remedial Investigation

The RI sampling and analysis was conducted in accordance with the Ecology-approved Work Plan (Geosyntec, 2022), the Work Plan Addendum (Geosyntec, 2023a), and Field Change Request FCR-001 (Geosyntec, 2023c). The RI sampling activities were conducted in phases (from 2020 to 2023), allowing results of the initial phases to inform future phases. A list of RI sampling activities and associated data quality objectives (DQOs) are reported in Table 4-2 and sampled locations are shown in Figure 3-1 and reported in Table 4-3. A summary of soil, groundwater, and sediment samples collected during the remedial investigation are reported in Table 4-4.

4.2.1 Physical Surveys

Investigation activities began in 2020 with preliminary physical surveys. RI physical surveys included the following:

- Cultural resources survey (Section 2.2)
- Bathymetry and Lidar surveys
- Sediment profile imaging and plan view (SPI/PV) survey
- Shoreline surveys for habitat, seeps, and structures
- Surveys for slag and wood waste
- Timber pile mapping
- Timber pile sampling
- Soil (surface and subsurface) sampling and analysis
- Groundwater monitoring well installation, sampling, and analysis
- Sediment (surface and subsurface) sampling, analysis, and bioassay testing
- Asbestos inspection and sampling

Results from the physical surveys informed the 2021 multi-media sampling events, which included the collection of soil, groundwater, and sediment samples. The bathymetry and Lidar survey conducted in fall 2020 provided elevation data for planning the 2021 shoreline surveys and upland and sediment sampling events. Results from the SPI/PV surveys provided benthic habitat conditions including substrate type, presence and relative abundance of wood waste, and depth of the biologically active zone, which were used for planning the wood waste and sediment data collection and data evaluations. Results of the Phase 1 investigations were reviewed in collaboration with Ecology, and areas requiring further data collection were identified for Phase 2 sampling.

Phase 2 RI field activities began in 2022 and included a slag survey, installation of monitoring wells and quarterly groundwater sampling, collection of additional soil and sediment step-out samples, and bioassay testing. Results of Phase 2 investigations were summarized in a technical memorandum submitted to Ecology in August 2023 (Geosyntec, 2023b). Data gaps identified after review of Phase 2 data were targeted for Phase 3 sampling. Phase 3 RI field activities included collection of additional surface soil and sediment step-out samples for further delineation of COPCs.

The details of the RI field activities are described below and in referenced appendices.

4.2.1.1 Bathymetry and Lidar

In the fall of 2020, David Evans and Associates, Inc, conducted a comprehensive high-resolution airborne Lidar and a high-resolution multi-beam bathymetric survey (supplemented with single beam bathymetric data where necessary). The purpose of the survey was to collect detailed Study Area elevation data to support the RI/FS field activities. Initially, ground elevations were used to help scope the field investigation and to provide information about boat access to the intertidal area and under the temporary pedestrian bridge. The survey included four components: geodetic control survey for establishing control points, an aerial Lidar survey of the upland topography, an in-water high resolution multi-beam bathymetric survey, and single beam bathymetric echosounder acoustic survey to in-fill spatial data gaps. The work product was a comprehensive Study Area-wide elevation contour map of upland topography and in-water bathymetry. Methods and results are discussed in Appendix B.

The fly-over Lidar survey was conducted at low spring tide to optimize aerial coverage over the shallow mudflats and allow observation of shoreline structures. The survey was conducted on September 28, 2020, during a low tide of 0.5 ft MLLW. The bathymetric survey was conducted by boat during a high spring tide to maximize the area available for surveying.

The horizontal datum for the survey is North American Datum of 1983 (NAD83) projected to Washington State Plane Coordinate System (SPCS), North Zone, with units in United States Survey Feet. The vertical datum is referenced to MLLW elevation in ft.

The upland area is topographically flat near the shoreline with ground elevations ranging from 1 to 38 ft MLLW near the former Mill structures. Near the former powerhouse, the ground elevations are between 10 and 16 ft MLLW and subject to high tide marine water inundation during a king tide (marshy habitat is present). Elevations of the vacant and forested upland area range from 15 to 40 ft MLLW. The elevation of the former Mill Pond is topographically flat, with elevations ranging between -5 and 15 ft MLLW. The deepest part of the former Mill Pond is near the temporary pedestrian footbridge, where the elevation decreases to -2 ft MLLW. The approximately 50 acres of intertidal/subtidal marine harbor ranges from elevation of 0 MLLW near the temporary pedestrian footbridge to depths of approximately -50 ft MLLW in the Outer Harbor. The elevation of the shoreline around the Study Area ranges approximately from 0.7 and 17 ft MLLW.

Two shipwrecks were noted during the survey near the edge of the former wharf footprint at approximately -15 to -20 ft MLLW. One boat is approximately 18 ft long and the other is

approximately 26 ft long. The diver probing confirmed the presence of these sunken vessels. The *Lidar and Bathymetric Survey Report* is included as Appendix B.

4.2.1.2 Sediment Profile Imaging and Plan View Survey

The SPI/PV survey was conducted in October 2020 by Integral Consulting Inc. (Integral) during Phase 1 of the RI. The purpose of the SPI/PV survey was to collect sediment profile images and plan-view images of surface sediments to characterize the biologically active zone (approximately top 20 cm), evaluate the presence and abundance of wood waste, and assess the successional stages and biological features in the Study Area.

The survey was conducted in two separate phases due to boat access constraints:

1. SPI images were collected in the former Mill Pond at low tide by overland access on foot. This survey was conducted using a lightweight, handheld SPI camera prism and housing. A Trimble® global positioning system (GPS) unit was used for location control. SPI imagery was collected at a total of 11 stations. PV images were not collected in the former Mill Pond.
2. SPI and PV images were collected in the harbor by deploying the SPI/PV camera system from a research vessel with digital GPS unit for location control. SPI/PV paired imagery was collected at 89 locations.

Three images were attempted at each sample location. The captured images were processed and analyzed by Integral staff for several parameters, including sediment texture and composition, presence and abundance of wood waste, prism penetration depth, surface boundary roughness, apparent redox potential discontinuity (aRPD) depth, organic loading, infaunal successional stage, and presence of other biological features.

SPI represents the upper 21 cm of sediment (maximum penetration) depending on prism penetration depths. Wood waste (ranging from splinters to chips and large chunks) were present in the vicinity of the former overwater structures, historical wharf, and within the former Mill Pond. Benthic habitat quality does not appear to be obviously impaired in areas with wood waste (discussed further in subsequent sections).

Benthic habitats vary across the Study Area, but the variations seem to be correlated with substrate texture rather than seasons (e.g., seasonal hypoxia would be revealed in SPI images by buried, relict aRPDs). The former Mill Pond appears to be an area of high organic loading and high sediment oxygen demand. The *SPI/PV Survey Report* is included as Appendix F. Additional assessment of the benthic community as it relates to wood waste is provided in Section 6.3.

4.2.1.3 Shoreline and Habitat Survey

The Shoreline and Habitat Survey was conducted in 2021 during Phase 1 of the RI. The purpose of the Shoreline and Habitat Survey was to characterize habitat and substrate along the shoreline and littoral areas to support the RI/FS.

The survey was comprised of three parts:

- A desktop review of existing shoreline types using aerial imagery
- A habitat characterization and substrate inventory field survey conducted by a Professional Wetland Scientist
- A shoreline type classification field survey, which was completed using this guidance:
  - Cowardin's classification of wetlands and deepwater habitats of the United States (Bailey et al., 1993; Cowardin et al., 1979)
  - Dethier's marine and estuarine habitat classification system for Washington State, which was further refined in the 2001 ShoreZone Inventory (Dethier et al., 1990)

The field components of the survey were conducted at low tide. During the visual field assessment, slopes were recorded along each transect, and observations were made regarding substrate types, vegetation coverage, and the presence of avian, terrestrial, and aquatic fauna. Classification of the shoreline into types was completed based on the two guidance documents noted above.

Six representative shoreline types were identified, including: Hardpan, Mixed Coarse, Sandflat, Mudflat, Mud/Sandflat, and Marsh–Spit/Berm. The *Shoreline and Habitat Survey Field Report* is included as Appendix G and provides a discussion of the habitats and substrates associated with each shoreline type along with details of the methods and equipment used to perform the survey.

4.2.1.4 Shoreline Structures and Seeps Survey

A visual shoreline inspection survey was conducted at low tide to identify the presence/absence of seeps and record locations of structures around the Study Area. Accessible features visible above the waterline were photographed, and upstream and downstream views of the shoreline were photographed to document typical shoreline conditions and potential access constraints for future sampling, remedial design, and construction.

Remnant structures were observed associated with the former Mill operations in the Inner Harbor and upland areas (e.g., brick fragments, concrete rubble). The location of the observed structures is reported in Figure 4-2a. Ten seeps, the unnamed creek on the west side of the Mill Pond, and one outfall were observed, and locations were recorded on a map (Figures 4-2b). The *Shoreline Seeps and Structures Survey Report* is included as Appendix H.

4.2.1.5 Slag Survey

Spot concentrations of slag were observed along the northern shoreline of the Inner Harbor during the site walk, shoreline survey, and site sampling. A semi-quantitative shoreline slag survey was described in Section 2.3.3 of the Work Plan Addendum approved by Ecology (Geosyntec, 2023a; Ecology, 2023) and completed as part of the Phase 2 RI to assess abundance of slag embedded in the beach substrate along the northern shoreline. Additionally, Phase 2 soil and sediment samples (discussed in more detail below) collected in the upland and the Inner Harbor along the northern shoreline were field screened to evaluate the presence of slag debris.

Percent surface coverage of slag was generally below 10% across the Study Area as shown in Figure 4-3. There were two primary areas where slag was observed in the Study Area: (1) in proximity of the former blacksmith and machine shops (on the eastern portion of the Inner Harbor

shoreline); and (2) adjacent to the temporary pedestrian bridge and riprap area (on the western portion of the Inner Harbor shoreline). The slag observed in these two areas had distinctive features that may indicate different origins. The *Slag Survey Summary Report* is included as Appendix I.

4.2.1.6 Probing and Wood Waste Evaluation

Wood waste was identified during historical and current site investigation activities. As noted in Section 4.1.2, Anchor conducted a diver survey in 2008 to estimate the extent of wood waste. More recently, locations of wood debris were observed during the shoreline seeps and structures survey (discussed in Appendix H),[23] and elevated percentages of surficial wood waste were also documented in the Inner Harbor area during the SPI/PV survey (Appendix F).

A transect probing survey was conducted during Phase 1 field investigations to evaluate the presence of soft sediments and the extent of wood debris. The survey was conducted from a small vessel along three transects in the Mill Pond, Inner Harbor, and Outer Harbor. A measuring rod was used to probe the soft sediment substrate.

Soft sediment thickness was greatest in the northern portion of the Mill Pond (thickness of more than 3 ft) and was generally greater in the Mill Pond compared to the Inner Harbor (thickness of 1 to 2 ft). Soft sediment thickness was less along the shoreline and increased in deeper portions of the Outer Harbor (maximum thickness observed is 2 to 3 ft).

In general, wood debris was observed at the sediment surface in subtidal and intertidal areas of the Mill Pond and Inner Harbor, corresponding to the footprint of former overwater Mill structures and the former wharf. Abundant wood debris was observed at depth in the northern upland area within the footprint of former Mill structures. A wood debris content below 10% in volume was observed in discrete sampling locations along the southern shoreline or in the southern upland area. This indicates that the presence of wood debris in soil and sediment in the Study Area is strongly associated with historical structures.

The *Probing and Wood Debris Evaluation Report* is included as Appendix J.

4.2.1.7 Timber Piling Mapping and Sampling

The presence of timber piles was noted during exploratory site visits performed prior to initiating RI field activities. Construction of buildings and overwater structures at the Mill dates to before the twentieth century before creosote was used for the preservation of wood materials. However, since some piles were installed after the Mill burned down when creosote was potentially in use (including at the nearby former Wyckoff facility), an evaluation was performed to inspect and map timber piles and collect samples from the surface of the pile to determine if the piles were treated with creosote.

Timber piles in the Study Area are distributed along the northern shoreline in the former Mill Pond and the Inner Harbor, and some of the piles in the Inner Harbor are submerged. The distribution

[23] Wood debris identification was not an objective of the shoreline seeps and structures survey, but observations were made when wood debris was encountered.

and structure of timber piles varies, and most timber piles are located along the eastern shoreline of the former Mill Pond and the shoreline in front of the Powerhouse. The degree of timber pile weathering and exposure above the mudline also differed based on mudline elevation and presumed age of the piles. The abundance and density of timber piles were considered together with visual characteristics, and five sampling areas were identified.

The *Timber Pile Mapping and Sampling Report* is attached as Appendix K.

4.2.2 Timber Pile Sampling

Pile scrape samples were collected for PAH analysis from piles within five areas identified as representative of the different ages/rebuilding of the former Mill, including four shoreline areas (located in the former Mill Pond and Inner Harbor) and one submerged area within the Inner Harbor. Individual piles in each pile field differed by the degree of weathering. Sample analyses showed that for the piles tested (1) PAH concentrations on the surface of Study Area piles were considerably lower than creosote reference samples, (2) PAH profiles did not resemble creosote signatures, and (3) differences between PAH datasets for the Study Area and reference samples were statistically significant (98.8% confidence level). The findings indicate the Study Area piles tested were not likely treated with creosote. No visual evidence of creosote was observed on the piles and many piles had features (e.g., remnant tree limbs) suggesting they were not milled.

A description of the sampling methodology, field observations, sample results, and PAH evaluation for creosote, are presented in the *Timber Pile Mapping and Sampling Report* included as Appendix K.

4.2.3 Asbestos-Containing Material Inspection and Abatement

Suspected asbestos-containing material (ACM) were visually identified along the southern shore of the Mill Pond and along the northern shoreline of the Inner Harbor during a site walk conducted on April 2, 2021.

Samples were collected of a fibrous, white, papery material (likely roofing insulation) identified within a block of soil (sand/gravel) and demolition debris along the southern shore of the Mill Pond, and samples were collected of fiber-wrapped rubber hose scattered on the northern shoreline of the Inner Harbor. The presence of asbestos was confirmed in the samples collected near the Mill Pond, but not in the samples collected near the Inner Harbor.

A site-wide inspection was subsequently conducted by an Asbestos Hazard Emergency Response Act (AHERA)-certified asbestos inspector, G2 Consultants, to evaluate the potential presence of other suspected ACM, include suspected ACM associated with former Study Area building materials, collect soil samples, and conduct abatement in the area where ACM was confirmed. The inspection did not identify additional ACM at the site and ACM was not identified in soil samples surrounding the area where asbestos was detected. Within the area of confirmed ACM, the portion of the material visible in the block of soil was removed (to be tested), and the abatement work limited airborne dispersion, therefore reducing the risk of exposure to asbestos, by confining the ACM in a solid matrix (liquid glue).

Suspected ACM was not encountered by field staff during the RI sampling activities, indicating that the presence of ACM is limited at the site. The *Asbestos Inspection and Sampling Report* is provided in Appendix L.

4.2.4 Soil Sampling and Analysis

During the three phases of RI investigation work, 185 surface and subsurface soil samples were collected from 54 locations throughout Blakely Harbor Park and surrounding properties. Target sampling locations included areas of historical operations (e.g., oil house, hog fuel/refuse burner, foundry) and areas where historical sampling activities identified COPCs exceeding preliminary screening levels (GeoEngineers, 2019; Shannon & Wilson, 1992a, 1992b). The RI soil sampling program included the following:

- Hand auger soil sampling (referred to as surface or shallow soil sampling in Work Plan documents). Soil samples were collected by hand augering to a maximum depth of less than 3 ft bgs. Samples were collected at 39 locations in the north and south upland areas and in proximity to the perimeter of the Blakely Harbor Park property line. A total of 83 surface soils samples were collected (73 primary samples and 10 field duplicates).
- Drill rig soil borings (referred to as subsurface soil sampling in Work Plan documents). Soil samples were collected by using direct-push drilling to a maximum depth of 25.5 ft bgs at 26 locations within the footprint of former Mill buildings, in the north upland, and in the south upland. A total of 105 soil samples were collected (94 primary samples and 11 field duplicates) from ground surface to depths of 24 ft bgs.

Field and QC samples are summarized in Table 4-4, and details of the sampling programs and procedure are included in Appendix D.

Soil samples were analyzed for metals (arsenic, cadmium, chromium, copper, lead, mercury, and zinc), TPH, PAHs, phenols and phthalates, and dioxin and furans. Soil boring logs are provided in Appendix C.

4.2.5 Groundwater Sampling and Analysis

Site groundwater was not sampled during previous investigations, so the RI sampling program was developed to assess potential groundwater impacts first from temporary and then from permanent sampling points. Groundwater was first monitored in five temporary wells located within the footprint of former Mill buildings in the north upland and along the shoreline in proximity of potential historical and ongoing sources of contamination (both historical and ongoing). Based on the information from the temporary wells, four permanent groundwater monitoring wells were installed and sampled quarterly over a one-year period to evaluate seasonal variability and potential impacts on water quality parameters. Groundwater samples were collected using low flow procedures, and sampling commenced approximately two hours before predicted low tide to approximately two hours after the predicated low tide to minimize the potential for tidal influence or flushing.

One field duplicate was collected during each sampling event, including the initial sampling event from the temporary wells. Field and QC samples are summarized in Table 4-4, and details of the sampling programs and procedure are included in Appendix D.

Groundwater samples were analyzed for dissolved and total metals (arsenic, cadmium, chromium, copper, lead, mercury, and zinc), PAHs, phenols and phthalates, and dioxin and furans. Conventional parameters including ammonia, sulfide, total solids, and dissolved solids were also analyzed. Field parameters collected during purging included depth to water, turbidity, dissolved oxygen, pH, conductivity, redox potential, temperature, and salinity.

4.2.6 Sediment Sampling and Analysis

During the three phases of the RI investigation work, 148 surface and subsurface sediment samples were collected from 57 locations in the Inner and Outer Harbor, the Mill Pond, and the unnamed creek. Surface sediment grab samples were collocated with sediment cores at 10 locations to assess sediment quality and physical characteristics throughout the sediment column at surface and depth. The RI sediment sampling program included the following:

- Surface sediment grab samples collected to a depth of 10 cm bml at 43 sampling locations. A total of 48 surface sediment samples were collected (43 primary samples and 5 field duplicates).
- Sediment cores advanced to a target depth of 10 ft bml at 24 locations. A total of 100 sediment core samples were collected (91 primary samples and 9 field duplicates) to depths ranging from 2 to 10 ft bml.

Field and QC samples are summarized in Table 4-4, and details of the sampling programs and procedure are included in Appendix D.

Sediment samples were analyzed for metals (arsenic, cadmium, chromium, copper, lead, mercury, and zinc), PAHs, phenols and phthalates, and dioxin and furans. Surface sediments were also analyzed for conventional parameters with the potential to impact aquatic life including ammonia, sulfide, simultaneously extracted metals, and acid sulfides. In addition, bioassay testing was performed on 20 surface sediment samples.

4.2.7 Inadvertent Discovery Plan

Archaeological monitoring was conducted as outlined in Appendix A of the Work Plan (Geosyntec, 2022), Section 2.6 of Work Plan Addendum (Geosyntec, 2023a), and FCR-001 (Geosyntec, 2023c).

An archaeological excavation permit (per RCW 27.53) was obtained from DAHP prior to ground disturbing activities conducted within the boundaries of archaeological site 45KP110. A licensed archaeologist was on-site during upland sampling and on-call during in-water sampling. No historical or culturally relevant artifacts were found during RI field activities.

4.2.8 Field Quality Assurance

A record of all field surveys and procedures was maintained, which included sampling locations, sample depths, sampling methods, sample handling procedures, preservation methods, and storage procedures. Dates and times of collection, preservation methods, and storage procedures were recorded in daily field logs or sampling logs, along with notable field circumstances affecting sampling procedures. Visual assessments of wood debris and other substrate conditions were documented in the designated field forms per Section 4 of the Work Plan (Geosyntec, 2022). A summary of these records is included in Appendix D.

Field QA/QC samples were collected in accordance with the sampling programs detailed in Appendix A of the Work Plan (Geosyntec, 2022), Section 2.4 of the Work Plan Addendum (Geosyntec, 2023a), and FCR-001 (Geosyntec, 2023c). Field QA/QC samples included the following:

- Field duplicates were collected to assess variability within samples. Field duplicates (collected as field splits of homogenized sample material) were collected from at least 5% of the samples. A total of 40 field duplicates were collected during the RI sampling program (Table 4-4).
- Equipment rinsate blanks were collected to assess inadvertent introduction of chemical contaminants during sampling and analytical activities. Rinsate blanks consisted of aqueous sampling equipment rinsates generated once for each sampling event (the methodology is described in Appendix D). Analytical parameters tested in rinsate blanks varied per matrix and sampling event. A total of 17 rinsate blanks were collected during the RI sampling programs (Table 4-4).

Analytical results of field duplicates and rinsate blanks were utilized in the data quality evaluation discussed in Section 6.5.

4.2.9 Investigation-Derived Waste Disposal

Investigation-derived waste generated during the field effort consisted of decontamination and rinsate water, soil and sediment cuttings, and solid waste (e.g., disposable one-time-use sampling materials). The investigation-derived waste generated from the upland and sediment sampling events were temporarily stored in labeled 55-gallon drums, securely staged in the Blakely Harbor Park parking lot, and once the disposal profile was approved by the landfill, they were transported off-site for disposal as nonhazardous waste to Arlington, Oregon. Drum inventory and disposal receipts are provided in Attachment D-4. Solid waste was disposed in municipal trash dumpsters.

4.2.10 Modifications and Deviations from Work Plan

Deviations from the Work Plan and Work Plan Addendum involved modifications to proposed sampling locations, sample acceptance criteria, and number of samples collected and submitted for analysis. These field deviations did not affect data quality and usability. Deviations were as follows:

- In the SPI/PV survey: Nine[24] of the 10 proposed sampling locations were surveyed, and images were collected at two additional stations not included in the original scope.[25]
- During the Phase 1 surface soil sampling:
  - Four sampling locations (HA-01, HA-04, HA-08, and HA-12) were moved more than 10 ft from proposed locations because of limited access due to heavy and dense vegetation.
  - A sample was not collected at the deepest sample interval at location HA-07 due to refusal by hard substrate.
  - The Work Plan initially specified that samples collected from 1 to 2 ft bgs would be held in archive, but these samples were analyzed immediately after collection to meet analytical hold times.
  - During the Phase 1 surface sediment sampling, multiple grab subsamples were collected and composited at Mill Pond intertidal locations SG-03 and SG-04 because of poor recoveries associated with limited capacity of the sampling method (ponar).
- During the Phase 1 sediment coring:
  - Cores were not collected at locations SC-16 and SC-17 because of limited boat access to proposed location and hard substrate limited recovery during attempts at nearby locations.
  - A core was collected at an alternative sampling location more than 50 ft from proposed location SC-12 because of limited boat access and refusal due to hard substrate. The collected samples were considered useable for horizontal and vertical delineation of nature and extent.
  - Cores were collected at multiple locations where acceptability criteria were not fulfilled because of shallow refusal and/or poor core recovery (SC-04, SC-05, SC-07, SC-12, SC-14, SC-24, SC-27, SC-32, SC-34, and SC-38).
- During the timber pile sampling:
  - Deeper sample material was not available for archive sample collection because of limited penetration through the timber piles.
  - A 4-point composite instead of a 5-point composite was collected in area PS-05, which included submerged piles within the Inner Harbor; the divers could not collect the sample because of access limitations.

[24] Planned station (Station 128) was not safely accessible for the field staff because of muddy, soft substrate and overlying water.
[25] Two additional stations (Stations 133 and 134) were added by the field team to collect additional images of wood debris observed in surface sediments at those locations.

- During the Phase 2 surface soil sampling, a sample was not collected at the deepest sample interval at multiple locations (HA-33, HA-34, and HA-36) where refusal was encountered before the target depth was reached because of hard substrate.
- During the Phase 2 surface sediment sampling, a sample was collected at an alternative location moved about 93 ft from the proposed sampling location because of poor recoveries and hard sediment substrate.
- During the Phase 2 sediment coring:
  - Cores were not collected at locations SC-16 and SC-50 due to limited boat access to the proposed locations and hard substrate limiting recovery during attempts at nearby locations.
  - Cores were collected at SC-17, SC-49, SC-51, SC-52, and SC-53 despite the acceptability criteria not being fulfilled due to both refusal before target depth and poor core recovery.
- During the Phase 2 sampling, 10 water samples, including 5 equipment blanks and 5 groundwater samples, were re-analyzed for dioxin/furans due to laboratory blank contamination.
- During Phase 3 surface soil sampling:
  - One alternative location (HA-50b) was sampled after multiple sampling attempts encountered refusal at location HA-50.
  - Refusal was encountered at multiple locations before the target depth was reached (HA-37, HA-46, HA-50b, and HA-51).

Additional details on deviations from the Work Plan and Work Plan Addendum are provided in Appendix D.

5. SITE SCREENING LEVELS, COPCS, AND COCS

The following sections discuss the site SLs and the SL refinement process for the RI dataset. A multi-step statistical approach was used to select refined SLs. This section also discusses the identification of site COPCs and the use of the refined SLs to identify site COCs. The process discussed in the following sections is depicted in Figure 5-1a and Figure 5-1b.

5.1 RI Dataset

The RI dataset includes soil, groundwater, sediment, and piling data collected from 2019 to 2023). The RI dataset includes 164 soil samples, 21 groundwater samples, 134 sediment samples, and 5 composite piling scrape samples (primary samples, not including duplicates) (Table 4-4). Summary statistics (i.e., number of samples, detection frequency, mean, median, 90th percentile, and maximum concentrations) are presented in Tables 5-1, 5-2, and 5-3 for soil, groundwater, and sediment respectively. Results of piling scrape samples are discussed in Appendix K. The RI soil, groundwater, and sediment dataset was used to refine the COPCs and determine site-related COCs.

5.2 Data Summations and Treatment

Data handling conventions, summations, and calculations for the RI dataset are described in detail in Appendix P and summarized below for specific chemical groups.

5.2.1 Total Carcinogenic PAH TEQ Calculation

The total carcinogenic polycyclic aromatic hydrocarbon (cPAH) TEQ was calculated for each sample in accordance with Ecology Implementation Memorandum Number 10 (Ecology, 2015a). A toxicity equivalency factor (TEF) was applied to individual cPAHs,[26] then summed to calculate total cPAH TEQs.[27] For individual cPAHs that were not detected in a sample, the TEF was applied to one-half the method detection limit (MDL)/practical quantitation limit (PQL) and included in the summation. For those instances where individual cPAHs were not detected in a sample, no total cPAH TEQ was calculated and the maximum MDL/PQL among the individual chemicals was selected to represent the sample and qualified as not detected.

5.2.2 Total TCDD TEQ Calculation for Dioxins/Furans

Total dioxins/furans are expressed as total 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) based on the TEQ. Total TCDD TEQs were calculated in accordance with Ecology implementation memoranda #11 (Ecology, 2015b) and #13 (Ecology, 2016). Development of the total TCDD TEQs concentrations within a sample incorporate a TEF specific to each congener and are then summed to calculate the total TCDD TEQ for each sample. Both mammalian and avian-based TEQs were calculated, and the mammalian-based TEQ was sufficiently protective of avian

[26] PAHs included in the total cPAH TEQ are benzo(a)pyrene, benzo(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, dibenz(a,h)anthracene, and indeno(1,2,3-cd)pyrene.

[27] Since benzo(a)pyrene concentrations detected in soil samples exceeded the preliminary SL, the development of the cPAHs utilizing the relative mobility factor (RMF) was not performed. The TEF and RMF for benzo(a)pyrene is 1; therefore, the cPAH TEQs with the TEF and RMF applied would also exceed the preliminary SL that is based on leaching to groundwater.

receptors. Therefore, the mammalian TEQs were used in the screening processes. For individual congeners that were not detected in a sample, the TEF was applied to one-half the MDL/PQL and included in the summation. The results are also shown using the MDL/PQL equal to zero for reference. For those instances where the individual congeners were not detected in a sample, the maximum MDL/PQL among individual congener results was selected to represent the sample and qualified as not detected (see details in Appendix P).

5.2.3 Organic Carbon Normalization of Sediment Results

Before sediment analytical results were compared to the SLs, non-polar organic chemicals were converted to an organic carbon (OC)-normalized concentration using the TOC concentration within a sample for comparison to SMS marine criteria (benthic Sediment Cleanup Objectives [SCOs]). OC-normalization accounts for the bioavailability of organics in sediment; however, this relationship is best suited for sediment samples within a "normal" TOC range of 0.5% up to 3.5% (Ecology, 2021). For those samples with a TOC greater than 3.5% or less than 0.5%, the OC-normalized concentration for non-polar contaminants was presented for informational purposes; however, the dry weight (dw) concentrations were compared to the relevant SL (i.e., apparent effects thresholds or natural background [NB]) for identification of COCs.

5.2.4 Treatment of Duplicates for COPC and COC Screening

Duplicate samples collected for QC purposes are presented separately in the data summary tables (Appendix M), but a single value for the pair was selected for evaluation in the RI using the maximum detected or the maximum MDL/PQL.

5.3 Screening Levels

Preliminary SLs were first presented in Section 4.2 of the Work Plan (Geosyntec, 2022) and further developed in Appendix B of the Work Plan Addendum (Geosyntec, 2023a) to incorporate additional risk-based SLs and updated Ecology values. The literature and regulatory sources for these values and the selection of SLs were presented in Appendix B to the Work Plan Addendum, and these values are further refined in this section. In summary, the soil and groundwater SLs used in this RI are the lowest applicable value among risk-based direct contact/ingestion (MTCA Method A/B), ecologically based SLs (soil only), or soil leaching-based values (soil only). If the lowest applicable SLs were below NB, then the NB value was selected as the SL if available. For soil COPCs without ecological SLs listed in WAC 173-340-900 Table 749-3, the plant, soil biota, and wildlife SLs were selected from the ecological soil screening levels (EPA, 2025), EPA Region 4 (EPA, 2018), EPA Region 5 (EPA, 2003), and the Los Alamos National Laboratory (2024). The lowest applicable value above background was selected.

For the selection of sediment SLs, if a chemical is classified as bioaccumulative, then NB was selected as the SL if available. If no NB value was available, then the lowest risk-based value was selected as the SL. For non-bioaccumulative COPCs, the lowest risk-based value was selected as the SL.

The RI dataset was screened against the most conservative screening criteria for each media, and the data summary tables and figures were submitted to Ecology in 2024 (Geosyntec, 2024).

Geosyntec reviewed the RI dataset in relation to the initial conceptual site model (CSM) presented in Section 5 of the Work Plan (Geosyntec, 2022) to determine if the SLs should be further refined. Additionally, the PQLs were reviewed to determine the average PQL, and if the average PQL was greater than the SL, the SL was revised to the average PQL.

The refined soil SLs are presented in Table 5-4a through 5-4c. The groundwater SLs are presented in Table 5-5. The sediment SLs (dw and OC-normalized) are presented in Tables 5-6a through 5-6c.[28]

The refined SLs presented in the RI were selected to be protective of risk exposure pathways (ingestion, direct contact, benthic toxicity, and bioaccumulation). The soil leaching/migration to groundwater pathway was not included because the pathway is incomplete. Metals and dioxins/furans were the only COPCs detected in site groundwater at low levels (below SLs), indicating that PAHs, phenols, and phthalates that were detected above SLs in soils are not migrating into groundwater. Metals and dioxins/furans are discussion further in Section 6.1.2.

5.4 COPCs

The COPCs identified in Section 4.3 of the Work Plan (Geosyntec, 2022) are contaminants that may be causing ecological and/or human health risk in the Study Area based on previous investigations, detection in multiple environmental media, SL exceedances, and association with historical operations. In addition, Ecology requested that certain chemicals be added as COPCs because of their presence in certain media or because more data was needed to verify historical results. In summary, the COPCs included the following chemicals:

- **Soil:** metals (arsenic, cadmium, chromium, copper, lead, mercury, and zinc), PAHs (including total cPAHs individually and based on TEQs), phenols, dioxins/furans individually and based on TEQs, TPH, and phthalates
- **Groundwater:** metals (arsenic, cadmium, chromium, copper, lead, mercury, and zinc), PAHs (including total cPAH TEQs), phenols, dioxins/furans (including total TCDD TEQs), TPH, and phthalates for protection of sediments
- **Sediment:** wood waste indicators,[29] metals (SMS metals: arsenic, cadmium, chromium, copper, lead, mercury, silver, and zinc), PAHs (including total cPAH TEQs), phenols, dioxins/furans (including total TCDD TEQs), and phthalates

[28] For sediment, the selected refined SLs are the same as the preliminary SLs, except for 2,4-dimethylphenol. The average PQL for 2,4-dimethylphenol is greater than the preliminary SL.

[29] Wood waste degradation indicators (i.e., TOC, TVS, total sulfides, ammonia, dissolved oxygen, and pH) are not included in the preliminary and refined screening process because there are no risk-based SLs available for these parameters. Instead, they are discussed in more detail in Section 6.2.

After completing RI data collection, the COPCs were further evaluated based on detection frequencies (DF), frequency of exceedance (FOE), and exceedance factors (EFs) for the RI data.[30] The maximum detected concentration of each analyte from each medium was compared to the SLs and if the maximum detected concentration exceeded the SL, then summary statistics for the COPC were reviewed (Tables 5-1, 5-2, and 5-3 for soil, groundwater, and sediment, respectively). This review included DF, FOE, 95% upper concentration limit (UCL) and maximum concentration greater than two times the SL of each COPC (similar to the MTCA 3-part rule). If the DF or FOE was greater than 5%, the COPC was identified as a COC and carried forward for additional review in the RI (Tables 5-7, 5-8, and 5-9). If the DF and FOE were less than or equal to 5%, the COPC concentrations that exceed the SL were not widely distributed and not considered major contributors to risk. As part of the risk screening, these low-detection COPCs are not considered further in the RI.

5.5 COCs

COCs are those contaminants present in the Study Area at concentrations that have been scientifically determined to pose risks to human health and the environment. Study Area COCs were identified using the results of the RI dataset and based on further refinement of the COPCs, using the screening process described in Section 5.3 The screening criteria and results (i.e., COCs) are presented in Tables 5-7, 5-8, and 5-9 for soil, groundwater, and sediment, respectively. The following COCs were identified:

- **Soil:** metals (arsenic, chromium, copper, lead, mercury, and zinc), TPH (diesel range organics [DRO] and heavy lube oils), several PAHs (except for anthracene, beta-chloronaphthalene, and low molecular weight PAHs), phenols (2,4-dimethylphenol 4-methylphenol), phthalates (bis[2-ethylhezy]phthalate, butylbenzyl phthalate, diethyl phthalate and di-n-butyl phthalate), and dioxins/furans (based on the total TCDD TEQ)
- **Groundwater:** dioxins/furans (based on the total TCDD TEQ)
- **Sediment:** metals (SMS metals: arsenic, cadmium, lead, and mercury), several PAHs (phenanthrene, benzo[g,h,i]perylene, chrysene, fluoranthene, indeno[1,2,3-c,d]pyrene, pyrene), total cPAH, phenols (phenol), phthalates (butyl benzyl phthalate), and dioxins/furans (based on the total TCDD TEQ)

The COC concentrations were compared to the refined SLs to identify the final list of COCs. The final COCs are presented in Tables 5-10 and 5-11 for soil and groundwater, respectively, and Table 5-9 for sediment,[31] and are as follows:

[30] The three-part MTCA rule was used as the basis for setting decision criteria based on detection frequency, frequency of exceedance, and exceedance factor (WAC 173-340-720(9) for groundwater compliance; WAC 173-340-740(7) for unrestricted soil compliance).

[31] Table 5-9 summarizes the sediment screening using the preliminary SLs, and the refined SLs were unchanged except for one chemical that did not impact the results of the screening, so Table 5-9 applies for both preliminary and refined SLs.

- **Soil:** metals (arsenic, chromium, copper, lead, mercury, and zinc), TPH (DRO and lube oil), PAHs (benzo(a)pyrene, dibenzofuran, high molecular weight PAHs (HPAHs) and total cPAHs, phenols (4-methylphenol), phthalates bis(2-ethylhexyl)phthalate, and di-n-butyl phthalate) and dioxins/furans (based on the total TCDD TEQ)[32]
- **Groundwater:** No COCs above refined SLs
- **Sediment:** metals (SMS metals: arsenic, cadmium, lead, and mercury), PAHs (phenanthrene, benzo[g,h,i]perylene, chrysene, fluoranthene, indeno[1,2,3-c,d]pyrene, pyrene), total cPAH based on the TEQ, organics/phenols (phenol), phthalates (butyl benzyl phthalate), and dioxins/furans (individually and based on the TEQ)

The COCs for each media are retained for further analysis in the RI, including an analysis of the nature and extent of contamination (Section 6) and evaluation in the risk screening for receptor-specific risk evaluation (Section 7).

[32] As part of the site-specific Terrestrial Ecological Evaluation (TEE) process, the identification of COCs was inclusive of identification of chemicals of ecological concern for which risk was characterized in Section 7.5.

6. NATURE AND EXTENT OF CONTAMINATION

The results of the RI sampling effort were used to determine the nature and extent of contamination in soil, groundwater, and sediment. The data collection DQOs are presented in Table 9 of the RI/FS Work Plan (Geosyntec, 2022). This section presents the horizontal and vertical extent of COCs (Section 6.1), extent of wood waste (Section 6.2), assessment of benthic infauna (Section 6.3) and results of the bioassay studies (Sections 6.4); summarizes the data quality reviews (Sections 6.5 and 6.6); identifies the RI boundary based on review of the step-out data and exceedances of SLs (Section 6.7); and interpolates the spatial distribution of COCs (Section 6.8).

6.1 Nature and Extent of Contamination

Contaminants in soil, groundwater, and sediment have been characterized using the analytical methods summarized in the SAP and quality assurance project plan (QAPP), Appendix A to the RI/FS Work Plan (Geosyntec, 2022). Following the first phase of sampling in 2021 and evaluation of results, additional samples were collected from step-out soil and sediment sample locations in 2022 to provide additional data for delineation. Overall, DQOs have been met (Sections 6.4 and 6.5), and the nature and extent of contamination in soil, groundwater, and sediment have been sufficiently delineated for the RI. Additional data will be collected during the FS to inform the selection of remedial technologies or after the remedial action is selected to inform the remedial design.

In this section, the nature and extent of Study Area contamination of metals, PAHs, phenols, TPH, phthalates, and dioxins/furans is discussed for each medium and portion of the Study Area using the RI dataset. For soil, the discussion is separated into the north upland area and the south upland area. Groundwater is treated as a single area, and sediment is discussed as three areas: the Inner Harbor, the Outer Harbor, and the former Mill Pond.

Generally, contamination is associated with the former Mill footprint, building debris, and fill materials present from ground surface to approximately 8 to 14 ft bgs in soil, 1 to 4 ft bml in sediment, and up to 10 ft depth in sediment cores in the high intertidal Inner Harbor area (see Table J-3 of Appendix J). Soil borings drilled through the fill units reached native soil at approximately 9 to 17 ft bgs, and sediment cores reached native material at approximately 2 to 4 ft bml, with corresponding chemical concentrations below SLs at these deeper depths in native material. Groundwater data were below refined SLs.

6.1.1 Soil Results

The extent of COCs in the Study Area soil was evaluated using a combination of concentration mapping, statistical analysis, and distribution comparisons. Soil COC concentration maps are presented as Figures 6-1 through 6-16. Statistical analysis was performed for a subset of chemicals to evaluate step-out sample concentrations compared to sample concentrations near historical

sources (i.e., from Mill operations). The statistical analyses[33] are provided in Section 7 for lead, copper, total cPAH TEQ, and total TCDD TEQ. Distribution comparisons were not developed for other COCs since they fall within the footprints of other COCs (primarily total cPAH, HPAH, and dioxins/furans). Instead, the average concentrations in the farthest step-out samples were compared to the next closest samples (next-in samples).[34] The concentration distributions in soil for the COCs are discussed in the following sections.

6.1.1.1 Metals

The highest concentrations of metals were detected in the locations associated with the historical Mill structures on the north upland area around the former sawmill and former foundry, blacksmithing, and machine shops and especially near observed slag piles. Concentrations decreased moving farther north, east, and west. Concentrations for each metal varied with depth, with higher concentrations located in subsurface soil between 2 ft and 6 ft bgs; however, elevated concentrations of arsenic, copper, and lead were detected above the refined SLs in both surface and subsurface soil near the former sawmill, machine shop, and slag piles. Below are descriptions of metal concentrations found in the Study Area:

- Arsenic was detected in 159 of 159 soil samples with 50% exceeding the NB-based refined SL (7 mg/kg). Two samples in the northern upland and five in the southern upland had concentrations that exceeded the refined SL with EFs between approximately 1 and 2. Arsenic in four borings (SB-17, SB-20, SB-22, and SB-23) exceeded the refined SL with an EF less than 2. Due to the low EFs, horizontal and vertical delineation has been achieved for arsenic in site soil, with one exception. Arsenic was detected in the deepest sample from location HA-13 (north upland area) at a concentration of 43.3 mg/kg. Because the concentrations in samples collected in the surrounding locations were below the refined SL, including those at depth, the area around HA-13 was delineated vertically.
- Chromium was detected in 159 of 159 soil samples with 14% exceeding the plant-based refined SL (48 mg/kg). Step-out sample concentrations and samples at depth were below the refined SL with five exceptions:
  - Concentrations in HA-35 exceeded the refined SL, but no additional samples were collected to the east of these exceedances because the ground surface was altered during residential property development. As a result, the boundary of the residential development is the RI boundary in this area.
  - Concentrations in HA-38, HA-46, and HA-52 exceeded the refined SL with EFs less than 2.

[33] The step-out sample locations selected for comparison to the remaining north upland area data include HA-38, HA-39, HA-40, HA-41, HA-44, and HA-52 (12 samples total). The step-out sample locations selected for comparison to the remaining south upland area data include HA-36 HA-42, HA-43, and HA-47 (seven samples total).
[34] The next closest sample locations (i.e., step-in samples) include HA-07, HA-31, HA-32, HA-33, HA-34, and HA-51 (nine samples total).

  - A result from one boring (SB-18) exceeded the refined SL at depth with an EF less than 2.
  - Due to the low EFs, horizontal and vertical delineation has been achieved for chromium in site soil based on total chromium concentrations.
  - Soil samples collected as part of the Phase 1 and Phase 2 investigations were analyzed for hexavalent chromium, but the data were rejected due to expiration of the hold times. Results of the 19 soil samples tested for hexavalent chromium were not detected at the method reporting limits (0.489 to 7.39 mg/kg; which is well below the SL of 19 mg/kg for hexavalent chromium). The data validation rules require a rejection flag for results showing no detections; however, validation would have applied an estimated flag had hexavalent chromium been detected (further discussed in Section 6.5).

- Copper was detected in 154 of 154 soil samples, with 66% exceeding the NB-based refined SL (50 mg/kg). Concentrations from step-out samples and at depth were below the refined SL, with five exceptions:
  - Copper was detected above the refined SL in samples from HA-16, HA-35, and HA-49, but no additional samples were collected to the east of these exceedances because the ground surface was altered during residential property development. As a result, the boundary of the residential development is the RI boundary in this area.
  - Copper concentrations in HA-02 and HA-52 also exceeded the refined SL, with EFs less than 2. Copper results from multiple borings exceeded the refined SL at depth and had EFs between 1 and 2. Based on the low EFs, the horizontal and vertical delineation has been achieved for copper in Study Area soil.
- Lead was detected in 159 of 159 soil samples, with 45% exceeding the plant-based refined SL (50 mg/kg). Two step-out samples (HA-02 and HA-42) in the southern upland exceeded the refined SL with EFs between 1 and 4. Eastern step-out sample concentrations were below the refined SL except at HA-16, HA-35, and HA-49. No additional samples were collected to the east of these exceedances because the ground surface was altered during residential property development. As a result, the boundary of the residential development is the RI boundary in the southeastern area of the Study Area. In the northern upland area, the deepest sample from SB-22 exceeded the refined SL with an EF of approximately 2. Therefore, based on the low EFs, horizontal and vertical delineation has been achieved for lead in soil.
- Mercury was detected in 129 of 147 soil samples, with 25% exceeding the soil biota-based refined SL (0.1 mg/kg). One northern step-out sample concentration exceeded the refined SL (HA-40) with an EF of 2.2. The greatest exceedance was at HA-02, near the former steam dry kilns/lumber shed/planing Mill in the south upland area, with a concentration of 22 mg/kg at 1 to 2 ft bgs. Since other soil borings showed declining concentrations when native soil was encountered (9 to 17 ft), and adjacent borings did not exceed the refined SL, horizontal and vertical delineation has been achieved for mercury in Study Area soil.

- Zinc was detected in 154 of 154 soil samples with 59% exceeding the plant-based refined SL (86 mg/kg). Five step-out samples from the northern upland area (HA-38, HA-39, HA-40, HA-44, and HA-52) and three from the southern upland area (HA-02, HA-42, and HA-46) had concentrations that exceeded the refined SL, with EFs between 1 and 2. In addition, concentrations in HA-16, HA-35, and HA-49 exceeded the refined SL, but no additional samples were collected to the east of these exceedances because the ground surface was altered during residential property development. As a result, the boundary of the residential development is the RI boundary in this area. Zinc was detected in multiple soil borings above the refined SL with EFs between 1 and 2. One exception was SB-22, with an EF of 10; however, nearby locations at similar depths were below the refined SL. Based on the low EFs, horizontal and vertical delineation has been achieved for zinc in Study Area soil.

6.1.1.2 Polycyclic Aromatic Hydrocarbons

The highest concentrations of PAHs were detected in the areas associated with the historical structures (i.e., around the former sawmill, machine shop, hog fuel burner, and refuse burn areas) located on the north upland area peninsula and south of Northeast Blakely Avenue. Concentrations in the south upland area decreased in samples farther from the historical structures. Concentrations of PAHs varied based on depth; the highest concentrations were detected in subsurface soil at depths ranging from 2 ft to 6 ft bgs. Except for boring SB-22, the deepest samples from each boring were below refined SLs. Overall, concentrations for PAHs were delineated horizontally and vertically in Study Area soil based on comparison to the refined SLs.

Concentrations of total cPAH TEQ were detected in 141 of 159 soil samples, with 35% exceeding the refined SL (100 micrograms per kilogram [µg/kg]), including step-out samples collected in the southern (HA-02 and HA-46) and eastern (HA-15) upland areas and at depth (SB-22). The EFs for HA-02 and HA-15 were between 1 and 2. Decreases in concentrations nearby at HA-46 and SB-22 at similar depths indicate the exceedances are relatively localized. Therefore, horizontal and vertical delineation is complete for total cPAHs in Study Area soil.

Concentrations of HPAH were detected in 149 of 159 (94%) soil samples with 41 (26%) exceeding the refined SL (1,100 µg/kg), while concentrations of dibenzofuran were detected in 54 of 154 (35%) soil samples, with 9 (6%) exceeding the refined SL (150 µg/kg). These exceedances were collocated with the total cPAH TEQ exceedances. Therefore, horizontal and vertical delineation is complete for HPAHs and dibenzofuran in Study Area soil.

6.1.1.3 Other Organics

TPHs (i.e., diesel range organics and lube oil range) were identified as COCs (Section 5). The sum of diesel and lube oil range TPH concentrations exceeded the soil biota-based refined SL (260 mg/kg) in 29 of 145 soil samples. The samples with the highest EFs were located in the northern upland area (i.e., around the former sawmill) at SB-19 (0–2 and 2–6 ft bgs) and SB-24 (0–4 ft bgs). Samples with exceedances were bounded spatially by concentrations below the SL. Therefore, delineation has been achieved for TPHs.

4-Methylphenol was identified as a COC for soil (Section 5). Concentrations of 4-methylphenol were detected in 27 of 156 soil samples with 6% exceeding the refined SL (80 µg/kg). Concentrations above the SL were at depth (8 to 15 ft bgs) and were distributed across the Study Area in the fill unit. 4-methylphenol concentrations below the refined SL declined as sample locations moved farther away from the former structures. The highest concentration was at SB-28 (north of the former sawmill) at 12 to 14 ft bgs. The 4-methylphenol concentrations were well below the refined SL in step-out samples to the north, where they ranged from 1.2 to 12.5 µg/kg. Therefore, horizontal and vertical delineation is complete for 4-methylphenol in Study Area soil.

Phthalates (bis(2-ethylhexyl)phthalate and di-n-butyl phthalate) were identified as COCs for soil (Section 5); however, historical Mill activities were not the likely source of phthalates based on historical Mill operations and uses. Because it is not a site-related COC, phthalates alone would not drive cleanup, however, the cleanup would need to be inclusive of this COC. The highest bis(2-ethylhexyl)phthalate concentrations were at HA-16 and SB-19. These are in close proximity to the former machine shop/blacksmith and the former sawmill, respectively. Concentrations of bis(2-ethylhexyl)phthalate were detected in 48 of 156 soil samples, with 5% exceeding the refined SL (80 µg/kg) and concentrations of di-n-butyl phthalate were detected in 14 of 156 soil samples, with 5% exceeding the refined SL (32 µg/kg).

Samples with concentrations of bis(2-ethylhexyl)phthalate above the refined SL are bounded (vertically and horizontally) by samples with concentrations below the refined SL, and the boundary of the residential development (west of HA-16) is the RI boundary because soils were altered during redevelopment. Samples with concentrations of di-n-butyl phthalate above the refined SL are bounded (vertically and horizontally) by concentrations below the refined SL. Therefore, horizontal and vertical delineation is complete for these two phthalates in Study Area soil.

6.1.1.4 Dioxins/Furans

The highest concentrations of dioxins/furans (based on the total TCDD TEQ) were detected in the footprint of and north of the former sawmill on the north upland area peninsula and south of Northeast Blakely Avenue. Concentrations decreased moving farther north and generally correspond to the same concentration gradients as PAHs and metals (highest concentrations observed near the former hog fuel burner, foundry, and primary Mill structure). The highest concentrations of dioxins/furans were in subsurface soil (4 to 12 ft bgs), but generally concentrations decreased with depth. Overall, concentrations of dioxins/furans are delineated horizontally and vertically in Study Area soil.

TCDD TEQ sample concentrations exceeded the NB-based refined SL (5.21 ng/kg) in 82 of 164 (50%) of soil samples. Results from the step-out samples were above the refined SL with EFs less than 2 except for HA-16, HA-35, and HA-49 (25.6, 26.6, and 19.9 ng/kg, respectively). No additional samples were collected to the east of these exceedances because the ground surface to the east was altered during residential property development. The boundary of the residential development is the southern and eastern RI boundary because soils at the adjoining residential properties were disturbed (e.g., excavated and graded) during redevelopment. In the north upland area, the TCDD TEQ in one boring (SB-22) at depth exceeded the refined SL; however,

concentration decreases in nearby samples at similar depths, which indicate the exceedances are localized. Therefore, horizontal and vertical delineation in soil is complete for dioxins/furans based on the total TCDD TEQ.

6.1.2 Groundwater Results

Between September 2020 and August 2021, 26 groundwater samples, including five duplicates, were collected during Phases 1, 2, and 3 of the RI. Grab samples were collected from four temporary wells in 2021; four permanent groundwater monitoring wells were installed on the north upland area and sampled over four consecutive quarters in 2022 and 2023.

Groundwater field parameters measured during purging of the four monitoring wells were variable across the Study Area and across seasons. Notable observations from the parameters were as follows:

- Generally, groundwater parameters indicated oxygenating conditions, based on positive dissolved oxygen and redox potential, except at monitoring well GW-24 where these positive conditions were only measured in the spring event (April). GW-24 is located adjacent to the former Mill Pond.
- Turbidity increased during January and April at monitoring wells GW-27 and GW-29, and turbidity at monitoring wells GW-24 and GW-26 was consistent over the four quarters monitored.
- Conductivity and salinity were relatively low in the winter and spring, and salinity was less than the average seawater salinity of 25‰ except during the summer (August) monitoring event. Temperature also increased during the summer event. Combined, these measurements possibly indicate less groundwater recharge and more influx of seawater during the summer.
- There was very little seasonal water level variability (an average 1–2 ft elevation change at each well). Sampling was completed during low tide (as targeted).

Combined, these results indicate variable redox conditions across seasons with relatively stable water levels. The exchange between seawater and groundwater is a dynamic system. Sampling was conducted at low tide because that is when the most upland groundwater is discharging to the Harbor and also when there is the lowest potential tidal dilution.

Given the amount of time that has passed since Mill closure, concentrations in soil and groundwater have reached equilibrium. It is possible that there could be more flushing during uncommon high tides (e.g., king tides) when water levels rise higher into the vadose zone soil, but this could also result in more dilution. To further evaluate potential impact to groundwater from soil, monitoring wells were screened in intervals with elevated soil concentrations, since there is the potential for soil contaminants to desorb into groundwater.

Total and dissolved metals were detected in all groundwater monitoring events, but metals concentrations were below the refined SLs, except total chromium concentrations. Total chromium concentrations exceeded the refined SL at well GW-27 three times and at well GW-29 once, in

unfiltered groundwater samples. Chromium concentration exceedances at GW-27 occurred in January, April, and August 2023 when turbidity ranged from 9 to 30 Nephelometric turbidity units and at GW-29 in January 2023 when turbidity was 34 Nephelometric turbidity units.

However, dissolved phase (filtered) chromium concentrations were less than the refined SL in all wells during all sampling events. Based on these results, the total chromium concentrations that exceeded the SL are due to material sorbed onto solids present in the unfiltered groundwater samples.

Chromium concentrations in soil samples collected from well screen depths were lower (12 to 38 mg/kg) in wells GW-24 and GW-26 and higher (39 to 51 mg/kg) in wells GW-27 and GW-29. These soil data further confirm that chromium sorbing onto soil particulates is the cause of the total chromium exceedances; dissolved phase chromium was not present in groundwater at concentrations above SLs.

PAHs were not detected in groundwater samples, and the MDLs/PQLs were below the refined SL except for benzo(a)pyrene and the total cPAH TEQ. One benzo(a)pyrene MDL/PQL (0.17 µg/L) was greater than the refined SL (0.12 µg/L), but this was a duplicate sample and the parent MDL/PQL (0.06 µg/L) was below the refined SL. There were three cPAH TEQ MDLs/PQLs above the refined SL; however, this parameter is based on individual chemical results that were used to determine the presence of PAHs in Study Area groundwater. Given that individual PAHs were not detected and MDLs/PQLs were below the refined SLs (with the exceptions noted above), it is unlikely that PAHs are present in Study Area groundwater. Therefore, the migration to groundwater exposure pathway for PAHs is incomplete.

Other organic classes of contaminants (i.e., semi-volatiles, phenols, petroleum hydrocarbons, and phthalates) were not detected in groundwater with the exception of one detection each of TPHs, bis(2-ethyhexyl)phthalate, and diethyl phthalate. The detected concentration and MDLs/PQLs for non-detected analytes were all below refined SLs. Total TCDD TEQ concentrations were below the refined SL.

The results indicate there are no impacts to groundwater within the Study Area above the refined SLs.

6.1.3 Sediment Results

The extent of COCs in sediment was evaluated using a combination of concentration mapping and distribution comparison (Figures 6-1 through 6-16). Average concentrations at the eastern step-out samples[35] were compared to the next-in samples[36] for the distribution comparison. The concentration distributions in sediment for the COCs are discussed in the following sections.

[35] The selected step-out sediment samples included were BH2-30, BH2-33, BH2-35, BH2-39, BH2-40, SG-55, SG-56, and SG-57.
[36] The next closest sediment (step-in) samples included were BH2-34, BH2-38, SG-28, SG-30, SG-37, SG-42, SG-53, and SG-54.

6.1.3.1 Metals

The highest concentrations of metals were detected in the locations associated with the historical wharf structure in the Inner Harbor, near the former sawmill and former machine shop structures in the north upland area. Concentrations in the Inner Harbor decrease in samples collected farther south and east from the former wharf near the northern peninsula. Concentrations detected in the former Mill Pond and Outer Harbor were lower than in the Inner Harbor. Metals concentrations in the Inner Harbor near the northern peninsula were greatest in subsurface sediment between 3 to 6 ft bml; metals concentrations in the former Mill Pond and Outer Harbor were greatest in surface sediment (i.e., top 10 cm) and decreased with depth. Overall, concentrations for metals are delineated horizontally and vertically in Study Area sediment based on comparison to the refined SLs. Additional discussion of the individual metals follows:

- Arsenic was detected in 180 of 180 sediment samples, with 28% exceeding the NB-based refined SL (11 mg/kg). These exceedances were bounded by samples below the refined SL with the exception of SC-21 and SG-43. The two deepest samples at SC-21 were preceded by samples below the refined SL, and their EFs were less than 2. SG-43 had a slight exceedance (11.6 mg/kg) of the refined SL (11 mg/kg) with an EF of 1.1.
- Cadmium was detected in 180 of 180 sediment samples, with 19% exceeding the NB-based refined SL (0.8 mg/kg). At SG-56 in the northeast Outer Harbor, the parent sample concentration was above the refined SL; however, the concentration in the duplicate was below the refined SL (as was the average of 0.71 mg/kg). The concentration of the deepest sample in SC-11 exceeded the refined SL, but this sample was collected from shallower depth and nearby samples were below the refined SL.
- Lead was detected in 180 of 180 sediment samples, with 58% above the NB-based refined SL (21 mg/kg). Lead concentrations exceeded the refined SL in two surface sediment step-out samples collected at the eastern portion of the Outer Harbor, with EFs of 8 for the SG-56 sample and 1.1 for the SG-57 sample.
- Mercury was detected in 180 of 180 sediment samples, with 24% exceeding the NB-based refined SL (0.2 mg/kg). Mercury concentrations in two of two samples from location SG-56 in the northeast Outer Harbor were above the refined SL; the primary sample had an EF of 3 and the duplicate sample had an EF of 1.4.

Out of the 89 surface sediment samples collected, arsenic and cadmium did not exceed the benthic SCO, and lead and mercury exceeded their respective SCO in 4% and 12% of samples near the slag piles (except mercury in single Outer Harbor location attributed to historical Outer Harbor uses that were not related to and unaffiliated with the former Mill).

6.1.3.2 Polycyclic Aromatic Hydrocarbons

The highest concentrations of low molecular weight (LMW) PAHs (LPAHs) and HPAHs in sediment were detected in the Inner Harbor near the former sawmill and former machine shop structures. Concentrations in the Inner Harbor decreased moving farther from the former wharf near the northern peninsula. Concentrations in the former Mill Pond and Outer Harbor were lower than the Inner Harbor. Concentrations of LPAH and HPAHs in the Inner Harbor near the northern

peninsula were greatest in surface sediment (top 10 cm), concentrations decreased in samples collected below surface sediments (deeper than 10 cm).

Total cPAH TEQ exceeded the NB-based refined SL (21 µg/kg) in 124 of 180 (69%) of sediment samples. Concentrations were greater in the northern half of the former Mill Pond, Inner Harbor, or Outer Harbor (i.e., closer to historical wharf structure). Total cPAH TEQ concentrations were greatest in surface sediment with relatively high concentrations in the top 3 ft bml near the northern peninsula in the Inner Harbor and sharp decreases in concentrations with depth. Total cPAH TEQ concentrations in the former Mill Pond and Outer Harbor were greatest in surface sediment (top 10 cm), concentrations decreased in samples collected below surface sediments (deeper than 10 cm).

6.1.3.3 Other Organics

Other organic chemical classes with identified COCs, including phenols and phthalates, had lower DFs compared to PAHs including a 71% DF for phenol and 17% DF of butyl benzyl phthalate. The FOEs of these COCs in these chemical classes ranged between 6 and 10%. The highest concentrations of phenol and butyl benzyl phthalate (indicators for other chemicals in these classes) were sporadically detected in the Inner Harbor near the former sawmill structure but concentrations generally decreased in samples farther out in the harbor. Spatial distribution patterns were generally similar to other COCs (e.g., PAHs) with the highest concentrations above refined SLs in the upper 3 ft of sediment. Exceedances were delineated both horizontally and vertically with one exception at location SC-11. The intertidal core (SC-11) located closest to the shoreline had 2-methylphenol and benzoic acid exceedances in the bottom sample at 8 to 10 ft depth. This sample was described as containing large dimensional lumber. The surrounding borings achieved vertical delineation or had concentrations below SLs at depth. Therefore, for RI purposes, delineation has been achieved for these COCs.

6.1.3.4 Dioxins/Furans

Total TCDD TEQ exceeded the NB-based refined SL (5.4 ng/kg) in 65 of 133 (49%) of sediment samples. The highest total TCDD TEQ surface concentrations were located in the Inner Harbor shallow intertidal area south of the former sawmill structure and peninsula at locations SG-09, SG-10, and SG-11. Inner Harbor concentrations decreased to the southeast, and concentrations in the former Mill Pond and Outer Harbor were lower than the Inner Harbor. Total TCDD TEQs in the Inner Harbor were higher from surface sediment to approximately 6 ft bml. The two highest subsurface concentrations were at depth (SC-14 and SC-34) located outside the former wharf footprint near the edge of the Inner Harbor, but concentrations decreased substantially below the top 3 ft bml. Overall, exceedances were bounded by samples below the refined SL; therefore, horizontal and vertical delineation was achieved.

6.2 Extent of Wood Waste

Large volumes of wood can physically smother biota in surface sediment if present in large enough volumes, or it can cause increased biological growth, resulting in decreased dissolved oxygen and the increased production of sulfide, ammonia, and phenols, which can impact sediment and surface water quality (Ecology, 2013b). Smaller particles (e.g., sawdust) with more surface area can degrade more rapidly. Sulfide, ammonia, and phenols are considered indicators of wood

degradation and including TOC and TVS, are discussed below in Section 7. Because of the large volume of wood in the Study Area (e.g., logs, pulp fibers, bark, ash, saw dust, dimensional lumber), the RI included a systematic field effort to map and quantify the wood. The survey scope, results, and conclusions are discussed in detail in Appendix J. Detailed field observations on discrete sediment and soil samples are reported in Appendix D.

6.2.1 Wood Waste Characteristics

Wood was observed in approximately 74% of field screened soil samples (77 hand auger samples; values ranging between 0 and 85%, mean of 15%, and median of 5%). Wood was described as roots or rootlets in 48% of logged samples, as small fibers with different degrees of weathering in approximately 12% of logged samples, and as fragments, woodchips, and scraps of what appeared to be weathered hardwood or bark in about 11% of logged samples (see Appendix D, Table D-3). Wood waste was observed in about 80% of field screened sediment samples (13 surface and subsurface samples; values ranging between 0 and 90%, mean of 19%, and median of 10%). Wood was described as small fibers with different degrees of weathering in about 50% of logged samples and as fragments, woodchips, scraps of what appeared to be weathered hardwood or bark in about 30% of logged samples (see Appendix D, Table D-5 and D-6b).

The presence of the marine sulfur-oxidizing bacteria *Beggiatoa*, historically an indicator of organic enrichment and wood decay at impacted sediment sites, was observed during a historical environmental investigation conducted in 2008 (Anchor 2009). *Beggiatoa* was observed during the shoreline survey conducted in 2021 at two seep locations (BH_SEEP_02 and BH_SEEP_03) out of the 10 seep locations identified along the northern and southern shorelines of the Inner Harbor and the former Mill Pond (see Figure H-2). *Beggiatoa* was described as a white filamentous mat (see photologs in Appendix H, Attachment H-1).

6.2.2 Wood Waste Extent

Wood was observed at depth in the soil fill unit within the footprint of former Mill structures (north upland area) as shown in Figure J-5 (Appendix J). Large dimensional lumber, wood fragments, fibers, pilings, sawdust, and wood debris was observed at depths up to 6 ft bgs in historical test pits advanced in the intertidal area along the eastern shoreline of the north upland peninsula (Shannon & Wilson, 1992a). Brick fragments were also observed in the fill.

During the RI investigations, soil borings advanced in intertidal areas displayed interlaying units of wood waste at depth up to 15 ft bgs (SB-17) (soil boring logs reported in Appendix B), however, soil explorations did not encounter refusal due to wood. The vertical extent of wood waste was refined during the RI using multiple investigative tools (sample observations, drilling observations, diver probing surveys, shoreline inspections, and SPI survey). The wood-fill layer extended offshore about 300 ft towards the east to water depths of about -16 ft MLLW (Anchor, 2009; supplemented with RI data).

Abundant wood waste was observed at the sediment surface and near-surface in subtidal and intertidal areas of the former Mill Pond and Inner Harbor, corresponding to the footprint of former overwater Mill structures and the former wharf (Appendix J, Figure J-4).

Less than 10% of wood was observed in discrete sample locations along the southern shoreline, the south upland area, and the Outer Harbor. Field observations collected during the RI indicate that wood in soil and sediment was present at locations associated with former historical structures and log rafting areas.

6.3 SPI Survey: Assessment of Benthic Infauna

Wood waste can have both physical and chemical impacts on the benthic communities if it is present at sufficient volumes (Ecology, 2013b). Wood waste may smother established benthic organisms by impairing settlement on the sediment surface or burrowing into the substrate. In addition, as wood waste decays, increasing aerobic microbial metabolism can drain oxygen from the pore water and potentially the water overlying the sediment

Multiple parameters were evaluated during the SPI/PV survey to determine whether wood waste in Blakely Harbor sediment affects the quality of the benthic habitat and the associated infaunal community. The SPI/PV survey report is included as Appendix F. As described in Section 4.2.1, the SPI/PV survey collected information on the successional stage of the benthic infauna, sediment grain size, extent of wood waste, aRPD, number of methane voids, and presence of sulfur oxidizing bacteria to determine if there were impairments on the benthic community related to these substrate conditions. Key findings were as follows:

- **Benthic Infauna Successional Stage**: Wood waste based on the percentage of the area measured by the SPI was not statistically related to successional stage. The identification of benthic infaunal successional stages is based on empirical evidence that organism-sediment interactions in fine-grained sediments follow this predictable sequence after a seafloor disturbance (Appendix F). Successional stages are classified on a scale of 0 through 3 based on abundance and variety of macrofauna observed immediately following a major physical disturbance. Stations with higher wood waste percentages did not result in a lower successional stage and instead demonstrated an average successional stage of 2.5 (i.e., the maximum successional stage is 3; Figure 6-17a; Appendix F). Higher successional stages are generally equated with healthier and more stable benthic communities.
- **aRPD Depth**: Current aRPD depth does not indicate benthic infaunal impairment (aRPD is the depth at which anoxic reducing conditions are observed. A deeper aRPD depth often means more oxygen). The aRPD depth results of the Study Area indicated aRPD depth ranges between 0.5 and 3.6 cm with an average of 1.9 cm across the Study Area (100 stations). Statistical tests indicate no significant decreases of aRPD depth at stations with medium (41–60%) and medium-high (61–80%) volumes of wood waste (Figure 6-17b).
- **Methane Voids**: A qualitative comparison showed no differences in the number of methane voids at stations with wood waste compared to those without (Figure 6-17c).
- **Sulfur-Oxidizing Bacteria**: One SPI station (112-A) out of 196 images analyzed captured sulfur-oxidizing bacterial colonies (*Beggiatoa*). In general, dissolved oxygen levels (aerobic conditions) in the greater Puget Sound area are subjected to seasonal

patterns with dissolved oxygen depletion over the winter months due to current circulation and associated temperature changes that can be attributed to large-scale ocean and climate variability (Ecology, 2014).

Multiple lines of evidence suggest that the benthic community, as measured by SPI/PV imaging at the locations tested, is not currently impaired due to wood waste. The successional stage, aRPD depths, and methane voids are not correlated with wood waste. These findings are comparable to those found in the Western Port Angeles Harbor Study Area (WPAHG, 2020) where high-order infaunal successional stage was present in all areas, including those with high volumes of wood waste. However, wood waste can have a physical impact in addition to chemical impacts from degradation. Supplemental testing for wood degradation parameters was completed in September 2025 in areas with high wood volumes in the Inner Harbor and former Mill Pond to provide additional data for the FS.

6.4 Evaluation of Benthic Toxicity

Bioassay testing was conducted to assess surface sediment quality and potential toxicity to benthic organisms. A total of 20 surface sediment samples were submitted for three marine bioassay tests, including at least two acute effect tests and one chronic test, as required to evaluate biological criteria in marine sediments (Ecology, 2021). Bioassay testing was performed at 14 locations during Phase 1 and at six additional locations during Phase 2. Locations were selected to help define the RI boundary and provide data for spatial bounding and defining sediment management areas, which will be helpful in evaluating remedial alternatives. Rationale for bioassay testing, results of relevant chemical and physical parameters at selected sampling locations, and bioassay results are summarized in Table 6-1. TOC, grain size, and wood waste size and volumes were evaluated along with the chemistry and the bioassay results.

Bioassay testing was performed because physical and chemical parameters were identified that could potentially be toxic to benthic organisms (Ecology, 2013a). These bioassay triggers included the following:

- Large volumes of wood waste observed during field screening
- Concentrations of either sulfide or ammonia above available threshold criteria
- Detected chemical exceedances of refined SLs based on benthic SCO/Contaminant Screening Level (CSL)

In summary, bioassay testing was performed at sampling locations for multiple purposes: (1) to evaluate chemical SMS exceedances; (2) to provide additional information on the biological impacts associated with wood debris, if any; (3) to refine the extent of adversely affected areas; and (4) to help define the RI boundary. The bioassay testing methods, results, and the overall implication for evaluating sediment quality and potential toxicity for benthic organisms are discussed below.

6.4.1 Bioassay Testing

The following marine sediment bioassay tests were performed:

- Polychaetae (*Neanthes arenaceodentata*) worm chronic growth and survival tests (20-day)
- Amphipod (*Eohaustorius estuaries*) acute survival test (10-day)
- Larval (*Mytilus galloprovincialis*) acute development test (10-day)

Tests were conducted according to the SMS guidance and as detailed in Section 3.3 of the Work Plan (Geosyntec, 2022) and Section 2.3 of Work Plan Addendum (Geosyntec, 2023a). Bioassay results were compared to SMS biological criteria, which include both numeric and statistical thresholds. Statistical significance was assessed by comparison to reference samples selected to provide a representative range of percent fine particles in tested sediments and negative control samples.

Laboratory reports that detail bioassay testing methods and results are included in Appendix N. A robust data quality review was conducted to confirm that quality assurance and control requirements for marine sediment toxicity tests were met. A detailed summary is provided in Section 6.5; results showed that data met the project DQOs and are acceptable for unqualified use in the RI.

6.4.1.1 Phase 1 Bioassay Testing

Bioassay tests were performed on 14 of the Phase 1 Study Area surface sediment samples collected between August 23, 2021, and August 27, 2021, and two reference samples collected in Carr Inlet, Washington, on October 1, 2021. Reference samples were selected with different percentages of fine sediment (12% and 48%, respectively). Total percent fines among Phase 1 bioassay samples ranged between 11.3% and 57% with a median of 18%. Eleven bioassay samples were compared to the reference sample with 12% fines, and three samples (SG-05, SG-06, and SG-33) were compared to the reference sample with 48% fines. The samples were also compared to a negative control test performed using clean sand. Bioassay tests were conducted between October 12 and November 1, 2021.

Exceedances of the SCO and CSL biological criteria were reported for the polychaetae test in one Phase 1 sample (SG-05 former Mill Pond), and two exceedances of the SCO were initially observed for the larval development test in two Phase 1 samples (SG-31 and SG-33) when compared to the reference but not when compared to the negative sand control. The negative sand control is an acceptable endpoint for comparing Study Area results, especially when the organisms performed exceptionally well in the native reference substrate (based on laboratory report in Appendix N).

6.4.1.2 Phase 2 Bioassay Testing

Bioassay tests were performed in 2022 on six Phase 2 sediment samples and two reference samples with different percentages of fine sediment content (10% and 36%, respectively). Test sediments were collected and triggered for bioassay testing on September 22, 2022, and October 12–13, 2022. Reference sediment samples were collected from Carr Inlet, Washington, on September 23, 2022. Total percent fines among the Phase 2 bioassay samples ranged between 4% and 32% with a median of 26%. Four bioassay samples were compared to the reference sample with 32% fines,

and two (SG-10A and SG-49) were compared to the reference sample with 10% fines. Bioassay tests were conducted between October 24 and November 14, 2022. No exceedances of either the SCO or CSL biological criteria were detected in Phase 2 sediment samples.

6.4.2 Bioassay Results

Phase 1 bioassay results indicated exceedances of CSL biological criteria at one location (SG-05). Additional tests performed during Phase 2 sampling to confirm these results indicated no exceedances of either the SCO or CSL biological criteria at locations proximal to SG-05.

Sampling station SG-05 was located in the former Mill Pond, and bioassay test results indicate one exceedance of the CSL biological criteria for the polychaetae test. SG-05 exceeded the chemical CSL for mercury, but other benchmarks that can contribute to toxicity, including wood waste, sulfide, and ammonia, were not elevated at SG-05. The worms used in the polychaetae test sometimes display adverse effects from physical sediment substrate type such as shell fragments, which might explain the failure. The Phase 2 bioassay results indicated no toxicity at locations adjacent to and surrounding SG-05 (SG-46, SG-47, and SG-48). Adverse biological effects in the vicinity of SG-05 could not be confirmed in the 2023 tests, therefore it is assumed that benthic toxicity at location SG-05 in 2022 is an isolated hit and is limited to a small footprint (less than 50 ft).

Results of bioassay testing indicate that Study Area surface sediment and wood waste at the locations tested are not having an adverse effect on biological resources or posing significant threats to human health with one potential exception in the former Mill Pond. While many sediment samples collected in the Inner Harbor and the former Mill Pond with elevated wood waste levels and degradation product concentrations (e.g., phenol) passed bioassays and did not contain hazardous substance concentrations that trigged SMS cleanup requirements, an area within the former wharf footprint contained elevated concentrations of hazardous substances associated with wood waste degradation (e.g., H_2S and *Beggiatoa* bacteria observed in two seeps). Confirmatory bioassays were not performed in and/or near this area (because of co-occurring elevated concentrations of bioaccumulative chemicals such as cPAHs), therefore, this area will require further evaluation in the FS. Additional wood decay indicator sampling and bioassay testing was completed in September 2025 at locations with high percentages of wood waste in the Inner Harbor and former Mill Pond to provide supplemental data for the FS.

6.5 Data Quality Assurance: Chemistry

Samples collected during the RI were reviewed by Geosyntec chemists (separate from the team developing the RI report) using Level IIA, Level IIB, and Level IV data validation, in accordance with EPA National Functional Guidelines for Data Review (EPA, 2020a, 2020b, 2020c). The laboratory reports are provided in Appendix N, and the data quality review reports are included in Appendix O. An evaluation of data usability compared to the project specific QAPP criteria is also provided in Appendix O. Historical analytical data were reviewed for their usability as part of development of the Work Plan. Further discussion of the reviewed historical data is provided in Section 5.5 of the Work Plan (Geosyntec, 2022).

Overall, the field and laboratory QC sample frequency met the requirements listed in Table 10 of the QAPP and supports the DQOs:

- The sample count, holding time, preservation requirements, and requested analyses were verified against Table 5 of the QAPP, the chains-of-custody, and sample login information. Several chain-of-custody discrepancies were identified in the data validation reports (DVRs) presented in Appendix O. Field duplicates are discussed in Section 6.5.1.
- The QAPP-specified holding times were met for the sample analyses, with exceptions resulting in 0.2% of rejected results[37] as discussed in the DVRs. Additionally, the samples were received at the laboratories within the QAPP-specified acceptance criteria except for a few laboratory-caused delays. For instance, results for hexavalent chromium were all rejected due to exceeding holding times from extraction to analysis.[38] For the minority of samples outside of the criteria, the samples are listed in the DVRs (Appendix O) and do not impact the completeness of the RI data which is based on total sample counts (discussed in Section 6.5.3).
- Qualifications that were applied due to holding time exceedances and improper sample preservation are discussed in the DVRs presented in Appendix O and summarized below.

6.5.1 Field Duplicates

Field duplicate pairs were collected with the sample sets, and laboratory replicates were also analyzed. For compounds with a result showing no detection but a result greater than the MDL or RL, the relative percent difference was noncalculable. For compounds with both an estimated concentration greater than the MDL and less than the RL and a concentration greater than the RL, the relative percent difference was noncalculable. Qualifications were also applied to concentrations with relative percent differences greater than the specified acceptance criteria. Qualifications applied to the data based on field duplicate and laboratory duplicate assessment were J qualifications as estimated and UJ qualifications as estimated less than the MDLs. None of the data were rejected based on field duplicate and laboratory replicate assessment.

[37] A total of 104 results were rejected due to exceeding holding times. Results included values for hexavalent chromium (19 soil samples, seven collected at five hand auger locations and 12 subsurface soil samples collected at 8 boring locations), sulfide (22 surface sediment samples collected at 11 locations and five groundwater samples collected at the monitoring wells in October 2022), 1-methylnaphthalene (11 subsurface soil samples collected at 3 boring locations), acenaphthene (13 subsurface soil samples collected at 4 boring locations), anthracene (8 subsurface soil samples collected at two boring locations), benzo[a]pyrene (11 subsurface soil samples collected at three boring locations), fluorene (14 subsurface soil samples collected at four boring locations), naphthalene (5 subsurface soil samples collected at three boring locations), and pyrene (2 subsurface soil samples collected at boring location SB-29).

[38] The holding time for the hexavalent chromium analysis of a solid sample is 30 days from collection to extraction and 168 hours from extraction to analysis. The holding times from collection to extraction were met but from extraction to analysis were not.

6.5.2 Qualifications

The following qualifications were applied to the data due to surrogate exceedances, matrix spike/matrix spike duplicate (MS/MSD) exceedances, internal standard exceedances, and laboratory control sample/laboratory control sample duplicate (LCS/LCSD) exceedances:

- J qualified as estimated
- J- qualified as estimated with low bias
- J+ qualified as estimated with high bias
- UJ qualified as estimated less than the MDL

There were several instances where results showing no detections were R-qualified as rejected due to surrogate exceedances, MS/MSD recovery exceedances, internal standard exceedances, and/or LCS/LCSD recovery exceedances. Further details of these instances can be found in the DVRs.

Qualifications applied to the data due to isotope dilution standard exceedances were J-qualified as estimated. None of the data were rejected due to isotope dilution standard exceedances.

Qualifications applied to the data due to exceedances during the initial calibration verification (ICV) and/or the continuing calibration verification (CCV), were J qualified as estimated and UJ qualified as estimated less than the MDL. None of the data were rejected due to verification exceedances.

6.5.3 Chemistry Summary

Most of the data that was assessed are usable based on the information provided and per the referenced validation guidance. The completeness percentage was greater than 95% and surpassed the completeness goal of 90% for all parameters (quality assurance for completeness as stated in section 5.2.2.4 of the SAP, Appendix A to the RI/FS Work Plan). Exceptions are noted below within subsets of percent completeness for each analyte:

- Sixteen sediment results for total sulfide and acid volatile sulfide (AVS) were R-qualified as rejected due to holding time exceedances. Therefore, the analytical completeness for the wet chemistry sulfide results is 79.2%.
- The hexavalent chromium data were flagged as estimated and rejected. Laboratory delays resulted in the 2021 samples being analyzed outside of hold times after waiting for primary total chromium results. Hexavalent chromium results from 2022 soil boring samples were within the 30-day sample to extraction hold time, and barely hours outside of the extraction to analysis hold time of 168 hours. Results for the 19 samples tested for hexavalent chromium were not detected at the method reporting limits (0.489 to 7.39 mg/kg, well below the screening level for hexavalent chromium). Since the samples were analyzed outside of the extraction to analysis hold time, the data validation rules require a rejection flag for non-detect results but would have applied an estimated flag had hexavalent chromium been detected. Therefore, the analytical completeness for the hexavalent chromium results is 0%.

- For soil, sediment, and groundwater samples, the field and laboratory QC sample frequency met the requirements for the project and supported the DQOs. The sample counts, holding time, preservation requirements, and requested analyses were verified against the chain-of-custody and sample login information. Several chain-of-custody notation discrepancies were identified and itemized in the DVRs presented in Appendix O but did not affect data quality. The QAPP-specified holding times were met for the sample analyses, with the exceptions discussed in the DVRs resulting in rejected data. Qualifications that were applied due to holding time and temperature exceedances are discussed in the DVRs presented in Appendix O. The sample-specific quantified results were compared to the project-specific PQLs, as outlined in the QAPP. The MDLs met the project-specific PQLs. Elevated results showing no detections were reported for some of the data because of sample dilutions due to either matrix interference or high target compound concentrations. In these cases, on a sample-specific basis, the PQLs for individual compounds showing no detections may not meet the project-specific PQLs.
- No evidence of an overall directional bias was observed based on associated field and/or laboratory QC exceedances, although in some instances results were rejected due to laboratory QC exceedances. In summary, five EPA 8270E benzoic acid results and two EPA 8270E SIM benzoic acid results showing no detections were rejected due to low MS/MSD pair recoveries. Nineteen hexavalent chromium results, five total sulfide results, and six AVS results showing no detections were rejected due to holding time exceedances. These rejected data were removed from the project's dataset for risk screening.

6.6 Data Quality Assurance: Bioassays

Bioassay test data were reviewed to determine if test conditions were followed, test acceptability criteria were met, and reference toxicant tests met both control acceptability requirements. The bioassay laboratory reports from EcoAnalyst are provided in Appendix N, and the data quality review reports by Geosyntec are included in Appendix O. Specific results were as follows:

- **Polychaete growth and survival test**. The tests met their acceptability criteria with mean control survival for polychaetes of more than 90% and a mean individual growth rate of at least 0.38 milligrams per individual per day. The median effective concentration (EC50) in each ammonium chloride reference toxicity test fell within two standard deviations of the mean of the previous laboratory tests for survival and growth. With the exception of ammonia in the Phase 1 testing, water quality parameters (temperature, salinity, dissolved oxygen, pH, sulfide) were within acceptable limits and other test conditions were met with minor deviations. Ammonia concentrations were above the purging trigger in the overlying water of samples SG-33 and SG-39 on Day 20 (0.537 and 0.513 milligrams per liter [mg/L], compared to purging trigger of 0.46 mg/L); however, they were both below the no observed effect concentration value derived from the concurrent ammonia reference-toxicant test (1.51 mg/L), indicating that ammonia did not confound the test results.

- **Amphipod survival test.** The tests met the acceptability criteria with mean control survival of more than 80%. The EC50 in each ammonium chloride reference toxicity test fell within two standard deviations of the mean of the previous laboratory tests for survival. Water quality parameters (temperature, salinity, dissolved oxygen, pH, and sulfide) were within acceptable limits for all samples and other test conditions were met with minor deviations.
- **Larval bivalve development test**. The tests met the acceptability criteria with mean control normal survivorship for bivalves of more than 70%. The EC50 in each ammonium chloride reference toxicity test fell within two standard deviations of the mean of the previous laboratory tests for survival. Water quality parameters (temperature, salinity, dissolved oxygen, pH, and sulfide) were within acceptable limits for all samples and other test conditions were met with minor deviations.

These findings indicate that the data are valid for use in the RI/FS without any qualifications.

6.7 RI Boundary Determination

The RI boundary was developed using the step-out sample contaminant concentrations while also considering, native conditions, and physical, regulatory, and legal constraints. The initial RI boundary was drawn considering the following:

- Mapping the extent of refined SL exceedances of COCs, including copper, lead, total cPAH TEQ, and total TCDD TEQ.
- Evaluating property boundaries and other landmarks (e.g., roads), including historical land use areas and site operations as well as properties with prior redevelopment activities.
- Evaluating physical and habitat features, sensitive environments, topography, land and water uses.
- Evaluating receptors and complete and incomplete pathways; evaluating benthic toxicity passes.
- Mapping the RI step-out samples and potential for historical or current transport pathways. The step-out samples were used to establish the boundary line of ambient concentrations.[39]

This boundary line is displayed on Figure 6-18. The area of contamination within this boundary is used to perform the risk evaluation, calculate spatially weighted average concentrations (SWACs), interpolate concentration gradients, and develop cleanup levels and points of compliance. The risk

[39] The in-water boundary is defined by the locations where individual contaminants of concern exceed the proposed sediment cleanup standards as specified in WAC 173-204-560. The upland boundary is defined by the locations where individual contaminants of concern exceed the proposed soil cleanup standards as specified in WAC 173-340-350 (5) (g) (ii) (C) and WAC 173-340-200.

screening (Section 7) will identify areas of unacceptable risk that will require remedial evaluation in the FS. This footprint becomes the final RI boundary that is carried forward into the FS.

6.8 Interpolated Distribution of COCs

The Study Area was spatially characterized using inverse distance weighting (IDW). IDW is a deterministic method preferred by Ecology for spatial interpolation of datasets used to evaluate soil and sediment chemistry, both area-wide and site-wide. When the IDW interpolation is conducted, values (e.g., concentrations) are assigned to a location by calculating a weighted average of the known values at nearby sample locations.

Using the RI dataset, a range of IDW settings and scenario combinations were evaluated to select the best fit IDW settings that minimize error among COCs. The same IDW parameterization will be used for all COC interpolations. The selected IDW settings for interpolating soil and sediment data for this RI evaluation include the following:

- Data transformation: logarithmic
- Power: 3
- Search radius: 200 ft
- Minimum/maximum number of nearest neighbors: 2/8

In 2020, IDW interpolations were conducted using the following settings:

- Data transformation: none
- Power: 2
- Search radius: 200 ft
- Minimum/maximum number of nearest neighbors: 3/5

The IDW parameters used in 2020 were based on a smaller dataset (Leidos, 2019, n = 44) compared to the RI dataset (2023, n = 336 samples) is considerably larger with improved spatial coverage. The IDW parameters were evaluated to determine the best settings for the RI dataset, and this evaluation is presented in Appendix Q.

For this RI evaluation, four different datasets were used for IDW interpolation using the 2023 dataset: surface soil data (0 to 6 ft), subsurface soil (more than 6 ft), surface sediment (0 to 10 cm), and subsurface sediment (more than 10 cm depth). For the next step, the concentration gradient maps were stacked together (surface soil and surface sediment together) for a wholistic view of surface conditions. Results of the IDW analysis are presented in Figures 6-19a through 6-34b. From these interpolations, surface SWACs will be derived in Section 7 to assess exposure risks.

6.9 Nature and Extent Summary

COCs with elevated concentrations above refined SLs are associated with (1) fill material in both surface and subsurface soil and sediment samples, (2) slag piles along the Inner Harbor shoreline,

and (3) the former wharf structure and northern shoreline. The nature and extent of COCs exceeding the refined SLs are discussed in more detail in the following sections. Soil and sediment sample results compared to refined SLs for select COCs are summarized by depth in Figures 6-1 through 6-16, and COC interpolations are presented in Figures 6-19a through 6-26b for soil and 6-27a through 6-34b for sediment. The percent of wood waste and bioassay results are shown in Figures 6-35a and 6-35b. COCs are generally below NB in the southern portion of the former Mill Pond and southern portion of the Inner Harbor and most of the Outer Harbor. While wood waste covers a much larger area than the former wharf structure, the footprint of the SCO/CSL sediment exceedances is smaller in extent. Of the 20 bioassays, 19 passed (SG-05 in the former Mill Pond did not pass), indicating the wood waste was not toxic to benthic biota at these locations at this time. However, bioassays were not collected in portions of the Inner Harbor where access was restricted and where COC exceedances were above screening criteria. Since wood waste can have physical and chemical impacts, additional wood degradation parameters and bioassay testing was completed in September 2025 in areas of high wood occurrences in the Inner Harbor and former Mill Pond to provide additional data for the FS.

6.9.1 North Upland

COC concentrations in the north upland area that exceed refined SLs are not contiguous both horizontally and with depth. Higher concentrations are present in the former Mill footprint, decreasing to the north and east towards the northern step-out samples (Section 7). Although somewhat sporadic, the depth of contamination ranged from a shallow depth of 2 ft bgs up to 6 ft bgs (in fill material) in most areas, and fill material included wood and building debris. COC exceedances were detected up to 12 ft bgs in one boring, SB-22, near the northwest corner of the former sawmill. Fill material was encountered in SB-22 to the maximum boring depth (12 ft bgs), and surrounding borings provided delineation. Metals (arsenic, lead, copper, cadmium), total cPAH TEQ, and the total TCDD TEQ were greater than refined SLs in boring SB-21, near the slag piles and in the former foundry/machine shop area. Elevated copper and lead exceedances were present in this area between 2–3 ft and 6–8 ft bgs. Arsenic and cadmium in two locations and mercury at one location were detected at elevated concentrations with exceedances up to 7 ft bgs.

Cadmium, chromium, copper, total cPAH TEQ, and total TCDD TEQ detected near the former mill structures were at or below NB in upland step-out samples. Zinc was up to two times the NB concentration.

Higher lead concentrations were detected at a sampling location in the northeast corner of the Blakely Harbor Park property (HA-35) where building debris (i.e., ceramic and brick fragments) was observed.

6.9.2 South Upland

In the south upland area, metals, the total cPAH TEQ, and the total TCDD TEQ concentrations were above refined SLs near the former planing mill and kiln structures, where small pieces of charcoal and asbestos were observed. Depths of exceedances extended from ground surface to 2 or 3 ft bgs, which was the bottom depth of the six hand auger borings. One soil boring, SB-38, located on the southern side of the temporary pedestrian bridge, was drilled to 20 ft bgs. Arsenic and zinc (16–18 ft bgs) and total cPAHs TEQ (14–16 ft bgs) concentrations were elevated at depths

but not consistently elevated in sample intervals from the ground surface to 20 ft bgs. Arsenic and total cPAH TEQ concentrations were below refined SLs in the maximum sample depth intervals at SB-38 and HA-37.

6.9.3 Former Mill Pond

COCs were detected at higher concentrations in subsurface sediment (below 10 cm) in the former Mill Pond compared to surface sediment and appear to be associated with wood waste in subsurface sediment. COCs were generally higher in the northern portion of the former Mill Pond, with the highest detections located within a low area where the stream discharges (near sample location SG-05). North of this area, sediment appears to accumulate behind the upland peninsula, and mudflats were exposed at low tides. The southern portion of the former Mill Pond is mostly intertidal and less contaminated than as compared to the northern portion of the former Mill Pond. The greatest concentrations of COCs were detected in the top 2 ft bml and were vertically delineated with the exception of arsenic at two locations (SC-05 and SC-07). In these locations, arsenic exceeded refined SLs in the bottom interval (3.8–6.5 and 4.4–6.8 ft bml, respectively), the depths where both cores hit refusal as shown in Figure 6-1.

Metals, total cPAH TEQ, and total TCDD TEQ concentrations were consistently detected near or below NB in the southern portion of the former Mill Pond and the creek sediment samples, except lead, which was above background but less than the SCO. In the northern portion of the former Mill Pond, higher metals concentrations, in particular mercury, were detected in a cluster of samples at and surrounding SG-05, where the single bioassay failed (SG-05). However, lead, mercury, and other metals concentrations were lower (less than SCO), and bioassay samples passed in the three surrounding locations.

6.9.4 Inner Harbor

The highest COC concentrations were detected in the Inner Harbor in both surface and shallow subsurface sediment with exceedances of the refined SL up to 6.5 ft bml (deepest at SC-24 and SC-34 locations), and up to 10 ft bml in the high intertidal area (SC-11 to bottom of core). The highest metals concentrations and exceedances were often observed in the top core interval from 0 to 1.5 ft bml. Observed exceedances above the refined SLs were often associated with the presence of wood debris in subsurface sediment and slag piles. COC concentrations were generally higher in northern portion of the Inner Harbor, particularly along former wharf structure and closer to the former foundry.

Metals and total TCDD TEQ concentrations at two locations (SG-08 and SG-13) were consistently below NB in sediment samples in the southern portion of the Inner Harbor near the private intertidal tax lots, except lead and mercury. Metals and total TCDD TEQ concentrations at two locations (SG-08 and SG-13) were consistently below NB in sediment samples in the southern portion of the Inner Harbor near the private intertidal tax lots, except lead and mercury. Lead is present in nearshore Inner Harbor at sample depths ranging from 0 to 3 ft bgs, with sporadic sample locations above NB extending beyond the wharf footprint. The highest lead concentrations above the refined SLs were detected near slag piles and westward along the shoreline. The highest mercury concentrations (above the refined SLs) were detected along the edges of the wharf structure (SG-11A, SC-21, SC-24, and SC-51) at depths ranging from the surface up to 4 to 6.5 ft

bml and did not appear co-located with the slag piles along the Inner Harbor shoreline. The total cPAH TEQ concentrations were above refined SLs in surface sediment along the southern portion of the Inner Harbor and were less than NB concentrations in core samples. All sediment bioassays in the Inner Harbor passed.

In the northern portion of the Inner Harbor, chromium, arsenic, cadmium, and/or zinc were detected in 100% of surface sediment samples. Chromium concentrations were below NB, and arsenic, cadmium, and zinc were detected above screening SLs in 28%, 19%, and 2% of samples, respectively, at depths up to 2 ft bml. Copper concentrations were above the benthic SCO in 2% of samples at depths ranging from surface up to 2 ft bml along the former wharf structure. Total cPAH TEQ and total TCDD TEQ concentrations were above refined SLs in 69% and 49%of samples, respectively, in surface sediment and core samples up to 6.5 ft bml.

6.9.5 Outer Harbor

RI sampling was focused on the northern portion of the Outer Harbor, and COC concentrations were mostly below NB for arsenic, cadmium, chromium, and zinc, total cPAH (based on the TEQ), SVOCs (phenols, phthalates), and dioxins/furans (using the total TCDD TEQ).

Results from the primary/duplicate pair were different from each other at one surface sediment sample (SG-56) located in the northeast Outer Harbor, likely due to sorption onto soil particulates or small metal-oxide compounds (i.e., “nugget effect”). Metals, PAHs, total cPAH TEQ, and total TCDD TEQ concentrations were below and above NB concentrations and other screening criteria in this primary/duplicate pair. Samples to the west of SG-56 had generally lower concentrations or were below NB concentrations, and the COC exceedances at SG-56 were isolated or sporadic.

A few metals (copper, lead, mercury) and total cPAH TEQ concentrations were above NB and sporadically above the SCO (metals) or human health criteria (total cPAH TEQ) in surface sediment, with declining concentrations away from the wharf footprint to the east and southeast and declining with depth. Total cPAH TEQ and mercury concentrations were above refined SLs in surface sediment samples along the northern shoreline, but not at consistent exceedance ratios. Three samples (SG-41, SG-54, and SG-56) located along the northern shoreline had high mercury concentrations; however, the locations with high mercury concentrations were not continuous as they were adjacent to sample results below NB concentrations or refined SLs. Total cPAH TEQ concentrations were above 10 times NB (0.21 mg/kg) but less than the refined SL for sediment (120 mg/kg) along the northern shoreline and the outermost sample to the northeast (SG-56). Total cPAH TEQ and mercury concentrations were below the refined SLs in subsurface sediment samples. All sediment benthic bioassays in the Outer Harbor passed.

7. CONCEPTUAL SITE MODEL AND RISK EVALUATION

The CSM summarizes potential historical and current contaminant sources, fate and transport mechanisms, potential receptors, and exposure pathways. A depiction of the current CSM for the Study Area is shown in Figure 7-1. The CSM provides the basis for developing remedial alternatives in the FS. Guidance on how to develop a CSM is provided in Ecology's Sediment Cleanup User's Manual (SCUM) guidance (Ecology, 2021).

7.1 Contaminant Sources

Historical industrial activities in the Study Area are described in Section 2.3, and their potential contributions to the distribution of COCs in the Study Area are summarized in Section 7.1.1 and Figure 7-1a. Potential off-site sources and current secondary sources of contamination are discussed in Section 7.1.2.

7.1.1 Historical Sources from Site Operations

Historical activities that may have resulted in spills and releases of hazardous substances to upland soil from historical Mill operations included the machine shop, powerhouse, blacksmith shop, oil house, hog fuel/refuse burner, foundry, steam dry kilns, planing mill, refuse burn piles, and warehouse facilities. Activities that may have resulted in spills and releases directly to sediment include overwater activities such as use of machinery and ships for debarking/rafting logs and loading/unloading materials onto ships at the wharf. The former foundry may have operated close to the shoreline and discarded slag waste near the intertidal sediments. In addition, burnt materials resulting from the fires that destroyed the Mill structures in 1888 and 1907 were deposited on surface soil and sediment and represent a potential source of hazardous substances. ACM (from historical roofing material) was identified within a piece of demolition debris along the southern shoreline near the former planing mill (see Appendix L and Section 4.2.3). ACM found in the Study Area was mitigated and is not an ongoing source of contamination.

Former Mill operations conducted from 1863 to 1923, were likely sources of site COCs, such as metals, organic compounds like PAHs and TPH, and dioxins/furans. In addition, wood waste was likely deposited in upland and in-water areas during Mill operations and log rafting. Wood, pilings, lumbered wood, foundry bricks, and other construction debris may have been used as fill material during reconstruction or expansion of the Mill after the 1888 and 1907 fires. Former Mill operations and their potential impact on contaminant distribution in the Study Area are discussed below.

7.1.1.1 Foundry and Blacksmith Operations

Metals such as copper, chromium, lead, mercury, and zinc were common in alloys used in historical foundry and blacksmithing operations at the time the Mill was operational. During the RI field investigation, slag piles were observed along the Inner Harbor shoreline in proximity of the former foundry and blacksmith shops (described in Appendix I and summarized in Section 4.2.1). Slag is formed during the cooling of melted ferrous metals and alloys, and the piles observed in the Study Area may be from melted metal mixtures released and cooled on the shoreline. The slag piles may be broken down by natural processes and become a secondary source

of COCs, as discussed in the Sections 7.1.2 and 7.2. Elevated concentrations of metals in soil and sediment proximal to the former foundry, blacksmith shop, and slag piles on the shoreline may have been released from these former activities.

7.1.1.2 Fuel Supply Lines and Timber Pilings

Diesel and petroleum-derived products were commonly used as fuel for operations in mills and vessel transport during this time period, as well as wood preservative products. TPH and PAHs may have been released during historical operations in both soil and sediments.

Wood structures are often preserved with materials such as creosote, which can result in releases of PAHs and other organic compounds into soil and sediment. Coal-tar creosote, the most common type of creosote, was commercially introduced in 1838 and was produced in the Wyckoff facility that began operations in Eagle Harbor in 1905. The Mill burnt down for a second time in 1907 and was reconstructed in 1909. Therefore, the potential use of creosoted timber pilings and wood during reconstruction and Mill operations was investigated during the RI, with a focused study summarized in Appendix K and Section 4.2.2. Scrape samples from Study Area timber piles were tested, and samples did not contain elevated concentrations of PAHs. Furthermore, the signature of the LPAH concentrations detected in the scrape samples show a statistically significant difference than PAH signatures typical of creosote as reported in literature (Appendix K). These results indicate that the Mill structures and timber pilings were not likely treated with creosote.

7.1.1.3 Refuse Burners and On-Site Fires

The Mill operated two refuse burners (hog fuel burners) during routine operations as a source of energy, and wood available from Mill operations was likely the fuel used in the burners. In addition, the Mill was destroyed in 1888 and 1907 by two documented fires and rebuilt. The use of hog fuel burners and the two historical Mill fires likely resulted in localized areas of combustion byproducts.

Elevated concentrations of dioxin/furans present in both soil and sediments in proximity to the former smokestacks or the former Mill structures are likely the result of historical refuse burner operations and the fires that burned down the Mill.

7.1.1.4 Wood Milling Operations and Wood Debris

In 1882, Mill production was 200,000 board-ft per day, and the Mill that was rebuilt in 1909 had a maximum output of 500,000 board-ft per day (Price, 1989). Historical industrial operations produced wood debris including saw dust, dimensional lumber, pulp fibers, wood chips, logs, and bark, some of which were observed during RI investigations (Appendix J).

Wood waste was found in subsurface soil and sediment in the north upland and the Inner Harbor areas within the former Mill footprint (Figures 6-35a, 6-35b). Log rafting (log booming) occurred in the former Mill Pond and in the portion of the Inner Harbor adjacent to the former Mill. Observed wood fragments (e.g., bark, dimensional lumber, wood chips) were likely dislodged and sloughed off during log rafting and settled into surface sediment. In some instances, wood waste has been shown to contribute to impairment of sediment and surface water quality by generating a toxic environment for benthic species. However, the results of the RI investigation show that benthic toxicity was not collocated with the wood waste in surface sediment at the locations

sampled (Figure 6-35a). Additional testing for wood waste degradation parameters and bioassay toxicity at locations in the Inner Harbor and former Mill Pond with the highest wood percentages was completed in September 2025 to provide supplemental data for the FS. At some sites, abundant wood waste in surface sediment has increased the biological oxygen demand (BOD) due to increased microbial activity in carbon rich environments; this resulted in oxygen depletion and increasing concentration of sulfide and ammonia due to biological activity under suboxic and anoxic conditions. Wood degradation indicators quantified are discussed further in Section 7.6.

7.1.1.5 Reconstruction and Shoreline Reshaping and Filling

Based upon our understanding of historical operations, the northern and southern shorelines were likely dredged and reshaped to extend the shoreline, build new Mill structures, and increase berthing depths for vessel traffic and mooring. Historical maps show that the former Mill Pond area and the shoreline between the former Mill Pond and the Inner Harbor were reshaped when the Mill was first built in 1863 and after the two subsequent historic fires (United States Coast Survey, 1856; United States Coast and Geodetic Survey, 1884; Port Blakely Mill Company, 1917; ERIS, 2019b; Geosyntec, 2019). RI findings of wood fill layers or lenses in the upland area at depths up to 15 ft bgs (see cross-section series Figures 3-3a through 3-3d), including near the shoreline, suggest wood was likely used as fill material. Bricks and brick fragments also were observed in soil and sediment within the fill layer (Appendices C and D) indicating building debris could have also been used as fill material during reconstruction following the Mill fires. The fill layers in the upland area are collocated with some slag piles along the Inner Harbor and elevated concentrations of metals and organic compounds in soil and Inner Harbor sediments. Although metals and organic compounds, when detected, were not present in groundwater above refined SLs (potential for leaching is further discussed in Section 7.2).

7.1.2 Current Potential Sources

Potential current sources of Study Area and vicinity contamination include outfalls, streams, other in water structures (e.g., personal docks/pilings), and airborne releases that have traveled long distances. There is one outfall and six natural streams that discharge to the Study Area marine embayment. The outfall is an unclassified pipeline according to data retrieved from Kitsap County and assessed by the RI field team during a shoreline survey conducted in 2022 (Figure 7-2). The largest stream discharging to the Study Area is located near the westernmost end of the former Mill Pond and identified as the “unnamed creek.” Other smaller streams are located to the southwest of the former Mill Pond, in the north upland area, and on private properties within the Outer Harbor northern and southern shorelines. Sediment samples collected within the unnamed creek and in proximity of other natural discharges indicated no receiving sediment areas with high concentrations of contaminants, except near the one outfall (i.e., surface sediment sample SG-25). At SG-25, detected concentrations of COCs exceeded the refined SL for cPAHs. Otherwise, streams and outfall discharges do not appear to be contributing sources of contamination to the Study Area.

Other anthropogenic non-point sources may also have contributed to ambient concentrations. EPA has identified combustion emissions as a primary category of dioxin sources to the environment, with contaminant loadings decreasing over time as a result of environmental regulation on emissions (EPA, 2006). TCDD and 1,2,3,7,8-pentachlorodibenzo-p-dioxin (PeCDD) are present

in combustion emissions globally and can come from a variety of regional sources that are not easily distinguishable at low levels (regional background), including incineration of municipal solid waste, sewage sludge, hazardous wastes, and fuel (e.g., coal, wood, petroleum), as well as uncontrolled burning (e.g., forest fires,[40] brush fires, open burning of wastes) (EPA, 2006).

Historical deposition of airborne arsenic and lead released from the former Asarco Smelter located in Tacoma, Washington, may have been transported to Bainbridge Island and the Study Area, based on historical wind patterns. The Study Area is within the 20 mg/kg arsenic zone mapped from the historic Tacoma Asarco Smelter Plume (Pacific Groundwater Group and TeraStat, Inc., 2005).[41] Between 2000 and 2004, Kitsap County collected 17 surface soil samples of an extended footprint study on Bainbridge Island (none of the 17 locations were in the Blakely Harbor site), and arsenic was detected in surface soil samples with two concentrations recorded (31 and 33 mg/kg) above regulatory screening levels (MTCA Method A 20 mg/kg) and NB (7 mg/kg).

7.2 Fate and Transport Pathways

Fate and transport pathways govern the distribution and transformation of COCs in environmental media. Fate describes the transformation processes that can change the concentration of a COC through time, such as adsorption, biodegradation, precipitation, dissolution, and advection. The transport pathways represent the physical and/or chemical processes resulting in contaminant migration from the point of release or source area to the impacted media. Transport pathways can mobilize contaminants from source areas of release (or hot spots) and transport them between or within environmental media by various mechanisms (Figure 7-1a). These transport pathways are shown conceptually on Figure 7-1b. Transport pathways at the Study Area are complete when the physical and/or chemical pathway exists and the COCs are present above SLs and are incomplete if either of these are not true. These pathways include the following:[42]

- Erosion of surface soil from overland runoff and deposition into sediment. This process occurs when surface water and tidal currents at extreme high tides unsettle and resuspend contaminated soil or sediment particles which are then transported to a new location (complete),
- Migration through groundwater advective flow. This process occurs when COCs are mobilized by the migration of groundwater either in the dissolved phase after partitioning to the water phase or in the form of small size soil particles (colloids) transported with the flux (not complete).

[40] As an example, during this RI, extensive regional forest fires were experienced in 2020 and 2023.
[41] Weather data prior to 1945 could not be found. Wind frequencies and velocities from the Air Weather Service, Data Control unit, U.S. Weather Bureau for the Central Puget Sound Region, and Seattle-Tacoma Airport are summarized in Figures 3-9 and 3-10 and Tables 3-4 and 3-5 (Brown and Caldwell, 1958).
[42] Since COCs in soil are not present in groundwater above refined SLs, the soil to groundwater and groundwater to surface water pathways are not complete transport pathways in the Study Area.

- Migration through groundwater to surface water. This process occurs when groundwater advective flux reaches surface water through seepage from upland areas or upwelling through submerged sediments (not complete).
- Atmospheric deposition. This process occurs when airborne contaminants are transported by wind and are deposited on surface soil or on the sediment bed (complete).
- Redistribution of sediment via erosion. Erosion and deposition occur when water currents mobilize intertidal sediment, intertidal debris, or subsurface sediments and transport them to a different location (complete).
- Upward migration from subsurface sediment into surface sediment. This process occurs when the sediment bed is disturbed by biological or physical activity, and sediment particles are mixed across the sediment column, such as bioturbation from benthic organisms (complete).
- Natural attenuation, which is the decrease of COCs over time due to the cumulative effects of transformation (fate) and transport processes. COCs can undergo a variety of transformation and transport processes including those listed above (complete).
- Wood waste degradation in the marine environment can have physical impacts (e.g., smothering) or degrade through bacterial activity to produce hazardous substances. The hazardous substances can accumulate in sediment pore water and impact surface water and create toxic conditions for aquatic organisms.

The primary fate and transport pathways and their areas of interest are described in detail in the following subsections, and wood waste degradation is discussed in Section 7.6.

7.2.1 Erosion of Surface Soil

Surface soil particles, including associated contaminants, can be eroded by tidal action and suspended by overland runoff during storm events and inundation during high tides. Slag piles, bricks, and wood debris present on the shoreline can be eroded by wave action and physical and chemical weathering into more mobile, smaller fragments over time. Mobilized particles can migrate towards lower elevation areas and deposit into intertidal and subtidal areas. While areas of large-scale soil erosion were not observed, smaller scale erosion is likely occurring along the northern shoreline in the former Mill Pond and Inner Harbor. Steeper slopes along the northern portion of upland area near the former Mill Pond could particularly be vulnerable to erosion at higher tides. Erosion (and/or weathering) and redistribution of slag debris could result in transport of small particles away from the areas where large slag piles were observed (Figure 4-3).

7.2.2 Advective Groundwater Transport

Contaminants associated with soil particles can dissolve into the water phase and become mobilized through advective groundwater flow. Advection is the transport of a substance by bulk motion of a fluid, and advective groundwater flow refers to transport of contaminants that are either dissolved in groundwater or attached to suspended particles that move through groundwater.

Chemical characteristics like solubility and an affinity for organic carbon can govern chemical partitioning into the water phase and transport through groundwater advective flow. Dissolved metals are likely to migrate in groundwater, although redox conditions can change the state of these compounds and result in formation of precipitates. Organic compounds with high solubility in water like LPAHs are likely to partition into water and be transported with groundwater, while contaminants with lower solubility like HPAHs and dioxins/furans are more likely to attach to organic carbon in soil particles.

Results from four quarters of groundwater sampling indicate that analytes were not detected or were detected at concentrations below refined SLs with the exception of total chromium (for additional details see Section 6.1.2). This indicates that COCs are not being mobilized via partitioning from soil into groundwater advective flow.

7.2.3 Groundwater to Surface Water to Sediment Pathway

Groundwater flow moves towards the nearest hydraulic depression, and dissolved contaminants can be transported to the nearest surface water bodies. Groundwater seeps were observed along the Inner Harbor shoreline (Figure 4-2b). Soluble contaminants dissolved in groundwater and/or attached to soil particles or colloids can migrate with groundwater into adjacent surface water and can deposit into sediments.

Results of the RI investigation indicated that chemicals were either not detected, or detected below screening levels, in groundwater during four quarters of groundwater sampling, except for total chromium which was likely sorbed onto particles. Chromium concentrations in shoreline sediments were detected below refined SLs, as shown in Figure 6-2. These data provide evidence that the groundwater to surface water to sediment pathway is not a significant transport pathway at the Study Area for metals and organics.

7.2.4 Atmospheric Deposition

There are no current airborne releases of contaminants at the Study Area, but historical emissions were likely during Mill operations (Section 7.1 and 7.9). Airborne release of contaminants can occur through volatilization during combustion or foundry processes, and/or distribution of contaminated particles generated from or associated with operations (e.g., dust and/or burning). Volatile or gas compounds and/or particles can be transported by wind over short and long distances and deposited directly to surface soil, surface water, and surface sediment. Non-point sources of low-level contaminants from urban activities such as car emissions, industrial operations, and street dust may be transported to the Study Area and may also contribute background levels of chemicals present at the Study Area.

7.2.5 Redistribution of Sediment via Erosion

Redistribution of sediment via erosion occurs when the shear stress applied by wave action and tidal currents can mobilize nearshore sediment or debris and transport them to a different location. Slag deposits, brick, and wood waste found exposed along the shoreline appear stable but may be vulnerable to redistribution from currents and tides. Recreational vessel traffic (temporary mooring, anchoring, propeller wash) is limited to seasonal use of the park and is not considered to

be significantly affecting the shoreline and substrate stability. Evidence of redistribution of sediment via erosion in different areas of the Study Area include:

- The thickness of unconsolidated sediment was higher in general in the former Mill Pond (thickness up to 4 ft) compared to the Inner Harbor (thickness of 1 to 2 ft) as shown in Figure 3 (Appendix J), suggesting the former Mill Pond is a depositional environment. Transport of sediment from the Inner Harbor to the former Mill Pond is possible during high tides or storm events, although likely limited by the small size of the channel connecting the former Mill Pond to the Inner Harbor.
- Fine-grained sediments were not abundant in the Inner Harbor shoreline adjacent to the north and south Upland areas. The observance of small grains of slag with fragments of wood in nearshore sediment indicate some erosion of and migration from the slag piles observed along the northern shoreline (see Appendix I for additional detail).

The RI bathymetric survey data collected in 2020 (Appendix B) was compared to the bathymetry survey data from a 2009 National Oceanic and Atmospheric Association survey to map elevation changes in the Study Area (Figure 7-3). Figure 7-3 provides an approximate estimate for bathymetric elevation changes where there is suitable data overlap as the former Mill Pond was not covered during 2009 survey. Based on this comparison, over the past 11 years (where there is overlapping data coverage), sediment bed elevation changes have been minimal (+ or – 0.5 ft) over most of the in-water Study Area, with few small erosional areas (elevation loss) corresponding to the location of floating docks and likely vessel activity. The southern shoreline shows small areas that appear to have more sediment deposition, such as sediment particle load coming from the former Mill Pond and unnamed creek or other non-point sediment loads. Results of recent surveys conducted to evaluate sediment aging by quantifying radioisotope content show low sedimentation rates. Sedimentation rates will be further evaluated in the FS.

Redistribution of sediment via erosion is considered a complete transport pathway in the Study Area.

7.2.6 Upward Migration from Subsurface Sediment

Multiple processes (physical or biological) may mobilize contaminants from subsurface sediment to surface sediment and promote vertical migration through the sediment column. In both the Inner and Outer Harbor, elevated COC concentrations were mostly found in surface sediment samples (collected between 0–10 cm bml) with few exceptions (Table 5-6).

Vertical COC distribution in sediment was assessed to understand the importance of potential vertical mixing pathways, and the potential for higher concentrations in the subsurface to migrate to surface sediment. Concentrations of five COCs (arsenic, mercury, lead, total cPAH based on the TEQ, and total TCDD based on the TEQ) were plotted to visualize data distribution between surface and subsurface sediment using a non-parametric hypothesis test[43] (Wilcoxon) to evaluate

[43] Non-parametric test assesses differences between medians instead of means (evaluated by using parametric tests) and are appropriate for small datasets that do not fit a particular distribution.

if differences between datasets were statistically significant. The Figure 7-4 (a–e) series show distribution of the five COCs.

Results indicate that there are no statistically significant differences between maximum concentrations of arsenic, mercury, and total TCDD based on the TEQ in surface and subsurface sediments (Figure 7-4a, 7-4b, and 7-4e, respectively). The concentrations of lead were higher in subsurface sediment and significantly different than surface sediment (Figure 7-4c), which appears to be localized to Inner Harbor locations where shoreline core intervals were characterized mainly as fill (Figure 3-3d). The total cPAH based on the TEQ concentrations were higher in surface sediment and significantly different than subsurface sediment (Figure 7-4d). Overall, results show that higher COC concentrations are mainly located in surface sediment, as there are no significant differences in COC concentrations between surface and subsurface. This indicates that surface-subsurface sediment is equilibrated.

Vertical mixing and upward migration of sediment particles can be promoted by bioturbation, where the movements of benthic organisms disturb the sediment bed. The SPI/PV survey (Appendix F) showed that successional stage 3 infauna populations are distributed across the former Mill Pond and the Inner Harbor Northern shoreline. Stage 3 suggests bed stability and limited physical disturbance and sediment resuspension, but it also may indicate biological activity by deep-dwelling, head-down deposit feeders can occur. SPI survey results noted distinctive feeding voids and aerated burrows in the former Mill Pond and the Inner Harbor Northern shoreline, which may indicate that shallow mixing due to bioturbation is extending across the surface sediment depth. Vertical mixing due to bioturbation is considered a transport pathway at the Study Area.

7.2.7 Natural Attenuation

Natural attenuation processes can decrease the overall mass of contaminants in environmental media, and include biodegradation, adsorption, chemical reactions like precipitation, dilution, and dispersion. Physicochemical characteristics of contaminants govern natural attenuation processes and are discussed in detail in the following sections.

Organic COCs include PAHs, dioxin and furans, and SVOCs (phenols, chlorinated organics, and phthalates) and inorganic COCs include metals like arsenic, copper, lead, mercury, and zinc. Attenuation of organic compounds can occur via adsorption or biodegradation, while attenuation of metals can occur by precipitation and adsorption on soil or sediment due to surface interactions with the minerals or partitioning into organic matter.

- Adsorption is a reversible process and plays an important role in the fate and transport of organic contaminants because adsorption delays the release of organic contaminants in the environment and is critical for evaluating overall decay rate of a compound (half-life). This process is likely to occur at the site, however, the variability of sediment organic carbon content and grain size impacts the magnitude and significance of this process.
- Biodegradation occurs when thermodynamic conditions are favorable to the development of a microbial community capable of oxidizing (breaking down) organic

contaminants with consequent reduction of a terminal electron acceptor. However, the significance of this process is linked to the magnitude of biodegradation rates. Biodegradation rates will vary within oxic, suboxic, and anoxic environments; with the process being faster in the presence of oxygen and slower when different terminal electron acceptors are present (nitrate in suboxic environments and sulfate or carbon dioxide in anoxic environments). Biodegradation rates for LMW organic compounds are on the order of days in oxic environments and months in anoxic environments, while biodegradation rates for high molecular weight organic compounds are in the order of years in oxic environments and decades in anoxic environments. Therefore, biodegradation can represent an important transport process for LMW organic compounds.

- Precipitation of metals will occur when redox conditions, concentrations of chelating agents, and ionic strength of groundwater or sediment porewater are favorable to formation of complexes with dissolved metals. This process can occur in saturated soil or in shallow and undisturbed sediment where redox conditions are stable and not altered by tidal currents or wake actions. Significant redox changes in the upland were not observed in Study Area soils (e.g., significant iron oxidation changes or evidence of metals/sulfides) and groundwater field parameters. In sediment, the aRPD was observed using the SPI/PV survey. Results indicated the aRPD in sediment ranges between 0.5 and 3.6 cm with an average of 1.9 cm across the Study Area (100 stations). Speciation of metals sensitive to redox changes like arsenic and mercury could occur in surface and subsurface sediments, but not enough significant field observations were collected to conclude this could be an important process contributing to natural attenuation.

The rate of natural attenuation was evaluated by comparing concentrations of five COCs (arsenic, mercury, lead, total cPAH based on the TEQ, and total TCDD based on the TEQ) in surface sediment collected in 2019 and 2021-2023. A non-parametric hypothesis test (Wilcoxon) was used to evaluate concentration changes through a time range (2019 to 2023). The dataset distributions for the five selected COCs are shown in the Figure 7-5 (a–e) series. Arsenic and total cPAH TEQ concentrations were lower in surface sediment collected in 2021–2023 and significantly different than surface sediment collected in 2019 (Figure 7-5a and 7-5d). There were no statistically significant differences between concentrations of mercury, lead, and total TCDD based on the TEQ in surface sediments over the 2-to-4-year time-difference (Figures 7-5b, 7-5c, and 7-5e, respectively). Despite a small timeframe compared to the time that has passed since the Mill was shut down, statistical evidence indicates that natural attenuation of arsenic and cPAH has been occurring at the Study Area, while other COCs are more stable or have already achieved ambient concentrations.

Natural attenuation is the result of cumulative contribution of on-site chemical and physical processes including adsorption, biodegradation, precipitation, and mixing or transport of particles. Temporal comparison of COC concentrations showed that natural attenuation is occurring in the Study Area.

7.3 Potential Receptors and Exposure Pathways

Potential human receptors in the Study Area include recreational and tribal users of the upland, intertidal, and subtidal areas, and construction workers. Receptors and exposure pathways are summarized in Figures 7-6a and 7-6b. Typical recreational activities include hiking and wildlife viewing in the upland area and wading, swimming, fishing, and shellfish harvesting in the intertidal or subtidal areas. On-water recreational activities, such as kayaking and boating, may occur, but the potential for contact with sediment is expected to be minimal. Construction workers, if working in the upland areas of the Study Area, are potential human receptors. The human health exposure pathways that are considered complete are as follows:

Soil

- Dermal contact and incidental ingestion pathways for recreational users in the upland soil areas. These pathways are also considered complete for construction workers, although they would have a shorter exposure duration.

Sediment

- Dermal contact and incidental ingestion pathways for recreational and Tribal users in both intertidal and Study Area-wide sediment. The exposure scenarios include beach play, clam digging, and net-fishing. These scenarios are also considered protective of recreational kayakers that launch their boats from the shoreline.
- Indirect exposures (shellfish and fish consumption) for recreational and Tribal fish/shellfish consumers due to bioaccumulation of contaminants.[44]

Potentially exposed ecological receptors in the uplands include terrestrial vascular plants; invertebrate communities; and herbivorous, omnivorous, and invertivorous wildlife following the site-specific TEE process (WAC 173-340-7490). Larger herbivorous and carnivorous wildlife are not expected to spend significant time foraging in the Study Area due to their large home ranges. In the intertidal and subtidal sediment areas, potentially exposed ecological receptors include the benthic invertebrate community, fish, marine mammals, and aquatic-life dependent wildlife. The ecological exposure pathways that are considered complete are as follows:

Soil

- Direct contact (ingestion, dermal contact) for terrestrial invertebrates and vascular plant communities.
- Incidental ingestion during foraging for terrestrial birds and mammals. Direct contact to surface soils is complete, but insignificant due to the presence of fur and feathers.

[44] Tribal and recreational consumers would have different consumption rates and other exposure factors; however, they are evaluated together using the more protective screening criteria provided in SCUM.

- Ingestion of plants or invertebrates (i.e., earthworms) for herbivorous, omnivorous, and invertivorous wildlife (e.g., shrew, vole, and American robin) due to bioaccumulation. Large terrestrial herbivore (e.g., deer) and carnivore exposure via bioaccumulation is complete; however, due to their large home ranges, exposure is limited, and the pathway is considered insignificant.

Sediment

- Direct contact (ingestion, dermal contact) for benthic invertebrates.
- Indirect exposures (shellfish and fish consumption) for aquatic-life dependent marine mammals (e.g., northern sea otter and harbor seal) and birds (e.g., spotted sandpiper and osprey) due to bioaccumulation.
- Direct contact (ingestion, dermal contact) to surface water for fish, however there are not screening values available for this pathway. Incidental ingestion of surface water for wildlife receptors is complete but insignificant due to saline water not being an appropriate potable water source. This pathway is discussed qualitatively.

The sediment bioaccumulation pathway for human and ecological receptors was evaluated by comparison of surface sediment data to bioaccumulative SCOs (i.e., NB or PQL SLs).

7.4 Human Health Risk Evaluation

The following sections discuss the risk screening performed for the complete human health exposure pathways. A summary of results is presented in Table 7-1a and 7-1b, and potential risk pathways are shown conceptually in Figure 7-1b. Media-receptor pairs with an excess lifetime cancer risk (ELCR) greater than $1x10^{-6}$ or a hazard quotient greater than 1 were identified as COCs that exceed Ecology's risk threshold. Cumulative risk was also considered for direct contact pathways (see Section 7.4.3).

7.4.1 Direct Contact with Soil and Sediment

The direct contact pathways (i.e., incidental ingestion, dermal contact and absorption, and inhalation [for soil only]) were evaluated for COCs identified in Section 5.3. The maximum detected concentration was compared to direct contact SLs. If the maximum was below the SL or the FOE was less than 5%, the COCs contribution to risk is insignificant. If a COC was retained, then an IDW-based SWAC and/or a 95% UCL (soil only) was developed (see methods in Section 6.7 for the SWACs and Section 7.5 for the 95% UCLs) for appropriate spatial scales and results were compared to the cancer and noncancer direct contact SLs. The SL comparison included the following:

- Upland: The maximum and 95% UCL from the top 15 ft of soil was compared to MTCA method B direct contact SLs (Table 7-2).
- Intertidal sediment: The maximum and SWAC from the top 2 ft was compared to the beach play (Table 7-3) and clamming (Table 7-4) direct contact SLs.

- Intertidal/subtidal sediment (site-wide): The maximum and SWAC from the top 10 cm was compared to the net-fishing direct contact SLs (Table 7-5).

Results of the screening identified the following:

- Upland soil area: Arsenic, total cPAH based on the TEQ, and total TCDD based on the TEQ were retained as soil COCs with risks exceeding the acceptable individual chemical threshold ($1x10^{-6}$) or for cumulative risk ($1x10^{-5}$) (see Section 7.4.3). The 95% UCL for lead (401 mg/kg) was above the MTCA Method A value for unrestricted site use (250 mg/kg).
- Intertidal sediment: Arsenic and total cPAH based on the TEQ were retained as sediment COCs because SWACs exceeded cancer SLs. The total cPAH TEQ SWAC did not exceed $1x10^{-6}$ for the beach play scenario. Total TCDD TEQ SWAC was below SLs.
- Intertidal/subtidal sediment: Arsenic and total cPAH based on the TEQ were retained as sediment COC with risks because SWACs exceeded cancer SLs, while the total TCDD TEQ SWAC was below SLs.

7.4.2 Human Heath Bioaccumulation

Surface sediment data (0 to 10 cm) for bioaccumulative COCs were compared to the bioaccumulative SCO (i.e., natural background or the average PQL) to determine risk related to human consumption of shellfish and fish consumption for recreational and Tribal fish/shellfish consumers. If the maximum detected concentration of the bioaccumulative COC was below the SL, or the FOE was less than 5%, then the risk is considered insignificant. For COCs that were retained, IDW SWACs (see methods in Section 6.7) were developed and compared to the bioaccumulation SLs (Table 7-6).[45] Lead, four HPAHs (benzo[g,h,i]perylene, fluoranthene, indeno[1,2,3-cd]pyrene, and pyrene), total cPAH based on the TEQ, and total TCDD TEQ SWACs exceeded their respective bioaccumulative SL. Arsenic, cadmium, and mercury SWACs were below their respective SL.

7.4.3 Cumulative Risk

The determination of whether a COC was present above an acceptable risk threshold included the consideration of the cumulative risk for a receptor in accordance with MTCA. The calculation of cumulative risk was conducted for human populations and not ecological communities due to the uncertainty related to combining risk estimates for ecological populations (e.g., toxicity values for one contaminant may not be applicable to another species). Therefore, the cumulative risk was calculated for human cancer and noncancer endpoints for soil and sediment.

The acceptable cumulative cancer risk when there are multiple hazardous substances and/or pathways is identified in WAC 173-340-700 as $1x10^{-5}$. Therefore, if the cumulative ELCR for a

[45] Benzo(g,h,i)perylene, fluoranthene, and pyrene are identified as bioaccumulative. The average PQL was selected for comparison.

receptor-media pair exceeded $1x10^{-5}$, those COCs with an individual ELCR equal to or exceeding $1x10^{-6}$ were identified as exceeding Ecology's risk threshold. For noncancer endpoints, hazard quotients were summed to develop a hazard index (HI). A summary of the cumulative cancer and noncancer risks follows:

- Direct contact for soil exposure (Table 7-2): the cumulative ELCR was $4x10^{-5}$; therefore, arsenic, total cPAH based on the TEQ, and total TCDD based on the TEQ were identified as COCs above Ecology's threshold. The HI exceed 1 due to total TCDD based on the TEQ (hazard quotient of 2).
- Direct contact for beach play intertidal sediment exposure (Table 7-3): the cumulative ELCR was $7x10^{-6}$; therefore, COCs with individual ELCRs greater than $1x10^{-6}$, arsenic and total cPAH based on the TEQ, were identified as COCs above Ecology's threshold. The HI did not exceed 1.
- Direct contact for clamming intertidal sediment exposure (Table 7-4): the cumulative ELCR was $2x10^{-5}$; therefore, arsenic, total cPAH based on the TEQ, and total TCDD based on the TEQ were identified as COCs above Ecology's threshold. The HI did not exceed 1.
- Direct contact for net fishing surface sediment exposure (Table 7-5) – the cumulative ELCR was $7x10^{-6}$; therefore, those COCs with individual ELCRs greater than $1x10^{-6}$ were identified as COCs above Ecology's threshold. Th HI did not exceed 1.

7.5 Ecological Evaluation

The following sections discuss the risk screening performed for the complete ecological exposure pathways, and the results of the TEE utilizing the table lookup method using SLs from WAC 173-340-7490 Table 749-3. The SLs were supplemented with SLs from authoritative sources (e.g., EPA Ecological SSLs, EPA Region 4, EPA Region 5, Los Alamos National Laboratory) and are discussed in Section 5.1. Results are summarized in Tables 7-1a and 7-1b.

7.5.1 Soil Terrestrial Ecological Evaluation

The direct contact (i.e., soil invertebrates and plant communities) and bioaccumulation (i.e., wildlife) pathways were evaluated for COCs identified in Section 5.3. For retained COCs, 95% upper confidence limit of the arithmetic mean (UCL) were developed for comparison to ecological SLs including data collected from the top 15 ft in soil. The 95% UCLs were developed using EPA's ProUCL v5.2 (2022) and the input and output files are provided in Appendix R. The maximum detected concentration and 95% UCL were compared to SLs.

Copper, lead, zinc, TPHs, HPAHs, bis(2-ethylhexyl)phthalate, di-n-butyl phthalate, and total TCDD based on the TEQ were retained as COCs above acceptable risk thresholds. All other COCs 95% UCLs were below their respective SLs, or their hazard quotients did not exceed 1 and were not retained as COCs above acceptable risk thresholds (Table 7-6).

7.5.2 Sediment Benthic Risk

Benthic risk was evaluated on a point-by point-basis with surface sediment data chemistry (0 to 10 cm bml) compared to dw or OC-normalized benthic SCOs. Summary statistics, DF, and FOEs are provided in Table 7-7.

Among the 89 surface sediment samples, lead, mercury, five HPAHs, phenanthrene, phenol, and butyl benzyl phthalate were detected above the benthic SCO with greater than 5% FOE (except lead, at 4% FOE). As discussed in Section 6.3, bioassay results indicated one CSL exceedance of biological criteria (SG-05) in the former Mill Pond, and one COC (mercury) exceeded the benthic SCO. Bioassay results from locations surrounding SG-05 (within 25 ft) did not exceed the SCO or CSL biological criteria. Overall, results of bioassay testing showed the surface sediment in the Study Area as being a healthy environment for the benthic community with one exception in the former Mill Pond. However, those COCs that exceeded the benthic SCO were identified as exceeding an acceptable risk threshold. Mercury was identified as a COC that exceeds an acceptable risk threshold based on the exceedance of the benthic SCO and the bioassay result that exceeded the CSL at SG-05.

7.5.3 Sediment Wildlife Bioaccumulation

Surface sediment data (0 to 10 cm bml) for bioaccumulative COCs were compared to the bioaccumulative SCO (i.e., NB) for aquatic-life-dependent wildlife and marine mammals (e.g., northern sea otter and harbor seal) and birds (spotted sandpiper and osprey). If the maximum detected concentration of the bioaccumulative COC was below the SL, or the FOE was less than 5%, then the risk is insignificant. For COCs that were retained, IDW SWACs (see methods in Section 6.7) were developed and compared to the bioaccumulation SLs (Table 7-8). Lead, four HPAHs (benzo(g,h,i)perylene, fluoranthene, indeno(1,2,3-cd)pyrene, and pyrene), and total TCDD TEQ SWACs exceeded their respective bioaccumulative SL. Arsenic, cadmium, and mercury SWACs were below their respective SL.

7.6 Evaluation of Wood Waste and Degradation Indicators

Results of the RI field activities showed that wood waste is present in surface sediment of the former Mill Pond and Inner Harbor areas, subsurface sediment of the Inner Harbor Area, and subsurface soil of the Upland areas in locations of former Mill buildings. The presence of wood waste at percentages higher than 40% generally overlaps with the location of former Mill buildings, wharf footprint, and log rafting areas of the former Mill Pond (Appendix J). Twenty bioassay tests were conducted at 20 sampling stations with varying abundance of wood debris (between 0 and 80% by volume) in October and November 2021 and 2022. A total of 19 of the 20 bioassay tests passed the SCO and CSL biological criteria. One station in the former Mill Pond (SG-05) failed the SCO and CSL biological criteria for the polychaetae test.[46] This bioassay failure

[46] Bioassays at two locations (SG-31 and SG-33) passed the biological criteria for the larval tested when compared to the negative sand control. Bioassay at those locations failed the SCO biological criteria when compared to the reference sample, but performance of the reference was exceptional and unusual. Therefore, determinations were based on the negative control which is acceptable under the SMS.

does not appear to be due to the presence of wood waste, because there was less than 10% wood waste at this location (Figure 6-35a).

A secondary analysis was conducted to further assess the potential impacts of wood waste on the aquatic environment. The following subsections discuss indicators of wood waste decomposition, correlation of wood waste with dissolved oxygen and aRPD depths in surface sediment, and collocation with identified COCs.

7.6.1 Indicators of Wood Waste Decomposition

Conventional analytes including TOC, TVS, dissolved oxygen, ammonia, and sulfides in bulk and porewater sediments were measured to assess the impact from decomposition by-products associated with wood waste. Summary statistics including minimum and maximum, median, and averages for these indicator parameters for the former Mill Pond, Inner Harbor, and Outer Harbor sediments are reported in Table 7-9a, and values for discrete samples are listed in Table 7-9b.

- TOC measured in bulk sediment samples was higher in the former Mill Pond, where the average was 5.1% compared to 3.9% in the Inner Harbor, and closer to the Puget Sound average of 2% TOC in the Outer Harbor. The maximum ranged up to 20.7% in Inner Harbor sediments.
- TVS measured in bulk sediment was also higher in the former Mill Pond where the average was 9.0% compared to 6.9% in the Inner Harbor, and 5.4% in the Outer Harbor. TVS percentages ranged up to 29.9% in Inner Harbor sediments.
- Average ammonia and sulfide concentrations were higher in the Outer Harbor with 11.4 and 363 mg/kg respectively, compared to averages of 8.6 and 276 mg/kg in the former Mill Pond, and 6.1 and 167 mg/kg in the Inner Harbor. However, no consistent spatial trend was observed across the Study Area. In addition, the aRPD depth, which indicates the depth to which sediment become anoxic and was measured during the SPI/PV survey (Appendix F). The average aRPD depth was deeper in the Inner Harbor (2.4 cm) compared to the depth measured in the Outer Harbor (1.9 cm). Measurements in the former Mill Pond were not conclusive due to a lack of SPI camera penetration due to debris within the former Mill Pond. .
- Dissolved oxygen was measured ex situ in sediment porewater prior to conducting the bioassay tests and values were found to be within normal ranges (between 6 and 8 mg/L). Ammonia and sulfide were also measured ex-situ in sediment porewater prior to bioassay testing and were analyzed in surface sediment during the tests. Total ammonia in porewater ranged between 1.09 and 26.9 mg/L, while total sulfide ranged between 0.002 and 5.22 mg/L. Concentrations did not appear to be positively correlated with bioassay results. A summary of dissolved oxygen, ammonia and sulfide measurements for bioassay testing is reported in Appendix N-4.

7.6.2 Correlation between Wood Waste and Other Analytes

A statistical analysis was conducted among surface sediment samples to assess the correlation between indicators of wood waste and ammonia, sulfides, TOC, TVS, and selected Study Area

COCs including cPAHs, total PAHs, dioxins/furans (TCDD TEQ), and phenols. The presence of organic compounds like phenol can be associated with decomposition of wood debris (Ecology, 2013a). Results of this analysis are reported in Table 7-10.

There is no strong correlation between wood waste percentage and any of the parameters analyzed (wood waste indicators and selected COCs). There is a statistically moderate correlation between wood waste and concentrations of ammonia, sulfide, TOC, TVS, and phenol. The strongest correlation is between wood waste and phenol. Correlations were statistically weak with PAHs and not statistically significant with dioxins/furans (Table 7-10). Consequently, a significant positive correlation was not identified to support a link of causality between the presence of wood waste and the Study Area COCs.

Concentrations of wood waste degradation indicators were compared to thresholds to assess potential toxicity caused by degradation of wood waste.

- Ammonia concentrations in bulk surface sediment samples were below the no-effect thresholds (115 mg/kg) for the *Neanthes* 20-day bioassay (Kendall and Barton, 2004) at locations tested including at SG-05, where the bioassay test failed the SCO and CSL biological criteria (Figure 7-10a).
- Unionized ammonia was measured in porewater for 18 of the 20 samples collected for bioassay tests[47] and compared to toxicity triggers (Inouye et al., 2015). Concentrations were above the trigger threshold for bivalve (0.04 mg/L) but below the trigger threshold for amphipod (0.46 mg/L) at the bioassay locations tested with the exception of location SG-06 (Figure 7-10b). The percentage of wood waste at location SG-06 was below 10%.
- Sulfide was measured in 43 surface sediment samples, and results met project quality objectives for 34 samples.[48] Concentrations in bulk surface sediment samples were above the freshwater cleanup screening level (61 mg/kg) (Ecology, 2013a) at 24 locations including at SG-05, where the bioassay test failed the SCO and CSL biological criteria (Figure 7-10c). Sediment in areas where wood waste was observed at percentages above 10% generally shows sulfide above the freshwater cleanup SL except for two locations in the former Mill Pond to the South (SG-03 and SG-04).

[47] Bulk sediment porewater measurements were conducted by EcoAnalyst after sample receival but prior to bioassay testing, to determine whether any methods modifications or supplemental testing would be required. Bulk sediment porewater concentrations were not measured when insufficient porewater volume was extracted from the sediment samples. The bulk porewater analysis represents a potential worst-case scenario for ammonia and sulfide exposure. Laboratory reports provided in Appendix N include additional details.

[48] Results for sulfide concentrations were rejected during data validation in 9 of 43 bulk sediment samples due to exceedances of holding time. Data quality assessment provided in Appendix O include additional details.

- Hydrogen sulfide was measured in porewater for 18 of the 20 samples collected for bioassay tests[49] and compared to toxicity triggers (Inouye et al., 2015). Concentrations were below the trigger threshold for bivalves (0.0025 mg/L) at 14 of 20 bioassay locations, above the bivalve but below the polychaeta trigger (0.122 mg/L) at two locations (SG-05 and SG-33), and above the polychaetae trigger at two locations (SG-36 and SG-41). Hydrogen sulfide was above thresholds at locations where the percentage of wood was below 10% (Figure 7-10b).
- TVS were measured in 43 surface sediment samples and compared to the thresholds identified at other wood impacted sites in Puget Sound.[50] The percentages of TVS were above the threshold (15%) at six of 43 surface sediment samples including at SG-05, where bioassay test failed the SCO and CSL biological criteria (Figure 7-10e). TVS exceed the thresholds at locations where wood waste was observed at percentage above 10% (SG-47, SG22, SG23) and below 10% (SG-05, SG-06).
- TOC was measured in 43 surface sediment samples and compared to the thresholds identified at other wood impacted sites.[51] The percentages of TOC were above the threshold (13.5%) at three of 43 surface sediment samples (Figure 7-10f). TOC exceeds the thresholds at locations where wood waste was observed at percentage above 10% (SG-47, SG22, SG23).

Overall, this analysis suggests that there does not appear to be a correlation between exceedances of thresholds for wood waste degradation indicators and wood waste percentages.

7.6.3 Overlap Analysis with Areas with Sediment Exceedances

A spatial overlap analysis was performed for total cPAHs and total TCDD, comparing the concentrations of these chemicals to the percentage of wood waste observed during field activities (e.g., chemistry sampling, SPI collection). Total cPAHs based on the TEQ and total TCDD based on the TEQ were selected because both have extensive footprints above refined SLs. The results for soil are presented on Figure 7-7a and 7-7b and for sediment are presented on Figure 7-8a and 7-8b.

The overlap of total TCDD TEQ concentrations to wood waste in soil is greater than for total cPAH TEQ concentrations; however, the overall overlap with wood waste was similar. The overlap of wood waste over 50%, and 75% and total cPAH TEQ concentrations above 100 µg/kg (MTCA method A) was 58% and 78%, respectively. The overlap of wood waste over 50% and 75% and total TCDD TEQ concentrations above 13 ng/kg (MTCA Method B cancer SL) was 75%,

[49] Bulk sediment porewater measurements were conducted by EcoAnalyst after sample receival but prior to bioassay testing, to determine whether any methods modifications or supplemental testing would be required. Bulk sediment porewater concentrations were not measured when insufficient porewater volume was extracted from the sediment samples. The bulk porewater analysis represents a potential worst-case scenario for ammonia and sulfide exposure. Laboratory reports provided in Appendix N include additional details.

[50] Cleanup levels for TVS were established for the Hylebos waterway and Port Gamble sites to be 15% (Ecology, 2013c).

[51] A cleanup level for TOC was established for the Quendall Terminal and Barbee Mill sites to be of 13.5% (EPA 2019; Aspect and Geosyntec, 2024).

and 89%, respectively. The comparison of the overlap analysis for soil indicates a positive correlation between wood waste percentage and concentrations of total cPAH TEQ and total TCDD TEQ.

The overlap of wood waste (>50%) with total cPAH concentrations and total TCDD concentrations was similar. The overlap of wood waste (>50%) and total cPAH concentrations (above 0.21 µg/kg, 100 times the NB) was 85%, and the overlap with total TCDD concentrations (above 4 ng/kg, NB-based SL) was 83%. The overlap analysis for sediment indicates spatial similarity between wood waste percentage and elevated concentrations of total cPAHs and TCDD. In addition, the footprint of wood percentages above 50% overlaps with former Mill structures including the submerged wharf structure in the Inner Harbor and log rafting areas in the former Mill Pond.

7.7 Summary of Site Risks

This section presents a summary of the human health and ecological direct contact/bioaccumulation risks in soil and sediment. While risk is identified for some COCs above Ecology's risk thresholds, no interim actions are required, and the park can remain open for public use. However, remedial alternatives for metals, PAHs, TPH, and dioxins/furans will be further evaluated in the FS. In addition, as discussed in the uncertainty section (Section 7.8.4), risks related to subsistence use and exposure to sediment may be higher than the estimates presented below due to using NB-based SLs to evaluate the pathway.

Soil

Human health: Arsenic, lead, TPH, total cPAH, and total TCDD concentrations exceed applicable direct contact SLs and risk exceeds acceptable thresholds. Total cPAH had the greatest 95% UCL EF compared to the MTCA Method A SL with the maximum concentration in the top 2 ft of soil, collocated with the maximum arsenic and TPH soil concentrations, near the observed slag piles. The maximum lead concentration (SB-19) was located within the former sawmill footprint at a depth of 0 to 2 ft bgs. The maximum total TCDD TEQ concentration (11,400 ng/kg at SB-22 from 4 to 6 ft bgs), and the maximum depth of exceedance was 10 to 12 ft bgs at SB-22, which was located west of the former Mill.

Ecological: Copper, lead, zinc, TPH, HPAHs, bis(2-ethylhexyl)phthalate, di-n-butyl phthalate, and total TCDD concentrations exceed applicable direct contact/bioaccumulation SLs and risk exceeds acceptable thresholds. Lead and HPAHs had the greatest 95% UCL EFs (compared to MTCA Method A SL and to the EPA Eco SSL, respectively) with the maximum concentration in the top 2 ft, collocated with the maximum copper, zinc, bis(2-ethylhexyl)phthalate, and di-n-butyl phthalate concentrations, located near the former machine and blacksmith shops. The maximum TPH concentration was located within the former sawmill footprint. The maximum total TCDD TEQ (SB-22 from 4 to 6 ft bgs) was located west of the former Mill.

Sediment

Benthic: Multiple chemicals exceed their dw or OC normalized SCO criteria; however, the bioassay results for the locations tested did not show effects from toxicity except at one location.

Some chemicals were identified as COCs where bioassay testing was not conducted. Overall, the bioassay results that passed indicate that surface sediment at the site is a healthy environment for the benthic community with one exception in the former Mill Pond (location SG-05). However, surface sediment samples were not collected in the nearshore intertidal area closest to the Inner Harbor shore due to access issues around the remnant pilings and slag piles. Groundwater seeps were noted in this area and *Beggiatoa* bacterial mats were observed at two seep locations. This area will be further evaluated in the FS.

Human health (direct contact): Arsenic and total cPAHs concentrations exceed applicable direct contact (clamming and net fishing) SLs and risk exceeds acceptable thresholds. The greatest SWAC exceedance factor was for arsenic. The maximum concentration of arsenic was in the top 2 ft bml (SC-17) of sediment near the observed slag piles. The maximum total cPAH concentration (BH2-32) was located near the former western lumber shed at 0 to10 cm bml. The depth of contamination was up to 10 ft bml.

Human health and ecological seafood ingestion: Lead, total cPAH, and total TCDD TEQ concentrations exceed bioaccumulative NB-based SCOs. The greatest SWAC EF was for total cPAH, with the maximum concentration (BH2-32) near the former western lumber shed at 0 to 10 cm bml.

7.8 Uncertainty

Uncertainties are inherent in the RI based on assumptions that are often intentionally conservative to ensure protectiveness when evaluating site risks. This section discusses the uncertainties related to assumptions made in the RI process and how they could impact conclusions.

7.8.1 Historical Data

The RI dataset includes historical data collected within the past 10 years as well as samples collected during the RI (see Section 4). In collaboration with Ecology, data collected more than 10 years ago were excluded from the RI dataset for mapping the RI boundary and evaluating site risks. While these older data may provide value when evaluating time trends, the older data were considered less reliable (e.g., higher detection limits, less field documentation).

7.8.2 Method Detection Limits

The MDLs/PQLs for the analytical methods of the RI dataset were compared to refined SLs. For sediment and soil (Table 5-9 and Table 5-10, respectively), the majority of MDLs/PQLs were below their respective refined SL or the FOE was less than 5%. For groundwater, some COPCs had high FOEs (COCs were not among them); specifically, benzo(a)pyrene (and total cPAH based on the TEQ), 4,6-dinitro-2-methylphenol, pentachlorophenol, and TCDD (and total TCDD based on the TEQ). When compared to the refined SLs, no MDLs/PQLs exceeded except for total cPAH based on the TEQ in one sample. Overall, the MDLs/PQLs did not impact the identification of COCs, development of the RI boundary, or characterization of site risk.

7.8.3 Unrestricted Land Use Assumptions

Unrestricted (residential) land use-based SLs were used for identification of COCs, the RI boundary, and evaluation of site risk. These unrestricted SLs overestimate calculated risk for exposure to soil and groundwater because they assume greater exposure than the current site use as a recreational area. Further, the groundwater SLs assume potable use, which is unlikely for the site and surrounding area due to saline conditions. For sediment, the exposure assumptions for human health assume use of the site for a majority of an individual's life (70 years), which more closely represent tribal use but overestimates recreational use of the site.

7.8.4 Assumptions for Bioaccumulative COCs in Sediment

Evaluation of the sediment bioaccumulation risk using NB- or PQL-based SCOs may be conservative for subsistence-level seafood consumption because it does not consider the variability of consumption patterns, age, food sources, etc. that are considered in a more quantitative food web model. Further, ambient conditions may result in sediment concentrations exceeding NB-based SLs. Therefore, identification of bioaccumulation COCs above acceptable risk thresholds based on NB- or PQL-based SLs could identify COCs that are associated with ambient conditions.

Shellfish and fish tissue data were not collected for direct evaluation of risk to human and ecological receptors, so SLs based on Tribal user consumption of fish and shellfish were not developed for the site; NB-based SCOs were used for screening. Collection of tissue data may potentially be a step for future evaluation of Study Area risk to refine the screening level.

Cumulative risk related to exposure to site COCs is underestimated because risks were quantified only for the direct contact pathways. The use of NB-based SCOs might overestimate potential risks related to the site contaminants depending on the degree of accumulation of site sediment COCs into biota. The contribution from consumption of biota was not quantified and therefore was excluded, but could be resolved through tissue sampling, which could be performed in the FS with Agency approval. Risk related to recreational consumption of fish and shellfish at the site is likely less than Tribal consumption, but the direction of the uncertainty is unknown with use of the NB-based SCOs.

Ecological receptors that could be exposed to COCs that bioaccumulate through the food web are also likely overestimated by comparison to NB- or PQL-based bioaccumulation SCOs. It is unlikely that the receptors obtain their entire diet from the site and the use of the bioaccumulative SCOs would overestimate risk to these receptors, especially if regional background is greater than natural background. In addition, NB-based SLs may under or overestimate risk for exposure to sediment due to other potential ambient non-point sources of contaminants (discussed in Section 7.1.1). For the purposes of the RI and to streamline evaluating the risks, NB-based SCOs are used for evaluating bioaccumulative risk, while recognizing there is some uncertainty.

7.8.5 Depth of Contamination

No exceedances of MTCA SLs were detected in the deepest samples from soil borings, with the exception of location SB-22 at 12 ft bgs. Multiple analytes in the deepest soil samples were below the applicable MTCA values but were above the surface soil NB. The surrounding information

from nearby borings was used to evaluate the depth of contamination in the area of SB-22, which was delineated in most of the upland soil borings.

The depth of contamination was fully delineated in 18 of 25 sediment cores. Exceedances of applicable sediment criteria were found in the deepest sample interval in the remaining seven cores, including three cores that were driven to 10 ft target depth in the northern shoreline of the Inner Harbor, and four cores that were not driven to the full planned depth (deepest sample at 4.4 ft bml) because of refusal (rocks or wood substructures). A list of exceedances at depth are reported in Table 7-11.

Soil, groundwater, and sediment media are delineated for purposes of the RI/FS. Additional sampling may be needed to more fully delineate the extent of exceedances at depth in soil and sediments at the site as part of the future remedial design.

7.8.6 Consideration of Background

NB was used as the SMS bioaccumulative SCO during risk screening to evaluate nature and extent of contamination for bioaccumulative COCs. The SMS rule also incorporates the concept of regional background (CSL) that considers concentrations of hazardous substances from regional diffuse sources such as stormwater runoff and atmospheric deposition (Ecology, 2021) that contribute low levels of concentrations of hazardous substances to the site. These ambient values provide context when evaluating concentrations of COCs at the site and their risks. For sediment, the regional background is a CSL for bioaccumulative compounds and, if available, will be used to identify a sediment cleanup level (WAC 173-204-560[4]). Regional background cleanup levels will be established as part of the FS.

As discussed in Section 7.1.1, one example of regional inputs is the historical deposition of airborne arsenic and lead released from the former Tacoma Asarco Smelter, upwind of the Study Area. For samples collected within the Blakely Harbor area, average arsenic concentrations ranged from 8.2 mg/kg in surface soil (2 to 6 in bgs) with maximum values up to 30.7 and 32.5 mg/kg and average lead concentrations ranged from 45.4 mg/kg in surface soil (0 to 2 in bgs) with maximum values up to 198 and 132 mg/kg (PgG and TeraStat, 2005). These results are above the MTCA Method A value of 20 mg/kg and NB value of 7 mg/kg for arsenic and above the NB value of 24 for lead.

7.8.7 Surface Water

The soil-to-groundwater pathway is not complete based on groundwater results, and therefore the groundwater-to-surface water pathway is not complete. Moreover, sediment data screening and bioassay results suggest that risks related to aquatic receptors are low (see Section 6.3). Seeps are present along the shoreline (Figure 7-2), and the presence of some bacteria at the groundwater/surface water interface (seeps) can provide indications of water conditions. Previous investigations at the site observed the presence of *Beggiatoa*, a sulfur-reducing bacteria that may have been associated with the multiple seeps located in the wood waste field along the northern shoreline of the Inner Harbor. Limited observations indicative of *Beggiatoa* were observed during the shoreline habitat survey (Appendix G). In addition, presence of *Beggiatoa* was not observed during the SPI/PV survey (Appendix F, Table 3-3 of Attachment F-1). Due to the incomplete

pathway, low potential risk of site COCs to surface water receptors, and lack of benthic toxicity, no further evaluation of surface water is necessary and cleanup standards for surface water will not be developed.

7.9 Conceptual Site Model Summary

The CSM is presented in Figures 7-1a and 7-1b. Historical Mill operations impacted soil and sediments within the RI boundary. The presence of fill in the subsurface reflects historical construction activities along the waterfront, conducted to expand the shoreline and accommodate the historical structures. Wood waste, bricks, pilings, and slag are remnants of former structures that were deposited or embedded within site soil and sediment. The former building materials (e.g. bricks) provide good visible markers of fill; they are present in the fill but not a source of contamination. Timber pilings were not treated with creosote or hazardous preservatives containing PAH, and therefore, are not considered a potential source of contamination or a risk to human health and the environment. The historical activities have impacted soil in the upland and along the shoreline and sediment in the Inner Harbor, with a range of COCs including metals (arsenic, copper, lead, mercury, zinc), PAHs, and dioxins/furans. A summary of the potential historical sources, COCs, and impacted areas are provided in Table 7-12.

The extent of contamination in soil and sediment and potential sources of individual COCs vary as described below:

- Arsenic is a COC in soil and sediment. Arsenic is a metal generally present due to the natural geology of Washington State, but other diffuse sources could have contributed to its accumulation in soil and sediments at the site. Atmospheric deposition of particles, including arsenic (and lead) transported from the Tacoma Asarco Smelter plume resulted in elevated arsenic concentrations in Puget Sound including Bainbridge Island (Pacific Groundwater Group and TeraStat, Inc., 2005). In addition, arsenic was historically used as a pesticide, in metal alloys, and was a byproduct of smelting. Arsenic concentrations above the MTCA Method A and SCO SL generally overlap with the footprints of former Mill structures in upland and in-water areas of the Study Aare, and concentrations above the NB-based SL in soil and sediments are widespread across the site.
- Copper is a COC in soil and sediment. Multiple sources could have contributed to the accumulation of copper at concentrations above SLs, including metal alloys (brass) in the foundry and blacksmith shop. Copper could also be present in slag piles left over from the foundry. Erosion or leaching of slag may contribute to its accumulation in near-shore soils. Copper concentrations above the MTCA Method B SL generally overlap with the footprints of the blacksmith shop and foundry, near the observed slag piles along the northern shoreline. Concentrations of copper in sediment adjacent to the slag pile area are above the SCO/CSL.
- Lead is a COC in soil and sediment. Potential sources of lead include aerial deposition from the former Tacoma Asarco Smelter Plume, metal forging, or other activities in the foundry and blacksmith shop and use of lead-based products (e.g., paint) in former Mill structures and Mill activities. Lead could also be present in slag piles, and erosion or

leaching of slag could contribute to its accumulation in shoreline soils and sediments. Lead concentrations above the MTCA Method A SL and SMS SCO generally overlap with the footprints of the former foundry and blacksmith structures and slag piles, but concentrations above NB-based SLs are also widespread across the site in soil and sediment.

- Mercury is a COC in sediment. Sources that may have contributed to the accumulation of mercury at concentrations above SLs include ship maintenance activities associated with the Mill activities and as a byproduct from the foundry and blacksmith shop, including exhaust emissions. Mercury concentrations above SMS SCO are in the former Mill Pond in proximity of the former Mill building are possibly due to sediment transport and accumulation, and in proximity to the northern shoreline in the Inner Harbor and Outer Harbor. Mercury concentrations were generally above the SL in near-shore sediments near the slag piles along the Inner Harbor.
- Zinc is a COC in soil. Potential sources of zinc include use in alloys (brass), metal forging, or other activities in the foundry and blacksmith shops, and possible use of zinc-based wood preservative in former Mill structures (e.g., zinc chloride was in use at the time the Mill operated). Zinc may also be present in slag piles, and erosion or leaching from slag could contribute to its accumulation in shoreline soils. Zinc concentrations above NB-based SLs generally overlap with the footprints of the former Mill structures and the observed slag piles on the northern shoreline but are also widespread across the site upland areas.
- TPH are a COC in soil. Potential sources of TPH are fuel transport and fueling operations in proximity of the former Mill building. TPH concentrations above MTCA TEE Soil Biota (200 mg/kg) are located along the northern shoreline in both surface and subsurface soil (up to 10 ft bgs) and generally overlaps with former Mill structure and platform.
- Phenols are considered COCs in sediment. Phenols are associated with degradation of wood polymers (i.e., lignins) in water; although very soluble and volatile, phenols can accumulate in sediment in areas where wood is abundant and decaying and can be toxic in the aquatic environment (Ecology, 2013a). Potential sources of phenol at the site include former Mill buildings, submerged wooden structures, and wood in the fill unit. Phenol concentrations above the SCO (0.420 mg/kg) are located in the former Mill Pond, along the north shore of the Inner Harbor and Outer Harbor, in correspondence with the historical areas used for log rafting or storage and the former Mill and wharf footprints.
- Butyl benzyl phthalate (BBP) is considered a COC in sediment. BBP is a ubiquitous compound widely used in the plastic and manufacturing industry during the twentieth century; it is highly degradable in oxic conditions but can accumulate in sediment under anoxic environments. Potential sources of BBP include construction debris in the fill units along the shoreline and discharge of products containing BBP (e.g., sealants, and paints) used during boat maintenance operations along the shorelines. BBP concentrations above the SCO (0.063 mg/kg) are located in the former Mill Pond, likely

due to accumulation of impacted sediment in depositional areas, and along the northern shoreline of the Inner Harbor, possibly due to the use of BBP-containing products during boat maintenance operations.

- PAHs are COCs in soil and sediment (total cPAHs in soil and sediment and HPAH in soil). PAHs are organic compounds generally present in urban environments due to combustion from automobile/truck and vessel traffic or other anthropogenic activities. Other diffuse sources could contribute to the accumulation in soil and sediments, such as wildfires, road runoff, and treated private docks and pilings. Sources of PAHs associated with former Mill activities include the use of oil products as fuel or as preservatives for wood and combustion. Concentrations of cPAH and HPAHs above MTCA Method B in soil and above the SMS SCO (bioaccumulative SCO corresponding to natural background) in sediment generally overlap with the footprints of former Mill structures such as the hog fuel burner, the saw mill, the foundry, blacksmith, machine shops, and planning mill in the upland areas, and the historical wharf and log rafting areas on the harbor and the former Mill Pond.
- Dioxins/furans (TCDD TEQ) are a COC in soil and sediment. Dioxins/furans are a byproduct of wood combustion, in particular salt laden wood from interaction with seawater. Both historical or current anthropogenic combustion activities may have contributed to accumulation in soil and sediments. Refuse and hog fuel burners were part of the former Mill structures, and atmospheric deposition of particles from the burners could have contributed to accumulation of dioxins/furans in site soils and sediment. In addition, dioxins/furans may have been present in fill material containing wood chips, sawdust, and combustion byproducts (ash). Fill was used in the upland to reshape the shoreline areas. Total TCDD TEQs above the MTCA Method B SLs and SMS CSL generally overlap with the footprints of hog fuel burner and machine shop, or are adjacent to the former Mill wharf and sawmill structures.
- Wood in soil and sediment was collocated with other COCs detected at concentrations exceeding their respective SLs. The RI data does not suggest impairment of the benthic environments due to the presence of wood since wood is not collocated with bioassay tests failing SCO and CSL biological criteria (wood at location SG-05 is below 10%). However, future wood degradation could produce byproducts that could impair the benthic environment. Observed wood percentages above 50% are in the northern portion of the former Mill Pond and in the Inner and Outer Harbor corresponding to the former wharf footprint. The RI dataset includes a limited number of bioassay tests that correspond to the submerged wharf footprint and highest percentages of wood waste. Supplemental testing for wood degradation parameters was completed in September 2025 in areas of high wood concentrations in the Inner Harbor and former Mill Pond to provide additional data for the FS.
- Asbestos was observed in one location in the south upland and mitigated. Asbestos was not found in other areas of the Study Area.

Transport pathways can mobilize COCs from impacted areas and further distribute them in the upland, the former Mill Pond, and Harbor. Based on empirical groundwater data from four quarters

of sampling, transport of COCs from soil to groundwater and groundwater to surface water are not active transport pathways at the site. Atmospheric deposition, erosion of soil, and sediment resuspension due to bioturbation are active transport pathways.

Potential human health receptors include recreational and Tribal users of the site for hiking and wildlife viewing in the upland area and wading, swimming, fishing, and shellfish harvesting in intertidal and/or subtidal sediment areas. Users could be exposed to contaminants via direct contact or ingestion of media. Ecological terrestrial plant and invertebrate communities and herbivorous, omnivorous, and invertivores wildlife are receptors in the upland area that could be exposed to contaminated soil, while the benthic invertebrate community, fish, marine mammals, and aquatic-life dependent wildlife could interact with contaminated sediment.

A summary of the CSM finding for COCs that exceeded an acceptable threshold is provided in Table 7-12. The overlap of areas with COC concentrations exceeding risk thresholds, slag piles, and wood waste are shown on Figure 7-9.

8. PRELIMINARY CLEANUP STANDARDS

This section outlines preliminary cleanup standards, which establish the initial basis for developing cleanup action requirements and evaluating remedial alternatives in the FS. Cleanup standards consist of two elements, the cleanup level (CUL) and the point of compliance (POC). The CUL is the concentration of a hazardous substance in a particular media that is determined to be protective of human health and the environment under specified exposure conditions. The CUL is established by considering applicable or relevant and appropriate requirements (ARARs), risk-based concentrations, background concentrations, and PQLs. The POC is the point or points where CULs must be attained. POCs are established for each media where there is an exposure pathway. At this site, the cleanup levels is applicable based on the location relative to the exposure pathway (i.e., intertidal area for protection of clam harvesting and beach play scenarios).

As discussed below, preliminary CULs identified in this RI report may be refined during the FS, incorporating additional bioassay and wood degradation indicators data collected in September 2025. Further refinement of cleanup levels in the FS may include risk-based concentrations for sediments based on sediment regional background level and tissue sampling if approved by Ecology.

The following sections identify potential chemical-specific ARARs, if available, and proposed cleanup standards for soil and sediment.

Cleanup levels are developed for the following site-related COCs with risk above acceptable thresholds and include the following:

- Soil: arsenic, copper, lead, zinc, TPH, total cPAH (TEQ), HPAHs, total dioxins/furans and two non-site related COCs bis(2-ethylhexyl)phthalate and di-n-butyl phthalate (Table 8-1).
- Sediment: arsenic, lead, mercury, phenanthrene, HPAHs, phenol, butyl benzyl phthalate, total cPAH (TEQ), and total dioxins/furans (Table 8-2).

In addition to positive correlations among COC concentrations, the footprints of elevated concentrations also show spatial overlap with higher concentrations located near historical Mill activities, and lower concentrations moving away from this source area. This correlation will be further evaluated in the FS.

8.1 Preliminary Soil Cleanup Standards

This section identifies preliminary CULs and POCs for COCs in soil. Each COC may have more than one CUL if there is more than one exposure pathway.

8.1.1 Preliminary Soil Cleanup Levels and Point of Compliance

At this site, CULs for soil are based on protection of direct contact exposure (i.e., incidental ingestion, dermal contact, and inhalation for human receptors and ingestion for ecological receptors) and bioaccumulation of COCs into higher trophic levels. There are no impacts to

groundwater and therefore the protection of groundwater as a drinking water source and the related protection of surface water and sediment as a result of groundwater migration are incomplete pathways. CULs considered risk-based concentrations for protection of the direct contact pathway (for human health and ecological receptors) for the COCs that exceeded acceptable risk thresholds (Section 7.5). The CULs were calculated as the highest of the risk-based concentrations or the NB level if available, or PQLs. Preliminary CULs for soil COCs are presented in Table 8-1. The MTCA POC for soil is 0 to 15 ft bgs.

8.1.2 Ecological Cleanup Level Considerations

Three soil COCs, copper, lead, and zinc, exceeded risk-based concentrations for ecological receptors. For these COCs, additional review was performed to refine CULs. Ecological points of compliance are discussed in Section 8.3.2.

Copper exceeded the risk-based concentration for protection of soil biota (see Section 7.5) and was below SLs for protection of plants and wildlife. The risk-based copper SL for soil-biota (50 mg/kg) was based on toxicity reference values (TRVs) from Efroymson et al. (1997a) and corresponds to a no observable effects concentration (NOEC) for earthworm cocoon production. NOEC values are considered protective of all individuals (i.e., below the concentration where effects on a single receptor were noted) and is highly conservative as the management endpoint for ecological receptors is the community level. An updated literature review of soil-biota exposure to copper (EPA, 2007a) provides a more robust soil-invertebrate based risk-based concentration of 80 mg/kg, which reflects the geometric mean of 10% effect concentrations (EC10) or maximum acceptable toxicant concentration from 10 studies capturing potential effects to six species. The soil 95% UCL (96.6 mg/kg) equates to a hazard quotient of 1 indicating that effects at the community level are not anticipated, however, copper was retained as a COC (the current SWAC is close to the higher SL of 80 mg/kg). Nevertheless, to ensure protection, the preliminary, conservative soil CUL for copper is 50 mg/kg.

Lead and zinc exceeded risk-based concentrations for plants and wildlife (see Section 7.5). Healthy flora is present across the site based on field observations, especially in the step-out samples where detected concentrations of both lead and zinc were above the risk-based concentrations for protection of plants (50 mg/kg for lead and 86 mg/kg for zinc), both derived from Efroymson et al. (1997b). Efroymson et al. also specifically noted, "*If chemical concentrations reported in field soils that support vigorous and diverse plant communities exceed one or more of the benchmarks presented in this report or if a benchmark is exceeded by background soil concentrations, it is generally safe to assume that the benchmark is a poor measure of risk to the plant community at that site.*" Additionally, an updated literature review of plant exposure to lead (EPA, 2005) and zinc (EPA, 2007b) identified risk-based concentrations for plant communities at 120 and 160 mg/kg for lead and zinc, respectively. The soil 95% UCLs (401 and 236 mg/kg for lead and zinc, respectively) are in the range of these more recent risk-based concentrations, and field observations support a robust plant community. Therefore, plant community impacts are not anticipated. Nevertheless, to ensure protection, the preliminary, conservative soil CULs for lead and zinc are 50 mg/kg and 86 mg/kg, respectively.

8.2 Groundwater Cleanup Standards

CULs for groundwater consider protection of drinking water and protection of surface water and sediment. However, there were no COCs identified in groundwater (see Section 5.3) and the migration to groundwater pathway is incomplete. Therefore, no cleanup standards were proposed for site groundwater.

8.3 Preliminary Sediment Cleanup Standards

Results of the RI showed that site sediments contain COCs at concentrations that can pose a risk to human health and the environment. Therefore, establishing cleanup standards is required to protect these risks.

No cleanup standard were developed for COCs that did not exceed acceptable risk thresholds or for other analytes that were not shown to be toxic. This section summarizes preliminary CULs for sediment COCs (Section 7.9) and POCs for receptor-specific pathways.

8.3.1 Preliminary Sediment Cleanup Levels

As described in the SMS, the default CUL is set as the SCO which is selected as the highest of the following:

- The lowest risk-based concentration protective of benthic organisms, human health (direct contact, bioaccumulation, 10^{-5} risk), or ecological receptors (bioaccumulation)
- Natural background
- PQLs

Sediment CULs are initially established at the SCO and in the FS may be adjusted up to, but no higher than the CSL considering the technical possibility of achieving these criteria and net adverse environmental impacts associated with their implementation. The CSL is established as the highest of the following:

- The lowest risk-based concentration protective of benthic organisms, human health (direct contact, bioaccumulation, 10^{-5} risk), or ecological receptors (bioaccumulation)
- Regional background, if it has been established
- PQLs

Site-wide CULs consider human and ecological receptors, benthic, direct contact and bioaccumulative exposure pathways, and spatial areas (intertidal, site-wide, subtidal). Preliminary sediment CULs for these receptors and COCs are listed in Table 8-2. The preliminary site-specific CSL will be developed in the FS so that cleanup standards can be established and used to evaluate remedial alternatives. A work plan for regional background sampling and tissue sampling, if requested, will be submitted for Ecology review, and the sampling will be performed as part of the FS. The FS will develop site-specific sediment cleanup levels for wood waste that are protective of benthic organisms based on measured wood waste degradation product hazardous substances (e.g.,

porewater hydrogen sulfide and/or sediment phenol concentrations) and confirmatory bioassay results.

8.3.2 Points of Compliance for Sediment

Sediment POCs address multiple exposure pathways and receptors based on the current or expected use of specific areas of the Study Area. The sediment POCs, exposure pathways, and COCs are described below and summarized in Table 8-2.

- The site-wide POC depth is 0 to 10 cm bml for site-wide exposure pathways (benthic). The depth 0-10 cm bml is the biologically active zone, as confirmed by the SPI survey for site sediment. COCs identified for this POC include lead, mercury, phenanthrene, Total HPAHs, phenol, and butyl benzyl phthalate.
- Ecological health has one point of compliance, 0 to 10 cm depth bml and applies site-wide. The depth of 10 cm bml is the biologically active zone, as confirmed by the SPI survey for Study Area sediment.
- Human health has two points of compliance, as follows: the depth of 0-10 cm bml is the biologically active zone, as noted above, and the depth 0-45 cm bml is based on the depth at which human disturbance is anticipated (e.g., for clamming).
  - 0 to 10 cm bml for human/ecological seafood consumption (bioaccumulative), human health direct contact net-fishing. COCs identified for this pathway include arsenic, lead, Total HPAHs, cPAH TEQ, and TCDD TEQ.
  - 0 to 45 cm bml for the human health beach play and clamming direct contact pathway. COCs identified for this pathway include arsenic, cPAH TEQ, and TCDD TEQ.

These depths are defined in the SMS for POCs based on the specific exposure pathway. The POC is established on a point-basis for benthic protection and an area-averaged SWAC-basis for protection of human and ecological health (bioaccumulation and direct contact), both for the Study Area as a whole (intertidal and subtidal zones combined; 0–10 cm POC), as well as for intertidal zones throughout the Study Area (0–45 cm POC) where beach play and clamming may occur, similar to Ecology's approach in Western Port Angeles Harbor, and other sites. Area-averaging is applied to two spatial areas. The first is the Study Area as a whole (intertidal and subtidal zones combined; 0–10 cm POC). The second spatial area applies to the intertidal zones throughout the Study Area (0–45 cm POC) where beach play and clamming may occur, CULs must typically be met at these depths after the restoration time period (usually, 10 years after completion of construction and natural recovery processes continue). Recovery time estimates will be evaluated in the FS.

9. RI SUMMARY AND CONCLUSIONS

Blakely Harbor Park Site includes 40 acres of upland land, and a natural marine embayment that was actively used for milling and industrial activities during the late 1800s until the early 1900s. The Mill was closed in 1923. The Study Area is currently a recreational Park and includes a residential waterfront area that supports recreational activities such as walking, boating and anchoring, and kayaking. Mill remnants include a concrete building foundation and walls, wood pilings, building debris (e.g., bricks), and slag piles along the shoreline. Sources of contamination are primarily historical and are associated with former operations at the former Port Blakely Mill. In addition, wood waste, lumbered wood, foundry bricks, and other construction debris may have been used as fill material during reconstruction or expansion of the Mill structures after the 1888 and 1907 fires and prior to 1923.

The Study Area was subdivided into five areas: (1) the north upland area where the majority of historical mill activities occurred and is currently the entrance to the public park; (2) the south upland area where the historical planing mill activities occurred, now occupied by the public park and bordered by residential landscaping; (3) the former Mill Pond, a quiescent depositional intertidal area exposed at low tides that was formerly used for log rafting; (4) the Inner Harbor, a tidally influenced area with submerged former Mill and wharf structures and slag piles on the shoreline; and (5) the Outer Harbor, an area with deeper water depths beyond the wharf footprint and former Mill activities.

Archaeological monitoring was conducted for ground disturbing activities associated with the soil, groundwater, and sediment sampling investigation, including both upland and nearshore sampling. No in-situ artifacts or features were encountered during the RI investigation (details provided in Appendix A).

Media sampled included soil, groundwater, and sediment. The Study Area soil and sediments were subdivided into three major stratigraphic units including: (1) surface fill material consisting of topsoil, sand fill, wood, metal, slag and brick debris in soil and silts, clays, sands, and wood in sediment; (2) geologically recent deposition characterized as a silty sand/sandy silt with no fill material above the native material at some locations but not site-wide; and (3) native alluvial deposits (silt, sand, with some gravel and shell fragments) observed in the majority of borings/cores. Bedrock (sandstone of the Blakely Formation) was encountered in few, shallow hand-auger borings in the north upland area.

COCs were found in soil and sediment above SLs in each of the five areas, and COC concentrations declined with depth and with increased distance from the former Mill. COCs include metals (arsenic, copper, lead, mercury, and zinc), PAHs, phenols, phthalates, TPH, and dioxins/furans. Elevated COC concentrations in soil and sediments are associated with fill material, and found near the former Sawmill, the former foundry, blacksmith shop, and slag piles, the hog fuel burner and smoke stack, and the footprint of the former wharf structure along the northern shoreline The vertical and horizontal extent of contamination has been delineated in both soil and sediment for the purposes of the RI. Groundwater is not impacted within the Study Area. Wood waste is present in the north upland area, the former Mill Pond, and the Inner Harbor at the surface and at depth in

varying amounts ranging from 0 to >80%. The highest concentrations of wood overlap with the former wharf structure and northern area of the former Mill Pond. Results of bioassay testing showed that abundant volumes of wood waste do not result in toxicity to the benthic community in the samples tested except for one restricted area (one of the 20 bioassays failed in the former Mill Pond). However, surface sediment samples and bioassay tests were not collected/analyzed from the nearshore Inner Harbor areas due to access constraints. Nearshore areas with elevated COC concentrations above screening criteria were not tested due to the chemical exceedances and assumed to require cleanup.

Data Gaps

Visual indications of wood degradation (i.e., presence of *Beggiatoa* and hydrogen sulfide) were also present in the Inner Harbor area. Additional sediment sampling for wood degradation products and bioassay testing was completed in September 2025 in portions of the former Mill Pond and Inner Harbor in areas with some of the highest concentrations of wood waste. The results will provide supplemental data for the FS.

Conclusions

Complete and active fate and transport pathways that could mobilize COCs include soil erosion, atmospheric deposition, sediment transport and redistribution, and upward migration (biological and physical) from subsurface sediment. Receptors potentially exposed to COCs include (1) human health recreational users, subsistence fishers, and potential construction workers and (2) ecological receptors terrestrial plants, invertebrate communities, and wildlife. Exposure pathways include direct contact, incidental ingestion, and seafood bioaccumulation. A risk evaluation identified existing risks for some COCs above regulatory thresholds; however, no interim actions are required, and the park can remain open for public use.

The identified COCs are as follows:

- Soil: arsenic, copper, lead, zinc, DRO plus lube oil, cPAHs, HPAHs, and dioxins/furans and two non-site related COCs, bis(2-ethylhexyl)phthalate and di-n-butyl phthalate.
- Sediment: arsenic, lead, mercury, phenanthrene, HPAH, cPAHs, phenol, butyl benzyl phthalate, and dioxins/furans.

Soil, groundwater, and sediment media are considered delineated for purposes of the RI and moving forward with the FS. Additional sampling may be needed in the FS to refine the extent of COC exceedances at depth in some areas, provide greater sample density to determine final remedial areas and volumes, and to establish final CULs. This RI Report provides a foundational understanding of site characteristics and risks so that remedial alternatives can be developed in the FS. The RI collected sufficient soil, groundwater, and sediment data to evaluate alternatives in the FS.

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