Lower Duwamish River
Natural Resource Damage Assessment: Injury Assessment Plan

Final Draft | July 2018

The Elliott Bay Trustees:

The National Oceanic and Atmospheric Administration,
The United States Department of the Interior,
The State of Washington, The Suquamish Tribe,
and The Muckleshoot Indian Tribe

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TABLE OF CONTENTS

LIST OF EXHIBITS

LIST OF ACRONYMS AND ABBREVIATIONS

Assessment Area	Lower seven miles of the Lower Duwamish River, including the estuary where the River enters Elliott Bay and the delta near Harbor Island
BEHP	bis(2-ethylhexyl)phthalate
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
COC	contaminant of concern
CSO	combined sewer overflow
DIVER	NOAA Data Integration Visualization Exploration and Reporting database
EPA	U.S. Environmental Protection Agency
EW	East Waterway
IC	institutional control
MLLW	mean lower low water
MNR	Monitored Natural Recovery
NOAA	National Oceanic and Atmospheric Administration
NRDA	Natural Resource Damage Assessment
OU	Operable Unit
PAHs	polycyclic aromatic hydrocarbons
PCBs	polychlorinated biphenyls
PI	Principal Investigator
Plan	Injury Assessment Plan
PRP	Potentially Responsible Party
QA	quality assurance
QAPP	Quality Assurance Project Plan
QC	quality control

RCDP	Restoration Compensation and Determination Plan
RI/FS	Remedial Investigation/Feasibility Study
RP/PEIS	Restoration Plan and Programmatic Environmental Impact Statement
SD	storm drain
Site	Harbor Island, Lockheed West Seattle, and the Lower Duwamish Waterway Superfund Sites
TBT	tributyltin
Elliott Bay Trustees	NOAA, United States Department of the Interior, State of Washington, Suquamish Tribe, and Muckleshoot Indian Tribe
U.S.	United States
USC	United States Code

EXECUTIVE SUMMARY

The Lower Duwamish River is an urban waterway flowing through Seattle, Washington that has been subject to considerable levels of industrial use throughout its history and into the present. Historically, the Lower Duwamish River and estuary meandered through tidal wetlands, entering Elliott Bay via three main distributary channels, and included a broad expanse of unvegetated intertidal flats and shallows that existed at the mouth of the estuary bordering the south margin of Elliott Bay (Blomberg 1988). Over time, the Lower Duwamish River changed significantly due to industrialization and the straightening, dredging, filling, and deepening of the river channel. In addition, since the early 1900s, oil and hazardous substances were discharged to the Lower Duwamish River as a result of industrial and municipal activities. Three active Superfund sites are located along the river and are undergoing remediation: the Harbor Island Superfund site, the Lockheed West Seattle Superfund site, and the Lower Duwamish Waterway Superfund site (together, the Site).

Despite these alterations, the Lower Duwamish River continues to provide important habitat for more than 50 fish species, including chum, Chinook, pink, and coho salmon, steelhead, and shellfish. Three salmon hatcheries within the Green/Duwamish River system release approximately 14 million juvenile salmon each year, and the river and its tributaries also support a natural salmon run (NOAA 2017). The Muckleshoot Indian Tribe and the Suquamish Tribe are involved in the management of net pen operations in Elliott Bay tied to these hatchery operations. The Lower Duwamish River also continues to support recreational harvest of fish by the general public and subsistence, ceremonial, and commercial harvesting of fish by tribal members.

Under the Comprehensive Environmental Response, Compensation, and Liability Act 42 United States Code (USC) §§ 9601, *et seq*. (CERCLA), and other applicable authorities, the United States (U.S.) Department of the Interior, the State of Washington, the U.S. Department of Commerce, represented by the National Oceanic and Atmospheric Administration (NOAA), the Suquamish Tribe, and the Muckleshoot Indian Tribe (collectively, Elliott Bay Trustees) are conducting a Natural Resource Damage Assessment (NRDA) for resources exposed to hazardous substances and oil in the aquatic habitat of the lower seven miles of the Lower Duwamish River, including the estuary where the River enters Elliott Bay and the delta area near Harbor Island (Assessment Area). The ultimate goal of NRDA is to restore, replace, rehabilitate, or acquire the equivalent of injured natural resources and resource services lost due to the release of hazardous substances. To achieve this goal, the Elliott Bay Trustees will complete a

number of steps outlined in the CERCLA NRDA regulations, including this Injury Assessment Plan (Plan).

This Plan describes the Elliott Bay Trustees' current understanding of the Lower Duwamish River, natural resources associated with the Assessment Area, and the types of existing data and information regarding the likely exposure to and effects of contamination on natural resources (e.g., NOAA Data Integration Visualization Exploration and Reporting database (DIVER), site-specific toxicity studies). To the extent possible, the Elliott Bay Trustees are using these data to begin to determine injury based on injury definitions in the CERCLA NRDA regulations, such as a measurable adverse change in the resource or the existence of a consumption advisory (43 Code of Federal Regulations (CFR) §§ 11.14(v) & 11.62). To evaluate the adverse effects of hazardous substances and oil on Assessment Area biota[1], the Elliott Bay Trustees are focusing efforts on injuries to benthic invertebrates (including shellfish), forage fish (sculpin), bottom-dwelling fish (English sole), and salmon and associated service losses as set forth more fully in the studies described in this Plan. At this time, the contaminants of concern (COCs) warranting immediate action by the Elliott Bay Trustees include polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), and tributyl tin (TBT) due to their elevated concentrations, widespread presence in sediments throughout the Assessment Area, and connection to industrial sources. The results of ecological, recreational, or tribal use injury studies may indicate connections between injuries and additional site-related contaminants. These additional contaminants of concern would then be included in pathway and other studies necessary to connect releases, exposure, and injuries as required by the NRDA regulations. Once all natural resource injuries and service losses are determined, the Elliott Bay Trustees will quantify those injuries to define the scope and scale of losses and to inform the selection and scaling of restoration projects.

For millennia, Native Americans have used the natural resources at, near, and within the Assessment Area for cultural and subsistence activities including harvesting fish and shellfish, gathering of plants for medicines, and religious ceremonies. Four archaeological sites documented in the Duwamish River drainage document that initial hunter-fisher-gatherer use of Duwamish River as early as 2,000 years ago (Larson 1995). Tribal Trustees have reserved fishing, hunting, and gathering rights (among others) under the 1855 Treaty of Point Elliott signed with the United States. Further, Trustee Tribes also have adjudicated usual and accustomed fishing areas that are located in the Assessment Area. The culture and way of life of Trustee Tribes are inextricably tied to the estuarine ecosystem resources that have been exposed to Assessment Area-related contaminants. Contamination in the Assessment Area has and continues to limit the use of resources in the Assessment Area and has a negative effect on the cultural and spiritual well-being of the Tribes.

[1] Biota are the animals and plants of a particular region or habitat.

At this time, the Elliott Bay Trustees anticipate assessing ecological, recreational, and tribal losses using the following approaches for injury quantification:

- **Ecological:** A variety of natural resources utilize the habitat within the Assessment Area. To determine the damages required to compensate for ecological injuries to these resources, the Elliott Bay Trustees intend to calculate the quantity of habitat needed to generate an equivalent quantity of injured species over time. The method(s) for determining damages will be further discussed in a separate document.
- **Recreational (human use):** To assess the scope of losses, the Elliot Bay Trustees will rely on existing information and interviews, and may implement survey-based methods for quantifying recreational losses due to contamination if warranted. The Elliott Bay Trustees may base damages either on the lost value of recreational use services or the cost of implementing sufficient restoration such that the amount of recreational use value created is equivalent to the value lost.
- **Tribal lost services:** The Elliott Bay Trustees will conduct a cultural assessment to quantify the change in services provided by natural resources and corresponding impacts to tribal communities due to contamination of resources.

To determine and quantify natural resource injuries using the methods described above, the Elliott Bay Trustees identified potential studies that may be implemented, and that will ultimately assist the Elliott Bay Trustees in identifying and scaling restoration projects that will compensate for those injuries. The studies focus on species tied most directly to the Assessment Area (e.g., benthic invertebrates (including shellfish), forage fish, bottom-dwelling fish, and salmon) and therefore have the highest likelihood of injury due to the release of Site-related hazardous substances. Each study will include the data collection and analyses necessary to evaluate baseline conditions of natural resources.

The Elliott Bay Trustees prioritized studies as nearer-term (Level 1), middle-term (Level 2), and longer-term priorities (Level 3) based on the dependence of each study on the results of previous studies; needs for clarifying extent of injury and connections to releases; and ability to assist in scaling restoration alternatives. Studies prioritized as nearer-term largely rely upon existing data or provide a foundation for subsequent studies. This systematic approach helps ensure that studies satisfy the standard of reasonable cost outlined in the CERCLA NRDA regulations, 43 CFR part 11. Additionally, study development may be coordinated with ongoing study efforts initiated by other entities (e.g., U.S. Environmental Protection Agency and Washington Department of Fish and Wildlife).

This Plan is not intended to limit additional or alternative studies that may be undertaken in the course of the assessment, as the Elliott Bay Trustees recognize that other studies may become necessary or advisable as the assessment proceeds and new information becomes available. In addition, the inclusion of a study within this Plan does not guarantee that it will be undertaken – the Elliott Bay Trustees may determine that some of

these efforts are not needed or may have lower priority. A Quality Assurance Project Plan will be developed for each implemented study to ensure that data are of sufficient quality to support Trustee decisions in the context of the NRDA process.

CHAPTER 1 | INTRODUCTION

The Duwamish River comprises the last twelve miles of the Green River Watershed, extending from the confluence of the Green and Black Rivers to its mouth at Harbor Island in Seattle, Washington (Exhibit 1-1). The lower seven miles of this estuarine system, known as the Lower Duwamish River, are characterized by industrial activity and historic discharges of hazardous wastes dating to the early 1900s. Industries that have operated or continue to operate along the Lower Duwamish River include airplane manufacturing, shipyards that manufacture and repair boats, cargo handling and storage, metal fabrication, lumber milling and storage, cement production, food processing, and petroleum storage (primarily on Harbor Island). The Lower Duwamish River is also the discharge point for many combined sewer overflows (CSOs) and storm drains (SDs).

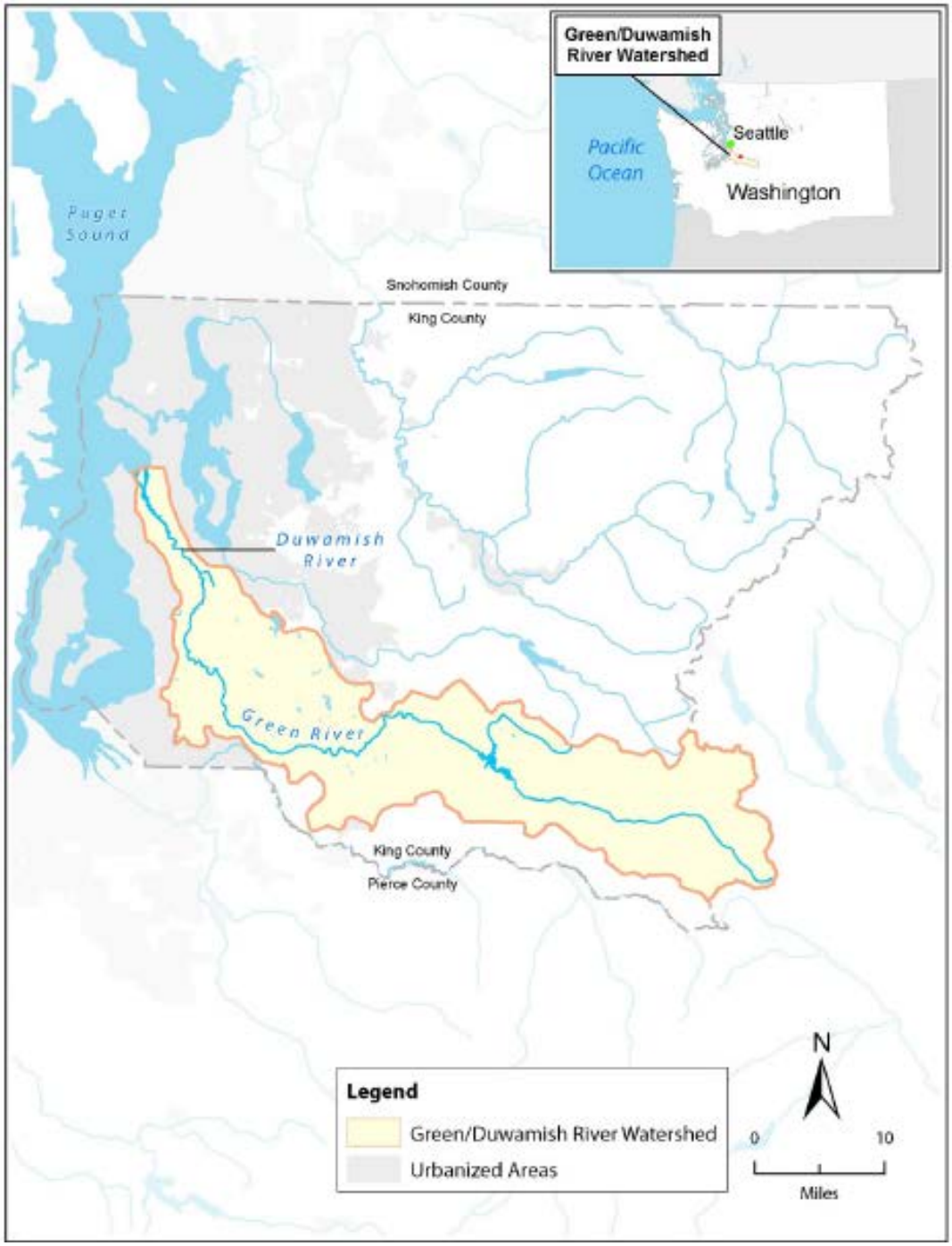
In addition to the adverse effects of contamination, the Lower Duwamish River has been physically modified and channelized. The lower portion of the river is periodically dredged to maintain the Federal navigation channel and, as a result, now contains deep water habitats where none historically existed. Wetlands have been dredged and filled, causing the Lower Duwamish River to contain only a fraction of the mudflats and tidal marshes that once existed.

Despite significant alterations, the Lower Duwamish River remains an important waterway for associated natural resources. For example, sampling efforts for the Lower Duwamish Waterway Remedial Investigation/Feasibility Study (RI/FS) identified dozens of species of fish, nine of which were salmonids and some of which are endangered (AECOM 2012, Windward 2010). The river is vital for migrating and spawning salmonids, serving as a transition area as these fish adapt to salinity changes, as well as an important foraging environment for juvenile salmonids. Remedial studies also identified over 80 species of birds and six species of mammals that use the Lower Duwamish River to feed, rest, and reproduce for at least part of the year (AECOM 2012, Windward 2010).

In addition to the ecological functions provided by the Lower Duwamish River, people are connected to and utilize the natural resources of the river. Indigenous Native American communities' relationship to the Lower Duwamish River pre-dates the arrival of European settlers to the Seattle area (Larson 1995, URS 1987). The cultural importance of this area to Trustee Tribes continues through the present. Examples of current tribal uses and connections include tribal treaty and subsistence fishing of migratory salmon, cultural events at parks along the river, utilization of the Lower Duwamish River as a migration corridor for hatchery-raised salmon from upriver operations, and the use of nearby areas for the harvest of crab and shrimp. Historically, tribes have also harvested clams in the area. Non-Native American members of the public

also make direct use of the Lower Duwamish River through activities such as recreational fishing, subsistence fishing, and boating.

EXHIBIT 1-1 **MAP OF THE DUWAMISH/GREEN RIVER LOWER WATERSHED AND LOCATION OF THE DUWAMISH RIVER (NOAA 2013)**



1.1 PURPOSE AND OVERVIEW

The purpose of this Injury Assessment Plan (Plan) is to outline the approach that the Elliott Bay Trustees will take in determining and quantifying injury[2] to natural resources[3] affected by the release of hazardous substances and oil and quantifying corresponding damages[4]. This process, natural resource damage assessment (NRDA), will ensure efforts are conducted in a systematic manner and at a reasonable cost, as required by the United States (U.S.) Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) NRDA regulations (42 USC §§ 9601 *et seq*., 43 CFR Part 11), and prepared in accordance with other applicable Federal and state laws.

The Plan will facilitate coordination between the Elliott Bay Trustees and the public, including a public comment period for this Plan, with the goal of creating a comprehensive strategy for assessing natural resource injury. It will also promote coordination between the NRDA and the remedial actions being conducted by the U.S. Environmental Protection Agency (EPA) and State of Washington.

This Plan represents a Phase I plan for a Type B assessment,[5] focusing on those steps required for injury determination and quantification as well as damage determination. As the Elliott Bay Trustees implement this plan, it may be modified to include additional studies as necessary.

1.2 SITE HISTORY

Historic maps of the Duwamish River estuary show a river meandering through significant areas of tidal wetlands and entering Elliott Bay via three main distributary channels (Blomberg 1988). The watershed area of the estuary included lakes Sammamish and Washington, and the Cedar, Black, Green and White Rivers. Historic discharge of freshwater through the estuary was estimated to range between approximately 2,500 cubic feet per second (cfs) and nearly 9,000 cfs (Blomberg 1988). A significant feature of the downstream portion of the estuary was a broad expanse of unvegetated intertidal flats and shallows (approximately 1,450 acres) at the mouth of the estuary bordering the south margin of Elliott Bay.

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[2] Injury is a measurable adverse change, either long- or short-term, in the chemical or physical quality or the viability of a natural resource resulting either directly or indirectly from exposure to a discharge of oil or release of a hazardous substance (43 CFR §11.14(v)).

[3] Natural resources are surface water (including sediment), groundwater, air, geologic, and biological resources managed by, held in trust by, appertaining to, or otherwise controlled by the United States, State or local government, or Indian Tribe (43 CFR §11.14(z)).

[4] Damages are the amount of money sought by the natural resource trustee as compensation for injury, destruction, or loss of natural resources (43 CFR§11.14(l)).

[5] A Type B assessment allows trustees to apply a variety of methodologies described in the CERCLA NRDA regulations to determine and quantify injury (43 CFR §11.60).

Over the last century, the Lower Duwamish River has been dramatically transformed from a dynamic estuarine system with adjacent wetland and upland riparian areas to a channelized, industrial waterway. Tidal flats and marshes were filled to create protected harbor areas as early as 1895 (Battelle et al. 2001). The early 1900s saw the construction of Harbor Island, the East and West Waterways, and the Duwamish shipping channel, elimination of distributaries[6], and straightening the sinuous shape of the original river. While the river still functions as habitat, these changes left a shoreline with steepened mudbanks and armoring in places.

Industrial use of the river in the early 1900s became especially prominent with the onset of World War I. These early industries included shipyards, airplane manufacturing, cement manufacturing, food processing, and cold storage in support of the war effort, as well as lumber storage and milling, metal fabrication, and equipment manufacturing. Residential areas in Georgetown and South Park were established during this time, and the popularity of motor vehicles grew, leading to the installation of a petroleum distribution plant on Harbor Island (MOHAI 2015). World War II led to an increase in airplane production and an increased need for shipyards and maintenance facilities (Windward 2010).

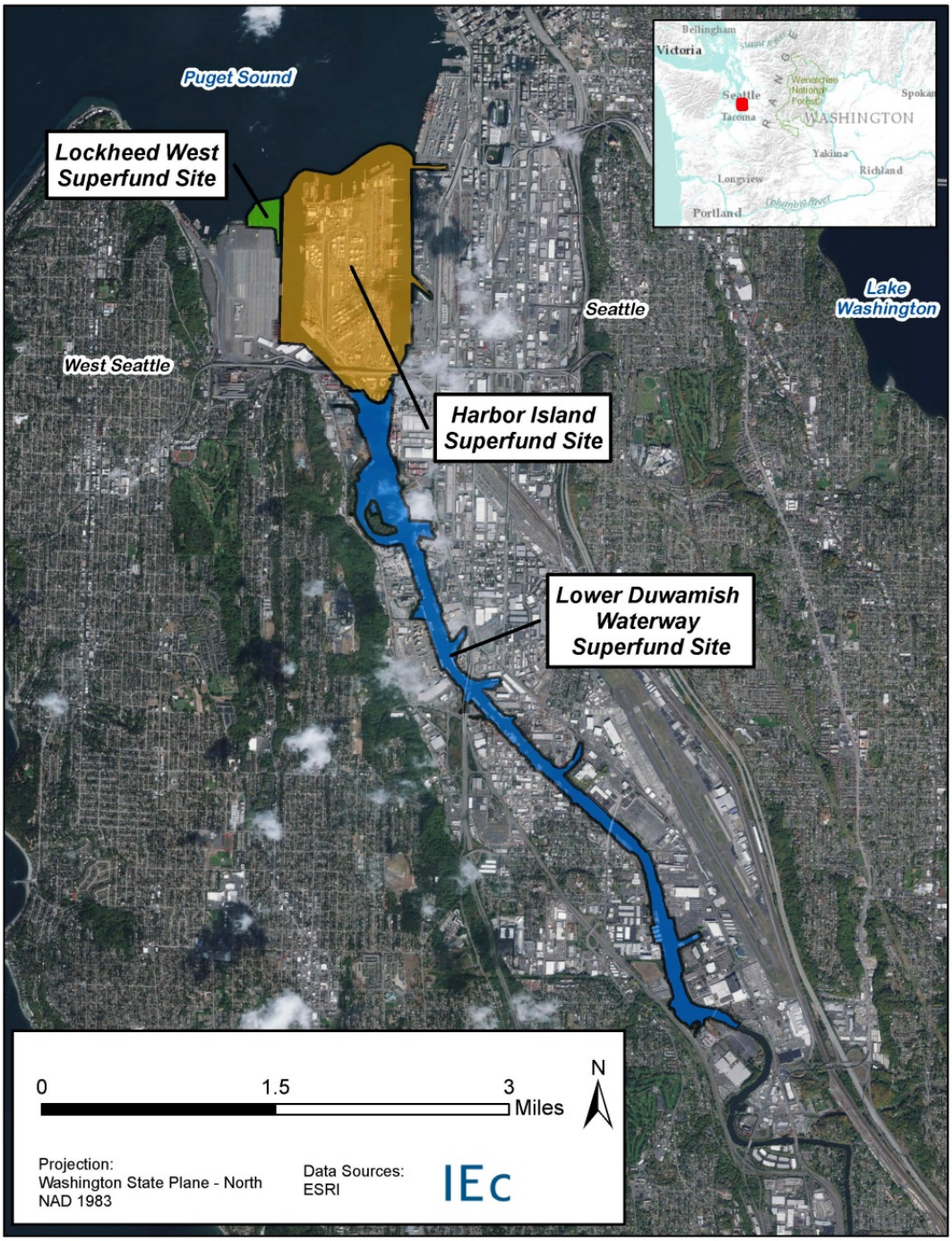
Leading up to the middle of the century, the industries along the Lower Duwamish River became more diverse, including the establishment of a lead smelter, cement manufacturers, construction companies, slaughterhouses, meat packing facilities, and a cannery. Lumber production continued to thrive and evolve, which included incorporating the use of pole treatments and wood preservation techniques. These industries, along with metal working, machine shops, asphalt companies, and chemical manufacturing facilities continued to flourish during the middle of the last century and into the post-World War II era. These industrial activities created a need for waste disposal areas, which started as casual dumping sites before some eventually became full-fledged landfills. In the second half of the century, other foundries and galvanization plants were established in addition to the lead smelter. The increased need for petroleum products gave rise to an expanded area of tank farms and petroleum storage facilities on Harbor Island. Many of the industries established in the middle to late part of the last century are still in operation today (Windward 2010).

The increasingly industrial uses of the Lower Duwamish River led to contamination of natural resources through multiple pathways from releases of hazardous substances upland and adjacent to the river. As a result of this contamination, EPA designated Harbor Island, Lockheed West Seattle, and the Lower Duwamish Waterway (collectively, the Site) as Superfund sites on the National Priority List (Exhibit 1-2).

EXHIBIT 1-2 APPROXIMATE LOCATIONS OF ACTIVE SUPERFUND SITES

[6] A distributary is a stream that branches off and flows away from a main stream channel. A common feature of river deltas, this phenomenon is known as river bifurcation. The opposite of a distributary is a tributary.

Harbor Island is situated at the mouth of the Lower Duwamish River. Petroleum tank



farms, shipyards, and a secondary lead smelter occupied most of the island, and sediments adjacent to Harbor Island are included in the site boundaries. The cleanup of this site was divided into operable units (OUs) for management purposes (EPA 2015). Five of the six OUs have been remediated. Sediment in the remaining OU, East Waterway (EW), is contaminated with high levels of polychlorinated biphenyls (PCBs),

arsenic, polycyclic aromatic hydrocarbons (PAHs), tributyltin (TBT), and mercury. Seafood consumption is the main route of human exposure to contaminants in the East Waterway, and despite consumption advisories, fishing does occur. EPA's Feasibility Study and preferred cleanup option for EW is expected to be available for public comment in 2018 (EPA 2018a).

Lockheed West is located in Elliott Bay near the mouth of the West Waterway of the Lower Duwamish River. Contaminants of concern are PCBs, PAHs, organic compounds, mercury and other metals, and other contaminants indirectly associated with shipyard activities (Lockheed Martin 2018). The selected remedy for this site consists of approximately sixteen acres of active dredging, backfilling, and/or capping, while a layer of clean backfill material will be placed over approximately thirty acres of sediment in order to support benthic organisms, promote enhanced natural recovery and help settle and cover particulates released during dredging (EPA 2013a). Institutional controls will also be put in place, but with no restriction on tribal fishing rights. The final remedial design is expected to be completed in 2018, with remedy construction following thereafter (Lockheed Martin 2018).

The **Lower Duwamish Waterway**, extending from the southern tip of Harbor Island upstream approximately five miles, is contaminated by numerous hazardous substances and oil, including PCBs, PAHs, arsenic, and dioxins and furans. Human health risk primarily stems from ingestion of contaminated resident fish and shellfish, while ecological risks are driven by direct ingestion of contaminated sediment and water as well as consumption of contaminated prey (EPA 2018c, 2014). EPA developed a series of early action plans for the Lower Duwamish Waterway, as well as a site-wide remedial plan. Two Early Action Area cleanups were conducted under a CERCLA NRDA Consent Decree to address contamination from CSOs (EPA 2013b). The first was conducted in 1999 to remove PCB-contaminated sediments adjacent to the Norfolk CSO. This area was dredged and backfilled. The second cleanup was conducted in 2003 and 2004 around the Duwamish/Diagonal CSO/SD. Sediment contaminated with PCBs, mercury, bis(2-ethylhexyl)phthalate (BEHP), and butyl benzyl phthalate was dredged and capped. Three additional early action areas were identified during the first phase of the RI:

- Slip 4. PCB-contaminated sediment was dredged and the area capped with clean sand, gravel, and activated carbon filter material in 2011 and 2012. Cleanup was completed in 2012. An additional benefit of remedial action was the creation of new shallow and riparian habitat for threatened Puget Sound Chinook salmon and other fish species.
- Terminal 117. Elevated concentrations of PCBs, dioxin/furans, and other hazardous substances in the upland soils as well as the sediments adjacent to the site were documented. Cleanup of this site was completed in 2016.
- Boeing Plant 2/Jorgensen Forge. Remediation of Boeing Plant 2 sediments and shoreline soils was completed in 2017 to address elevated levels of PCBs, as well as metals, petroleum products, and chlorinated solvents including trichloroethylene.

The remaining cleanup activities at Boeing Plant 2 are focused on upland source control work at nine EPA-designated remediation areas. In 2014, some PCB-contaminated sediment was removed at Jorgensen Forge, which sits adjacent to Boeing Plant 2. With EPA oversight, Jorgensen Forge will evaluate additional cleanup options to address in-water sediment contamination at the site. This evaluation will be described in a Supplemental Engineering Evaluation and Cost Analysis (EPA 2018c). Upland remedial actions at the Jorgensen Forge site were completed in 2017, with the excavation of a 24-inch underground pipe (and surrounding soil) that historically released PCBs to a former outfall.

The Selected Alternative for remediation of the in-water portion of the Lower Duwamish Waterway Superfund site involves active remediation (dredging, capping, and potentially applying contaminant-sequestering agents, such as activated carbon) of 177 acres of the river, in addition to Monitored Natural Recovery (MNR) of approximately 235 acres. Long-term monitoring data will indicate whether additional cleanup actions will be necessary in MNR areas. The entire Lower Duwamish Waterway, which encompasses 441 acres, will be sampled during baseline, construction, post-construction, and long-term monitoring. The remedy also involves implementing institutional controls (ICs) advising against human activity that may lead to contaminant exposure (e.g., consumption advisories) and protect the remedy's integrity (e.g., restricted navigation areas to protect caps). The Selected Alternative addresses unacceptable human health risks associated with consumption of resident fish and shellfish, as well as direct contact from net fishing, clamming, and beach recreation. It also addresses ecological risks to benthic invertebrates, fish, and wildlife (EPA 2014). The remedy will be implemented after Early Action Area cleanup is complete, source control minimizes recontamination, additional sampling and analysis are conducted, and the remedy design is complete. To date, these criteria have not been met (EPA 2018c). Once construction of the Selected Alternative begins, it is estimated to take seven years to complete, with cleanup objectives expected to be met seventeen years from the construction start date (EPA 2014).

In addition to the EPA-led in-water sediment cleanup, the State of Washington's Department of Ecology has been leading the upland source control effort (Ecology 2012). Their goal is to reduce and eliminate sources of sediment contamination to the Lower Duwamish Waterway. The focus of their initial efforts was on the early action areas, such as Terminal 117 and Slip 4 (discussed above).

1.3 TRUSTEESHIP AND AUTHORITY

Under Federal and state regulations, designated Federal, state, and tribal governments are authorized to act on behalf of the public as trustees of natural resources. The legal framework for trustees' actions is provided by CERCLA 42 U.S.C §§ 9601 *et seq.*; the Oil Pollution Act of 1990, 33 USC § 2701, *et seq.*; the Clean Water Act, 33 USC § 1251, *et seq.*; the National Oil and Hazardous Substances Pollution Contingency Plan, 40 CFR Part 300, Subpart G; Executive Orders 12580 (as amended by Executive Order 13016) and 12777; and other applicable Federal and state laws and regulations. Under these legal

authorities, natural resource trustees may assess and recover damages for natural resource injuries caused by the release of hazardous substances. Natural resource trustees seek damages (defined in Footnote 4 and Section 1.4.2) with the goal of ensuring that the resources, as well as the services that would have been provided by injured resources (but for the release of site-related hazardous substances and oil) are restored and that the public and environment are made whole for any interim losses. Damages collected by the trustees from potentially responsible parties are then used to plan and implement restoration projects outlined in a restoration plan (described in Section 1.4.2 below). For example, restoration projects may be designed to improve habitat for native biota, create recreational opportunities for the public, and/or create key services that address tribal losses to compensate for injuries attributable to contamination.

The trustees for natural resources affected by hazardous substances released into the Lower Duwamish River and Elliott Bay entered into a Memorandum of Agreement in January 2006, forming the Elliott Bay Trustee Council (Elliott Bay Trustees). The Memorandum of Agreement provides the framework for coordination and cooperation among the Elliott Bay Trustees, managing natural resource damage recoveries, and implementing joint damage assessment and restoration actions. Elliott Bay Trustee members for this NRDA include:

- The U.S. Department of Commerce, acting through the National Oceanic and Atmospheric Administration (the Federal agency that serves as the lead administrative Trustee for this site),
- The U.S. Department of the Interior,
- The State of Washington, acting through the Department of Ecology and the Department of Fish and Wildlife,
- The Suquamish Tribe, and
- The Muckleshoot Indian Tribe.

1.4 OVERVIEW OF NATURAL RESOURCE DAMAGE ASSESSMENT

The Elliott Bay Trustees intend to conduct a NRDA that follows the CERCLA NRDA regulations (43 CFR Part 11).

1.4.1 DETERMINATION TO PURSUE A TYPE B ASSESSMENT

Sections 11.34 through 11.36 of 43 CFR set forth two different assessment methods: Type A and Type B. Type A assessments rely on a computer model where certain site-related input parameters are required, such as mass or volume of the substance released, the duration of the release, the location of the release, air temperature, and wind conditions. Type B assessments are conducted through the review of existing data and the collection of additional data to fill information gaps. Type B assessments are typically selected when a hazardous substance release occurs over a long timeframe, consists of multiple contaminants, or occurs in a complex system that cannot be simplified and accurately modeled by a computer program.

Due to the physical, ecological, and cultural complexities of the Lower Duwamish River and the variety and duration of hazardous substance releases that occurred along its length, the Elliott Bay Trustees determined that a Type B assessment is most appropriate.

1.4.2 STEPS IN THE NATURAL RESOURCE DAMAGE ASSESSMENT PROCESS

The NRDA process includes three distinct phases: Preassessment Phase, Assessment Phase, and Post-assessment Phase. These phases are described generally below, with the specific phases for this Site described in Section 1.7.

During the Preassessment Phase, trustees review readily available information and existing data related to the release of hazardous substances and the potential impacts of those substances on natural resources. The review leads to a determination of whether there is evidence to support claims for natural resource damages against the parties responsible for releasing these substances to the environment. This step also documents the trustees' determination that further investigation and assessments are warranted (i.e., that a NRDA could and should be performed). This phase is a prerequisite to conducting a formal assessment.

Development of an Injury Assessment Plan is often the first step in the Assessment Phase. The second step is implementation of the plan. The subsections below describe the various stages of drafting this Plan and conducting the NRDA.

The Post-Assessment Phase requires a Report of Assessment and project-specific Restoration Plan. The former describes the results of the Assessment Phase and includes all the documentation supporting the determinations that were made in the Assessment Phase (e.g., the Preassessment Screen Determination; the Assessment Plan and documentation used in the Injury Determination, Quantification, and Damage Determination phases; and the Restoration and Compensation Determination Plan (RCDP)). Using information from the Assessment Phase, the RCDP describes how natural resources and associated services will be restored and specifically informs the scale and scope of that restoration such that sufficient compensation for injuries is achieved.

In addition, trustees may identify early restoration opportunities, that is, chances to commence with a restoration project before the assessment has proceeded completely through earlier phases. Because these opportunities may be short-lived in duration, or there may be a benefit to earlier implementation (e.g., restoration of natural resources earlier than may otherwise be achieved), trustees may agree to pursue them. Using available information, trustees estimate restoration credits for such projects and identify offsets against future tallies of natural resources damages. Such early restoration projects, by definition, take place before completion of the assessment process. However, these early restoration projects still need to satisfy priorities with regard to project type.

Therefore, trustees may develop a Restoration Plan (RP) and conduct appropriate environmental analyses under the National Environmental Policy Act and other

authorities to address early restoration opportunities, provide a general framework for restoration actions, and fulfill the trustees' compliance obligations. In this matter, the Elliott Bay Trustees prepared a Restoration Plan / Programmatic Environmental Impact Statement (RP/PEIS) to meet environmental compliance requirements for early settlement opportunities. The RP/PEIS developed for early restoration does not supplant the Elliott Bay Trustee's need to develop an RCDP, contemplated within the post-assessment phase, which contains the details that specifically inform the scale and scope of restoration to compensate for losses (43 CFR §11.81 and 11.93).

Assessment Planning

The assessment planning step is encompassed in this Injury Assessment Plan and may be amended in the future by the Elliott Bay Trustees. This Plan sets forth the method for the determination and quantification of natural resource injury and damages.

Injury Determination

Determination of injury to natural resources under the CERCLA NRDA regulations consists of documentation that there is: (1) a pathway for the released hazardous substance from the point of release to a point at which natural resources are exposed to the released substance, and (2) that injury to a natural resource of interest (i.e., air, surface water, sediment, soil, groundwater, biota) has occurred, as defined in 43 CFR §11.62. Generally, injury is defined as a measureable adverse change in the chemical or physical quality or viability of a natural resource resulting either directly or indirectly from exposure to a discharge of oil or release of a hazardous substance (43 CFR §11.14(v)).

Injury Quantification

Once it has been determined that a resource or resources have been injured, the scope and scale of the injury will be quantified for each resource for which damages will be sought. Quantification can use a wide range of metrics, depending on the injured resource and corresponding lost service (discussed further in Chapter 4). Baseline conditions, that is, the condition of the resource(s) that would have existed but for discharge of oil or release of hazardous substances (43 CFR §11.14(e)), must be considered and accounted for in this and all phases of the injury assessment.

Damage Determination

During damage determination, damages resulting from the release of hazardous substances are determined, relying upon the information obtained in the injury quantification phase. Damages are defined as, "the amount of money sought by the natural resource trustee as compensation for injury, destruction, or loss of natural resources" (43 CFR §11.14(l)). Damages can be quantified based on the cost of restoration that is capable of providing the same services as those that were lost, accounting for the interim loss of services (past and future); and/or the monetary value of lost resources and/or services. Damage determination often includes the development of a RCDP, which describes options for achieving the scale of restoration or

replacement/acquisition of equivalent resources. The RCDP may build upon previous restoration evaluation and implementation efforts.

Restoration of Injured Resources

Following completion of the assessment process and recovery of damages, a Restoration Plan may be developed based on the RCDP (if completed), or updated based on previously completed restoration planning documents to more fully develop the preferred restoration alternative to compensate for losses.

1.5 SUMMARY OF NRDA ACTIVITIES AT THE SITE

NRDA activities at the Site have been ongoing for several years.

- The Elliott Bay Trustees conducted a Preassessment Screen and Determination, finalized in December 2009, which determined that hazardous substances were released from the Site and potentially caused injury to natural resources. The Elliott Bay Trustees also determined that data sufficient to pursue an assessment are readily available or may be obtained at a reasonable cost (NOAA 2009).
- The Elliott Bay Trustees reached early settlements with some potentially responsible parties (PRPs) for damages resulting from injuries to trust resources in the Lower Duwamish River. These settlements are supported by the extensive breadth of existing information, including the results of remedial studies; academic research; reasonably conservative, simplifying assumptions to the extent practicable; and guidance in the Federal regulations. The Elliott Bay Trustees characterized natural resource injuries and lost services using methods typically applied in the context of NRDA and identified the cost of restoration sufficient to compensate the public for these losses. Per the terms of these settlements, settling PRPs implemented or funded restoration that benefited natural resources injured by Site-related contamination.
    - Under a 1991 consent decree (as amended in 1999), the City of Seattle and King County (formerly Municipality of Metropolitan Seattle) completed four habitat restoration projects on the Duwamish River (Herrings House and Hamm Creek, both built in 2000; Cecil Moses Park, built in 2003; and Kenco Marine, built in 2006), contributed to several other habitat projects in the watershed, completed two sediment remediation projects (Norfolk CSO sediment remediation completed in 1999 and the Diagonal/Duwamish CSO sediment remediation project completed in 2004), and source control activities, as well as additional restoration and remediation in Elliott Bay (e.g., Elliott Bay nearshore substrate enhancement project completed in 1998).
    - Consistent with a 2010 consent decree, Boeing completed two habitat restoration projects on their own property in 2014, totaling approximately five acres. The Elliott Bay Trustees determined that these projects resolved

Boeing's liability for natural resource damages at identified facilities in the Assessment Area.

- The Elliott Bay Trustees released a RP/PEIS in June 2013. The RP/PEIS was developed for early restoration purposes and describes the Elliott Bay Trustees' preferred alternative for the Site, "Integrated Habitat Restoration," which is a comprehensive plan based on restoration of key habitats that together will benefit the range of natural resources injured by releases of hazardous substances in the Lower Duwamish River (NOAA 2013). The development of the RP/PEIS allowed the Elliott Bay Trustees to prioritize restoration options for the purposes of early settlement agreements. It is anticipated that, to the extent necessary, the RP/PEIS will be updated with information regarding project scale and scope once the assessment process and is complete and an RCDP has been developed.

A timeline of selected historical contamination and NRDA-related events is presented in Exhibit 1-3.

1.5.1 COMPARISON OF REMEDY AND NRDA

With oversight from EPA and the State of Washington, many remedial efforts have occurred and are planned for the Site (Section 1.2). The distinction between remedial activities and NRDA is an important one, particularly since both sets of activities often operate concurrently and overlap in geographic scope. Remedial actions aim to remove and/or reduce to acceptable levels the human health and ecological risks associated with hazardous substances at a site. This process is described in CERCLA (42 USC §9601(24)). These efforts are typically funded by the PRPs, the EPA CERCLA Superfund program, or a combination of both. Remedial activities range from dredging and capping contaminants in place to removal and disposal of contaminated materials in landfills, all of which can, for a short time period, re-expose natural resources to the hazardous substances of concern and physically impact habitat. It is an anticipated risk that is tempered by the knowledge that long-term benefits will be obtained through reduction of human and natural resource exposure to the hazardous substances.

EXHIBIT 1-3 TIMELINE OF SELECTED EVENTS RELATED TO CONTAMINATION, NRDA, AND RESTORATION WITHIN THE LOWER DUWAMISH RIVER AND THE MOUTH OF ELLIOTT BAY

YEAR	SELECTED CONTAMINATION AND NRDA EVENTS CHRONOLOGY
1914-1918	Shipyards, airplane and cement manufacturing, food processing, cold, lumber, and petroleum storage, milling yards, metal fabrication, and equipment manufacturing were prevalent industries supporting World War I.
1928	Seattle's first municipal airport opened (Boeing Field).
1939-1945	• Boeing Plant II supports World War II effort by building military aircraft. • Shipyards, salvaging, and maintenance companies were prevalent, supporting the U.S. Navy.
1950s-1960s	Metal working facilities (including a smelter on Harbor Island) were established and petroleum storage facilities were expanded and operating.
1962	Howard Hanson Dam construction completed.
1980	CERCLA enacted.
1983	Harbor Island, located at the mouth of the Lower Duwamish River, is placed on the National Priorities List.
1991	NRDA settlement with City of Seattle and King County (formerly Municipality of Metropolitan Seattle), which provided funding for two sediment remedial activities, construction of four restoration sites, source control activities, and additional restoration and remediation in Elliott Bay. Amended in 1999.
1994	NRDA settlement with Pacific Sound Resources/Wyckoff through bankruptcy proceedings.
2000	City of Seattle and King County complete two habitat restoration projects (Herrings House and Hamm Creek) as a result of the 1991 NRDA settlement.
2001	The Lower Duwamish Waterway is placed on National Priorities List.
2003 – Current	Fish Consumption Advisories are put into effect for the Lower Duwamish River. A shellfish advisory was already in effect due to sewage.
2003	City of Seattle and King County complete habitat restoration at Cecil Moses Park as a result of the 1991 NRDA settlement.
2006	City of Seattle and King County complete habitat restoration at Kenco Marine as a result of the 1991 NRDA settlement.
2007	Lockheed West, located adjacent to Harbor Island at the mouth of the Lower Duwamish River, is placed on National Priorities List.
2009	Preassessment Screen is released for the Lower Duwamish River. Formal NRDA process is initiated.
2010	NRDA settlement with Boeing to build two restoration sites on the river.
2013	The Final Lower Duwamish River NRDA Restoration Plan and Programmatic Environmental Impact Statement is released.
2014	• Record of Decision released for Lower Duwamish Waterway Superfund site. • Boeing completes two habitat restoration projects under the 2010 NRDA settlement.
2018 - Future	The Lower Duwamish River Injury Assessment Plan is developed.
Sources: EPA 1992; Batker 2005; Consent Decree 1991, 1994, 1999, 2010; WA DOH 2005; Windward 2010; King County 2011; EPA 2014; Boeing 2015; DOJ 2016; and EPA 2018a, 2018b, 2018c.	

Also under CERCLA, NRDA is a process separate from remediation by which natural resource trustees can determine compensation (i.e., restoration, replacement, or acquisition of equivalent lost resources or resource services) for injuries to natural resources (43 CFR Part 11). When conducting a NRDA, natural resource trustees can take into account the interim losses that the public has incurred due to the release of hazardous substances, as well as the release of hazardous substances and physical injuries resulting from remedial activities. The natural resource trustees' objective throughout the NRDA process is to compensate the public for ecological losses as well as lost human use services including, but not limited to, foregone or diminished recreational fishing and boating trips and lost tribal services, including cultural losses. The natural resource trustees calculate damages that may be recovered through the NRDA process and then translate those damages into actions that restore the injured resources and/or services that have been lost, including those resources injured or lost as a result of remedial actions (43 CFR §11.15(a)(1)).

Despite the different goals and timeframes for NRDA and remedial activities, the Elliott Bay Trustees and their remedial counterparts at the Site are coordinating efforts to the extent practicable in accordance with the CERCLA NRDA regulations (43 CFR §11.31(a)(3)) to avoid situations where natural resources are unnecessarily injured by the remedy and to maximize potential efficiencies (e.g., coordinated sampling and data sharing).

1.6 USE OF EXISTING INFORMATION

Consistent with the CERCLA NRDA regulations, which require that the assessment be conducted in a planned, systematic manner and at a reasonable cost (43 CFR §11.13(c)), the Elliott Bay Trustees prioritize cost effectiveness in planning and implementing studies. As such, the Elliott Bay Trustees will review existing data prior to undertaking any new data collection, including data collected as part of remedial and restoration efforts. Where existing data do not allow for the determination of the nature or extent of injuries, the Elliott Bay Trustees will implement studies focused on filling those data gaps. These studies will be designed and implemented in phases to allow for subsequent adjustments in study design based on initial findings.

1.7 COORDINATION WITH OTHER PARTIES

The Elliott Bay Trustees have and will continue to coordinate NRDA activities with ongoing remedial actions to conduct the NRDA efficiently, cost effectively, and with minimal duplication of effort (43 CFR §11.31(a)(3)). In addition to working with remedial agencies at the Site, the Elliott Bay Trustees invited Site PRPs to participate in a cooperative NRDA (43 CFR §11.32(a)(2) & (d)). For example, the Elliott Bay Trustees conducted assessment efforts with PRPs, with the goal of relying on existing information to settle the cooperating PRPs' natural resource damages liability and implement early restoration. The Elliott Bay Trustees will continue these cooperative efforts as appropriate.

1.8 COORDINATION WITH THE PUBLIC

The Elliott Bay Trustees will continue to actively encourage public participation and consider such participation to be an important component of the NRDA process. Comments on this draft of the Plan will provide valuable assistance in planning a cost-effective and technically rigorous assessment. This process will include an opportunity for review and comment by PRPs as well as affected Federal, state, or tribal entities in addition to any interested members of the public (43 CFR §11.32(c)(1)).

Therefore, the Elliott Bay Trustees will make this draft of the Plan available for review for a period of thirty days in accordance with 43 CFR §11.32(c)(1). Comments must be submitted in writing to:

> Rebecca Hoff
> NOAA Assessment and Restoration Division
> 7600 Sand Point Way NE
> Seattle, WA 98115
> or via email: rebecca.hoff@noaa.gov

All comments should include "2018 Plan" in the title or subject line.

A copy of this document is available for review online at the NOAA Damage Assessment, Remediation, and Restoration Program Lower Duwamish Case website:

> https://darrp.noaa.gov/hazardous-waste/lower-duwamish-river

Other previously prepared Trustee documents, some of which are referenced in this Plan, are also available on this website.

Interested parties can obtain a hard copy of this Plan by submitting a written request to the address listed above.

The Elliott Bay Trustees will accept public comments and will document responses to those comments as part of the final Plan for the Site.

As the Elliott Bay Trustees move forward with this NRDA, there will be additional opportunities for public participation. Examples include review of significant changes to the Plan, future restoration plans, and proposed settlements. For example, this Plan provides a list of potential studies and brief discussions of study goals and objectives to describe the approaches the Elliott Bay Trustees will follow in this assessment (Chapter 5). However, study-specific plans and associated Quality Assurance Project Plans (QAPPs) will be developed by the entity or individual conducting the study in collaboration with the Elliott Bay Trustees. These study plans will be made public and the Elliott Bay Trustees will determine whether individual studies constitute a significant modification to the Injury Assessment Plan subject to public comment (43 CFR §11.32(c) and (e)). The Elliott Bay Trustees will provide sufficient notification to the public in advance of these opportunities.

1.8.1 ADMINISTRATIVE RECORD

Pursuant to 43 CFR §11.91(c), the Elliott Bay Trustees maintain a publicly available Administrative Record for the Lower Duwamish River NRDA, which includes documents relied upon for the NRDA as well as this draft Plan and restoration planning documents. The Administrative Record is available on NOAA's Lower Duwamish River website: https://darrp.noaa.gov/hazardous-waste/lower-duwamish-river.

CHAPTER 2 | NATURAL RESOURCES AND RESOURCE SERVICES

The focus of a NRDA is the natural resources and resource services that are exposed to and injured by hazardous substances and oil. Therefore, this Chapter describes the geographic scope within which that exposure has likely occurred, the physical and biological characteristics of the area including natural resources, the types of services natural resources provide, and confirmation that resources have been exposed to Site-related contaminants.

2.1 GEOGRAPHIC SCOPE

Based on the industrial history of the Lower Duwamish River, remedial actions (ongoing and planned), the RP/PEIS, CERCLA NRDA regulatory definition of an assessment area ("the area or areas within which natural resources have been affected directly or indirectly by the discharge of oil or release of a hazardous substance" (43 CFR §11.14(c))), and a review of available Site data, the Elliott Bay Trustees identified the Assessment Area for the Lower Duwamish River as:

- The lower seven miles of the Duwamish River, from bank to bank,
- The mouth of the Duwamish River and its confluence with Elliott Bay in Puget Sound, and
- The delta area near Harbor Island (i.e., the East and West Waterways and nearshore areas adjacent to Harbor Island; Exhibit 2-1).

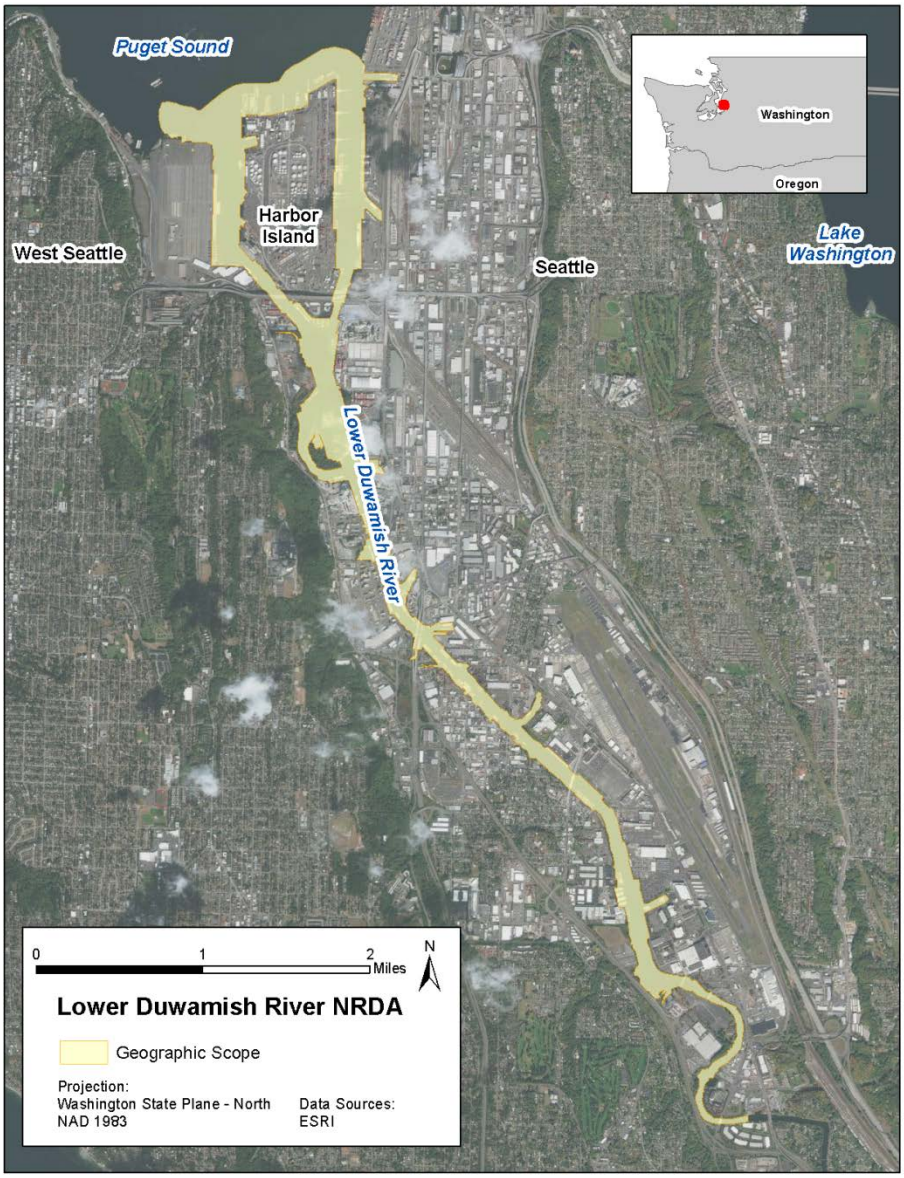
The greater Elliott Bay, relevant tributaries (e.g., Longfellow and Hamm Creeks), and upland areas are not included at this time in order to focus the assessment. However, the Elliott Bay Trustees may expand the geographic scope of their studies in the future as the assessment progresses.

2.2 DESCRIPTION OF THE ASSESSMENT AREA

The Green-Duwamish watershed extends from the headwaters of the Green River near the Cascade Mountains downstream to the mouth of the Duwamish River, which discharges into Elliott Bay at Harbor Island (Leidos 2014). Land uses adjacent to the river vary from managed forest lands near the headwaters, through farm and residential areas in the middle and lower reaches, to the heavily industrialized waterway that characterizes the Site (Herrera 2007). Two dams exist on the upper reach of the Green-Duwamish River, the Howard Hanson dam and Tacoma Water's Headworks diversion dam. The former was built in 1962 for flood control purposes and as a drinking water supply (Batker et al. 2005). The Howard Hanson dam interrupts the natural sediment flow to

downstream areas and chronically floods upstream habitat when the reservoir reaches full capacity. The Tacoma diversion dam is 3.5 miles downstream from the Howard Hansen dam and is used for municipal purposes. Below this area, the Green-Duwamish River has been levied or revetted for flood protection and most of the floodplain has been drained, filled, and developed (Batker et al. 2005). As described in Section 1.2, tidal flats and marshes were filled to create harbor areas, Harbor Island was constructed (along with the East and West Waterways), and the development of the shipping channel eliminated the original sinuous shape of the river. The riverbed still serves as habitat for organisms, but construction efforts resulted in a hardened, steepened shoreline.

EXHIBIT 2-1 MAP OF ASSESSMENT AREA



Historically, three major tributaries joined the Green-Duwamish River: the Cedar, White, and Black Rivers. Diversions of these tributaries, or waterways that discharge to these tributaries, have decreased the drainage area and flow volumes to the Duwamish River by about 65 percent from historic levels (Kerwin and Nelson 2000). One tributary, the Black River, joins the Green River to form the Duwamish River approximately 10.5 miles upstream of its mouth. Tidal fluctuations are observed at this junction, so the Duwamish River is considered to be tidally influenced, and is characterized as a salt-wedge estuary, with the toe typically situated approximately seven miles upstream from the mouth (Dexter et al. 1981).

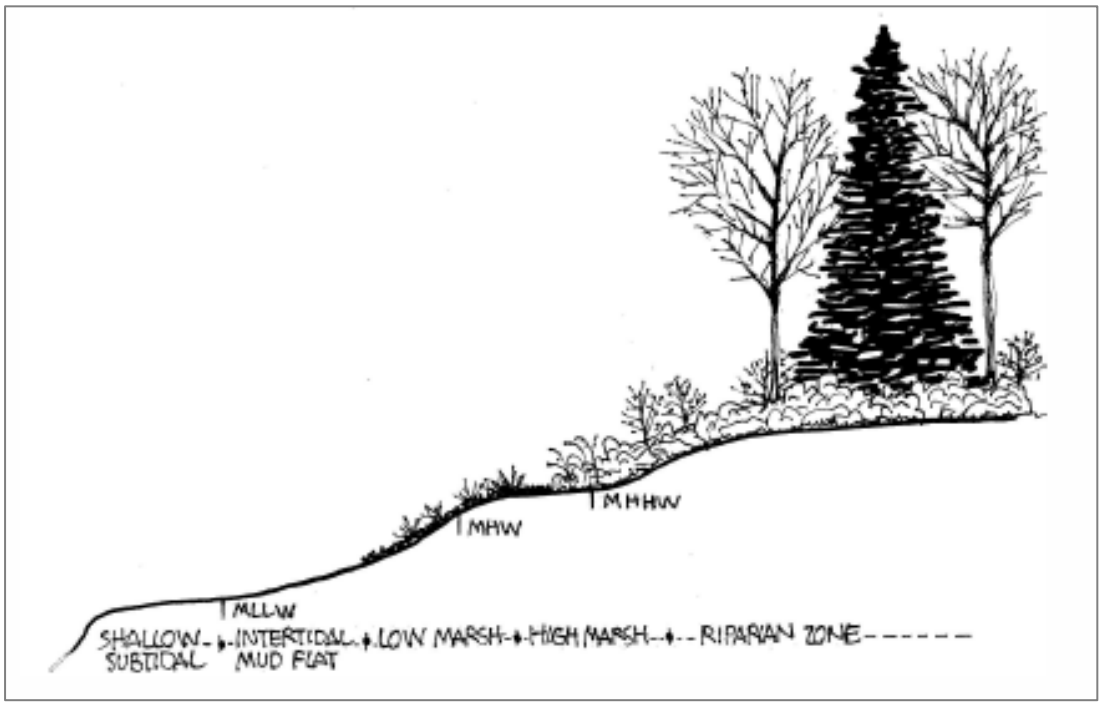
Climate in the area is characterized by cool (35-40^{0}F, nighttime lows), wet winters and mild summers (73-80^{0}F, daytime highs). Annual rainfall ranges from 39 to approximately 100 inches, with 75 percent of the precipitation occurring between October and April (NOAA 2013). As a result, the river experiences low flow and high temperature conditions during the summer months.

The delta portion of the river offshore of Harbor Island was built on deposits shaped by sea level rise, volcanism, and seismicity (Kayen and Barnhardt 2007). The Seattle Fault Zone in particular runs directly beneath the Duwamish River and downtown Seattle. This fault zone experienced a large earthquake event as early as 1,000 years ago and was active in prehistoric times as evidenced by uplift, subaqueous landslides, and tsunamis (Kayen and Barnhardt 2007 and references therein). Additional regional sources of ground motion include the Tacoma Fault to the south and the Cascadia megathrust. Ground movements due to moderate to large magnitude earthquakes can result in liquefaction of river deposits, which in turn can cause serious damage to infrastructure (e.g., bridges, building foundations) and pipelines, and uplift of storage tanks (due to their positive buoyancy).

The Lower Duwamish River has been straightened and dredged over time, in part to fulfill navigational needs and accommodate new infrastructure and vessels. The authorized navigational channel depth is maintained between -30 feet (ft) and -15 ft mean lower low water (MLLW) in the upper reaches, but the river varies in depth from approximately -56 ft MLLW near the mouth to -10 ft MLLW near the head of the navigation channel (Windward 2010).

In spite of anthropogenic modifications, the Site supports extensive aquatic habitat (the focus of this Plan). Key components include open water (in the river and estuary), estuarine marsh, intertidal mudflat, shallow subtidal, and riparian areas (together, aquatic habitat complex; Exhibit 2-2; NOAA 2013). This aquatic habitat complex supports a variety of species including plants, benthic invertebrates, amphibians and reptiles, fish, birds, and mammals. Some areas are able to support native vegetation, while others are dominated by invasive and/or weedy plant species. For example, nearshore marshlands are largely comprised of *Carex* sp., *Scirpus* sp., *Salicornia* sp., *Distichli* sp., *Atriplex* sp., *Carex lyngbyei*, *Distichlis spicata*, *Juncus balticus*, and *Phragmites* sp. (Battelle et al. 2001, Cordell et al. 1999). A description of the biota that utilize Lower Duwamish River habitats is provided in Section 2.3.2.

EXHIBIT 2-2 CROSS SECTION OF SHALLOW SUBTIDAL, MUDFLAT, MARSH, AND RIPARIAN HABITAT (NOAA 2013) - THE AQUATIC HABITAT COMPLEX



2.3 NATURAL RESOURCES IN THE ASSESSMENT AREA

Natural resources have been exposed to, and likely injured by, hazardous substances released into the Lower Duwamish River. This section defines natural resources as stated in the CERCLA NRDA regulations and generally describes the biological resources within the Assessment Area. Section 2.4 discusses the ecological, recreational, and tribal services that these resources provide.

2.3.1 NATURAL RESOURCES

Natural resources include:

> *…land, fish, wildlife, biota, air, water, ground water, drinking water supplies, and other such resources belonging to, managed by, held in trust by, appertaining to, or otherwise controlled by the United States . . . any State or local government, any foreign government, any Indian tribe, or, if such resources are subject to a trust restriction on alienation, any member of an Indian tribe* (43 CFR §11.14(z)).

Under the CERCLA NRDA regulations, natural resources have been categorized into the following five groups: surface water (including sediments), groundwater, air, geological, and biological resources. This Plan focuses on biological resources in the aquatic habitat complex of the Assessment Area, including both the ecological and human services provided by those resources. While surface water, sediment, groundwater, air, and

geologic resources also have been exposed to Site-related contaminants, at this time the Elliott Bay Trustees do not anticipate quantifying distinct injuries to these resources. Rather, this Plan incorporates these resources as pathways of hazardous substances to biological resources considered as part of the aquatic habitat complex.

2.3.2 BIOLOGICAL RESOURCES

> *Biological resources means those natural resources referred to in section 101(16) of CERCLA as fish and wildlife and other biota. Fish and wildlife include marine and freshwater aquatic and terrestrial species; game, nongame, and commercial species; and threatened, endangered, and State sensitive species. Other biota encompass shellfish, terrestrial and aquatic plants, and other living organisms not otherwise listed in this definition* (43 CFR §11.14(f)).

Biological resources exposed or potentially exposed to releases from the Site include, but are not limited to, plants, invertebrates, reptiles and amphibians, fish, birds, and mammals that utilize the aquatic habitat complex in the Assessment Area. For example:

- A total of sixty-one **benthic invertebrate** taxa were identified in core and transect samples from a Lower Duwamish Waterway Group benthic community survey (Windward 2010).
    - The infaunal[7] community consists of polychaetes (e.g., *Hobsonia florida*, *Manayunkia aesturina*, *Pygospio elegans*, and *Capitella capitata*), bivalves (e.g., *Axinopsida serricata*, *Parvilucina tenuisculpta*, and *Macoma sp.*), and oligochaetes. Common clam species include *Macoma baltica*, *Mya arenaria*, and *Macoma nasuta*. Less common are *Macoma inquinata* and *Macoma secta* (Cordell et al. 1999, Windward 2010).
    - Epifaunal[8] organisms include larger crustaceans (e.g., Dungeness crab, red rock crab, slender crab, crangon shrimp, and coonstripe shrimp), mussels, anemones, echinoderms, small crustaceans that serve as important food for fish (including amphipods, ostracods, and copepods), gastropods (e.g., *Alvania compacta*), and ceratopongonidae fly larvae. Species from nematoda, turbellaria, and foraminifera are also present (Cordell et al. 1999, Windward 2010, EPA 2013b, WA DFW 2014).
- Fifty-three species of **fish** were identified during the RI for the Lower Duwamish Waterway, such as English sole, Pacific staghorn sculpin, and shiner surfperch (AECOM 2012, Windward 2010). Nine species of fish that either reside in the Lower Duwamish River or migrate through it are listed as threatened or candidate species under the Washington State Department of Fish and Wildlife or under the Federal Endangered Species Act: Chinook salmon, coho salmon, Puget Sound steelhead, river lamprey, bull trout, Pacific herring, Pacific cod, walleye pollock,

[7] Infaunal organisms live within aquatic bottom sediment.

[8] Epifaunal organisms live on the surface of aquatic bottom sediment/substrate.

and rockfish species (e.g., brown rockfish). The river is an important migratory corridor for salmon smolts throughout the year, with peak migration occurring between late April and early June (Simenstad et al. 1982).

- Over eighty species of **birds** that use the Lower Duwamish River were identified during the RI (AECOM 2012, Windward 2010). Three of these species are listed as threatened under the Federal Endangered Species Act: Marbled murrelet, Streaked horned lark, and Yellow-billed cuckoo, with 11 more species listed as Federal birds of conservation concern, including the bald eagle and peregrine falcon (FWS 2016, FWS 2008).

  The observed diversity of bird species and abundance of individuals is often highest around Kellogg Island because of its relative seclusion and contiguous, varied habitats. Each guild utilizes different behaviors to target different types of prey species within the Assessment Area:

  - Shorebirds/waders mostly consume invertebrates picked out of the mud: Dowitcher, dunlin, great blue heron, green-backed heron, killdeer, lesser yellowlegs, sanderling, and spotted sandpiper.
  - Waterfowl are often found swimming and dive deep for fish and other benthic organisms, although some do feed on land: American coot, American wigeon, Barrow's goldeneye, common goldeneye, bufflehead, cackling goose, canvasback, green-winged teal, gadwall, horned grebe, eared grebe, pied-billed grebe, red-necked grebe, western grebe, Pacific loon, red-throated loon, common merganser, hooded merganser, and red-breasted merganser.
  - Seabirds often nest colonially, feed on fish or aquatic invertebrates, and have varied feeding methods (e.g., surface feeding, pursuit diving, plunge diving, predation, and scavenging): Caspian tern, double-crested cormorant, mew gull, pigeon guillemot, and ring-billed gull.
  - Raptors, such as peregrine falcon, osprey and bald eagle, forage for prey in the Elliott Bay/Lower Duwamish River area, usually by diving towards their prey and grabbing it in their talons. Raptors can capture prey in the air, on land, or in the water. Some raptors also nest along the river.
  - Many passerine bird species including neotropical migrants depend on riparian areas for nesting, overwintering, and during migration (e.g., willow flycatcher, yellow warbler, Wilson's warbler, common yellowthroat, Western wood-pewee, black-headed grosbeak, Bullock's oriole). Often these birds rely almost exclusively on aquatic emergent insects, which link the food web at the aquatic-terrestrial interface, as a food source to support critical life functions such as migration and rearing young.

- The presence of **amphibians and reptiles** in or along the main stem of the Duwamish River has not been reported in previous wildlife surveys, with the exception of a large tadpole at Slip 4 (Windward 2010). Additionally, limited habitat presently exists for these species in the Assessment Area.
- Several marine **mammals** may occasionally enter the Assessment Area, including California sea lions, harbor seals, and harbor porpoises (Dexter et al. 1981). These mammals consume fish, invertebrates, and cephalopods depending on availability and ease of capture. There are also several species of semi-aquatic mammals that utilize the Assessment Area. Examples include river otters, raccoons, and muskrats. Otters typically consume fish, but may also target clams and mussels. There is evidence of otters' existence along the Assessment Area and also anecdotal evidence of their occupation of Kellogg Island. In addition, there is evidence of land mammals utilizing the Assessment Area and nearby areas. Raccoons are typically found slightly west of the Assessment Area in forested slopes, but they also feed on fish when they are not scavenging carrion. Muskrat populations exist at Terminal 107 and near the Upper Turning Basin, and feed on aquatic and semi-aquatic plants (Windward 2010).

  The Puget Sound southern resident orca population segment is on the Federal endangered species list and Washington State's endangered species list. While orcas do not use the Lower Duwamish River, they can be found in Elliott Bay and other waters in the Seattle area (Windward 2010). As such, they consume prey exposed to Site-related contamination. Similarly, harbor seals, protected under the Marine Mammal Act (16 USC § 1361, *et seq*.), use the Assessment Area, and may be exposed to Site-related contaminants by consuming prey species that have spent time in the Assessment Area (Windward 2010).

2.4 NATURAL RESOURCE SERVICES

The Assessment Area is comprised of interconnected and interdependent structures, organisms, and processes. As described in Section 2.2, the Assessment Area consists of an aquatic habitat complex including marsh, mudflat, shallow and deep sub-tidal, riparian, and other estuarine and shallow water areas, which in turn support the natural resources described in Section 2.3.

This aquatic habitat complex provides physical structure to the Assessment Area; offers wildlife access to food, water, and shelter; and enables services such as sediment and pollution control, localized microclimate and shading, and provision of overwintering, migrating and breeding services for songbirds, raptors, waterfowl, and shorebirds. Though parts of the Assessment Area have been modified to accommodate industrial activities (e.g., armored riverbanks), an interest in improving intertidal habitat and other uses has stimulated restoration projects in the Lower Duwamish River area including the creation of public parks. These projects have been implemented with objectives such as removal of rip-rap and over-water wharf structures, restoration of natural tidal flows, and recolonization of native wetland plants (Windward 2010). The aquatic habitat complex

provides structure and vegetation that supply important services to the biological resources in the Assessment Area. For example, because streams accumulate woody debris from upland and riparian habitats, which increases habitat complexity, species such as the threatened bull trout and salmon use the habitat to find prey, hide from predators, and spawn (NOAA 2013). Man-made construction, including pilings and overwater structures (e.g., floating or permanent docks), also influences the quality of the aquatic habitat complex and may provide points of attachment for invertebrate communities and nesting sites for birds (e.g., osprey, cliff swallows; Adolfson Associates 2009).

Together, the components of a habitat support both ecological and human use services. The CERCLA NRDA regulations define services as, "the physical and biological functions performed by the resource including the human uses of those functions," which can be used as, "a metric for measuring resource conditions and resource restoration" (43 CFR §11.14(nn); 73 Fed. Reg. 57,259 at 57,263-57,264). Services include, but are not limited to ecological, recreational, and tribal services, each described in more detail below. The resources that comprise and utilize the aquatic habitat complex are essential for the sustainable provision of those services. Because of the interrelatedness and interdependence of resources within a given habitat, impacts to one component (e.g., individual species or species group) may cause cascading impacts to the natural resource services provided by other resources and the habitat as a whole.

2.4.1 ECOLOGICAL SERVICES

The aquatic habitat complex and its associated resources in the Assessment Area provide a variety of ecological services. For example, surface water found in estuaries and rivers provides habitat for numerous aquatic plants and animals. Sediments provide habitat and prey resources for numerous fish, shellfish, avian, and mammalian species. Riverbank and riparian areas provide protective cover, feeding, spawning/nesting, and nursery habitat for aquatic and terrestrial biota; aid in nutrient cycling; maintain hydrologic flows; and improve water clarity by promoting sedimentation of particulate matter. Phytoplankton, zooplankton, and benthic invertebrates serve as prey for other aquatic organisms and help to cycle nutrients throughout the habitat. Fish also contribute to nutrient cycling. For example, post-spawning salmon carcasses provide an influx of nutrients to the Assessment Area ecosystem. Fish and amphibians help to control insect populations and serve as prey for higher trophic level organisms, such as birds and mammals.

2.4.2 RECREATIONAL USE SERVICES

People also utilize the Lower Duwamish River for recreational purposes. Activities include recreational fishing, subsistence fishing and shellfishing, kayaking, boating, beach play (including swimming), walking and hiking, picnicking, and bike riding (Windward 2010, EPA 2013b). There are several public parks along the river (e.g., Gateway Park, Herring's House Park, Duwamish River Park, and the Duwamish Diagonal Way) and twenty-seven sites where potential human access points have been

identified (Windward 2010, EPA 2013b). There are also plans to create additional recreational access points (EPA 2013b).

Despite the industrial nature of the Site and the fish consumption advisories present at the Assessment Area, these recreational uses continue. However, it is likely that there are recreational visits foregone due to the presence of hazardous substances at the Assessment Area, and for visits that are taken to the Assessment Area, there is potentially diminished enjoyment due to the presence of hazardous contaminants. These types of changes indicate a potential loss in recreational use services (NOAA 2013).

2.4.3 TRIBAL SERVICES

Native American people occupied and used natural resources in the Duwamish River drainage, including the Assessment Area, for thousands of years prior to the arrival of European settlers in the 1850s. Extended family groups living in permanent villages and seasonal camp sites fished for salmon and non-anadromous marine fish; hunted marine and land mammals; collected plants for food, medicine, and technological uses (e.g., baskets, clothing); and collected shellfish. Five archaeological sites (an ethnographic village site and four shell middens) have been identified in the Duwamish River drainage, the mouth of the river, and upriver, documenting hunter-fisher-gatherer use of the Duwamish River as early as 2,000 years ago (Larson 1995).

The river served as a travel corridor for native people traveling between marine waters and the upper portions of the Duwamish River drainage. Chief Seattle was appointed the paramount Chief at the signing of the Treaty of Point Elliott in January 1855. Seattle was designated by George Gibbs of the Treaty Council to represent bands of Duwamish people as well as the Suquamish people. Descendants of Duwamish family groups formerly living on the Black River and Duwamish River have been incorporated into contemporary recognized tribes, including the Muckleshoot Indian Tribe and Suquamish Tribe.

In exchange for ceding their territory and moving to established reservations, Indian people entered into treaties with the United States of America that reserved and protected their fishing, gathering, and hunting rights and provided health care and education. Two Federal court decisions adjudicated tribal treaty fishing rights for Tribes including those in the Puget Sound area. In *United States vs. Washington* (1974), Judge George Hugo Boldt held that Washington's Native American treaty tribes reserved the right to take up to 50 percent of the harvestable salmon in their respective usual and accustomed fishing grounds (384 F. Supp. 312 (W.D. Wash. 1974)). This ruling (known as the Boldt decision) established geographic usual and accustomed fishing areas ("U&A") for individual treaty tribes in the State of Washington and served as the basis for the Tribes' co-management responsibilities of fishery resources with the State of Washington. Twenty years later, in subsequent cases under *United States vs. Washington* (1994), the United States district Court for the Western District of Washington held that the treaty right extended to finfish other than salmon, and to shellfish, including oysters, clams, and

Dungeness crab (873 F.Supp. 1422 W.D. Wash. 1994)[9]; OCNMS IPC 2008). The Tribal Trustees (the Muckleshoot Indian Tribe and the Suquamish Tribe) are the only treaty tribes who have adjudicated U&A in the Assessment Area.

Despite the industrialization of the Assessment Area, Tribal Trustees continue to harvest natural resources from the Duwamish River and other portions of the Assessment Area for subsistence, ceremonial, cultural, and commercial tribal uses. These resources include but are not limited to salmon, other finfish, and shellfish such as crab and shrimp, in the Duwamish River area including the Assessment Area. The Duwamish River is also a migratory corridor for hatchery-raised salmon as part of salmon co-management efforts by Tribes and the State of Washington. The Tribal Trustees are involved in the management of net pen operations in Elliott Bay tied to these hatchery operations. In addition, various parks along the Lower Duwamish River, such as Herring's House Park, are utilized for cultural outings and gatherings.

Ancestors of the present day Muckleshoot Tribe resided throughout the Duwamish River drainage, and relied upon the harvest of fish and other resources available to them from the Duwamish River and adjacent portions of Elliot Bay. The Suquamish Tribe is a saltwater-oriented people whose homeland significantly "lacked any major rivers, so their subsistence adaptation required extensive travel to collect supplies needed for winter, in addition to the harvesting of local foods from sheltered bays and local small streams" (Miller 1999). Historical records document Tribal Trustees use of natural resources in the Assessment Area and that use has continued to the present.

Seafood is an integral part of the Tribal Trustees' diet and culture. A published Seafood Consumption Survey reported that 100 percent of Suquamish tribal members consumed seafood (Suquamish Tribe 2000). Ceremonies, social gatherings, and community events are places where seafood was typically consumed. Fish and shellfish comprise a higher proportion of Suquamish and Muckleshoot community members' diets, as compared to the general population and other tribal populations (two to five times higher than the national average). For this injury assessment, the term "shellfish" applies to crab, shrimp, and bivalves.

In addition, a variety of culturally important archaeological resources have been documented within the Assessment Area, including remnants of residential or village sites, base camps, and specialized fishing, hunting, and plant collecting sites (NOAA 2013).

2.5 CONFIRMATION OF EXPOSURE

Consistent with 43 CFR §11.31(c)(1) and §11.37, this Plan documents that natural resources have been exposed to hazardous substances, thereby supporting the Elliott Bay

[9] Provides information regarding the Rafeedie decision. Also referred to on the WA Department of Natural Resources website at: http://www.dnr.wa.gov/programs-and-services/aquatics/shellfish.

Trustees' decision to implement a formal assessment[10]. There are a number of sources that report measured concentrations of contaminants in Assessment Area natural resources, confirming exposure of those resources to Site-related contaminants. The Preassessment Screen summarizes contaminant levels in sediment and fish within the Assessment Area (NOAA 2009). NOAA also maintains an environmental database with contaminant concentration and toxicity data (Data Integration Visualization Exploration and Reporting database (DIVER); https://www.diver.orr.noaa.gov/), which contains records from thousands of surface water, sediment, benthic invertebrate, and fish samples collected within the Lower Duwamish River. Reflecting a wide range of spatial and temporal coverage, these data also confirm exposure of natural resources to Site-related contaminants. For example, average PCB concentrations in whole-body fish in the Assessment Area were highest in English sole and shiner surfperch (ranging from 1,000 to 3,900 µg/kg ww in English sole and 457 to 4,300 µg/kg in shiner surfperch) (Lower Duwamish Waterway Group 2007). Contaminants concentrations in sediment were reported for PCBs (up to 223,000 µg/kg), low and high molecular weight PAHs (up to 44,000 µg/kg and 85,000 µg/kg respectively), and tribuytl tin (TBT) (up to 3,000 mg/kg; EPA 2014). After review of available data, the Elliott Bay Trustees may collect additional data to confirm that contaminant pathways are complete and that adverse effects on biota are associated with Site-related contamination.

[10] In this case a Type B assessment as described in Section 1.4.1.

CHAPTER 3 | APPROACH FOR INJURY DETERMINATION

The CERCLA NRDA regulations require that the assessment be conducted in a planned, systematic manner and at a reasonable cost (43 CFR §11.13(c)). Consistent with the regulations, the Elliott Bay Trustees identified a set of contaminants, natural resources, and pathways on which to focus assessment efforts. This assessment will emphasize the use of existing information, identify data gaps, and evaluate potential methods for addressing those data gaps. Studies will be designed and implemented in phases to allow for subsequent adjustments in study design based on initial findings. In addition, the Elliott Bay Trustees will consider the relationship between injury and restoration to ensure that the metrics used to assess each of these components are comparable and that restoration will provide resources of a type and quality that are consistent with what was lost.

This Chapter identifies the hazardous substances and natural resources on which the Elliott Bay Trustees plan to focus this assessment, discusses pathways for contaminants to reach natural resources, approaches for injury determination for biological resources and their human uses, as well as how the Elliott Bay Trustees will evaluate impacts of remediation.

3.1 HAZARDOUS SUBSTANCES

This NRDA will focus on direct and indirect injuries stemming from exposure to released hazardous substances as defined in section 101(14) of CERCLA. Many hazardous substances have been and continue to be released to the Assessment Area, and continue to be found in sediments, and/or the Lower Duwamish River food web. These include metals (e.g., aluminum, arsenic, barium, cadmium, chromium, copper, iron, lead, manganese, mercury, molybdenum, nickel, silver, thallium, vanadium, zinc), organic compounds (e.g., aldrin, dichloro-diphenyl-trichloroethane [DDT], dieldrin, dioxins/furans, PAHs, PCBs, pentachlorophenol, tributyl tin (TBT), toxaphene, and phthalates), and petroleum products (Windward 2010, EPA 2013a, b).

In order to conduct this NRDA efficiently and at a reasonable cost, the Elliott Bay Trustees plan to select a subset of these contaminants on which to focus. At this time, the contaminants of concern (COCs) warranting immediate action by the Elliott Bay Trustees include PAHs, PCBs, and TBT due to their elevated concentrations, widespread presence in sediments throughout the Assessment Area, and connection to industrial sources. In contrast, EPA selected contaminants on which to focus remedial analyses based on human exposure pathways rather than risk to ecological receptors: PCBs, PAHs, arsenic, and dioxins/furans (EPA 2014). The results of ecological, recreational, or tribal use injury

studies may indicate connections between injuries and additional site-related contaminants. These additional contaminants of concern would then be included in pathway and other studies necessary to connect releases, exposure, and injuries as required by the NRDA regulations.

3.2 NATURAL RESOURCES

For this NRDA, the Elliott Bay Trustees are prioritizing the assessment of impacts to the aquatic habitat complex within the Assessment Area (including estuarine marsh, mudflat, shallow and deep subtidal, and riparian areas). As described in Section 2.4, the aquatic habitat complex is comprised of a combination of interdependent natural resources, including surface water, groundwater, sediment, soils, and biological resources. Changes to the condition of individual organisms or the health and survival of populations that utilize a habitat reflect the services provided by that habitat as a whole. Thus, habitat services and biological resources are linked, and impacts to one will influence the other.

The Elliott Bay Trustees are initially focusing their assessment of COC-related injury on organisms mostly likely to use the aquatic habitat complex, including benthic invertebrates (e.g., amphipods, midges, and shellfish), forage fish (e.g., sculpin), bottom-dwelling fish (e.g., English sole) and Chinook salmon. These resources are key elements of the aquatic ecosystem, have been exposed to Site-related contaminants, are representative of impacts to the habitat within the Assessment Area, and may also be resources of particular significance to both the general public and tribal members. The Elliott Bay Trustees are also evaluating potential injuries to birds and mammals that utilize the Assessment Area to determine if additional assessment is warranted.

3.3 INJURY DETERMINATION

Determining injury to natural resources under the CERCLA NRDA regulations requires documentation that: (1) there is a pathway for the released hazardous substance from the point of release to a point at which natural resources are exposed to the released substance (43 CFR §11.61(c)(3)) and (2) injury of a natural resource of interest (in this case, biological resources) has occurred, as defined in 43 CFR §11.62. Exposure pathways and injury categories are described below.

3.3.1 PATHWAY

An important step in determining injury to natural resources is to establish a pathway from a known release of a hazardous substance to exposure of a natural resource. Pathway is defined as:

> *The route or medium through which oil or a hazardous substance is or was transported from the source of the discharge or release to the injured resource* (43 CFR §11.14(dd)).

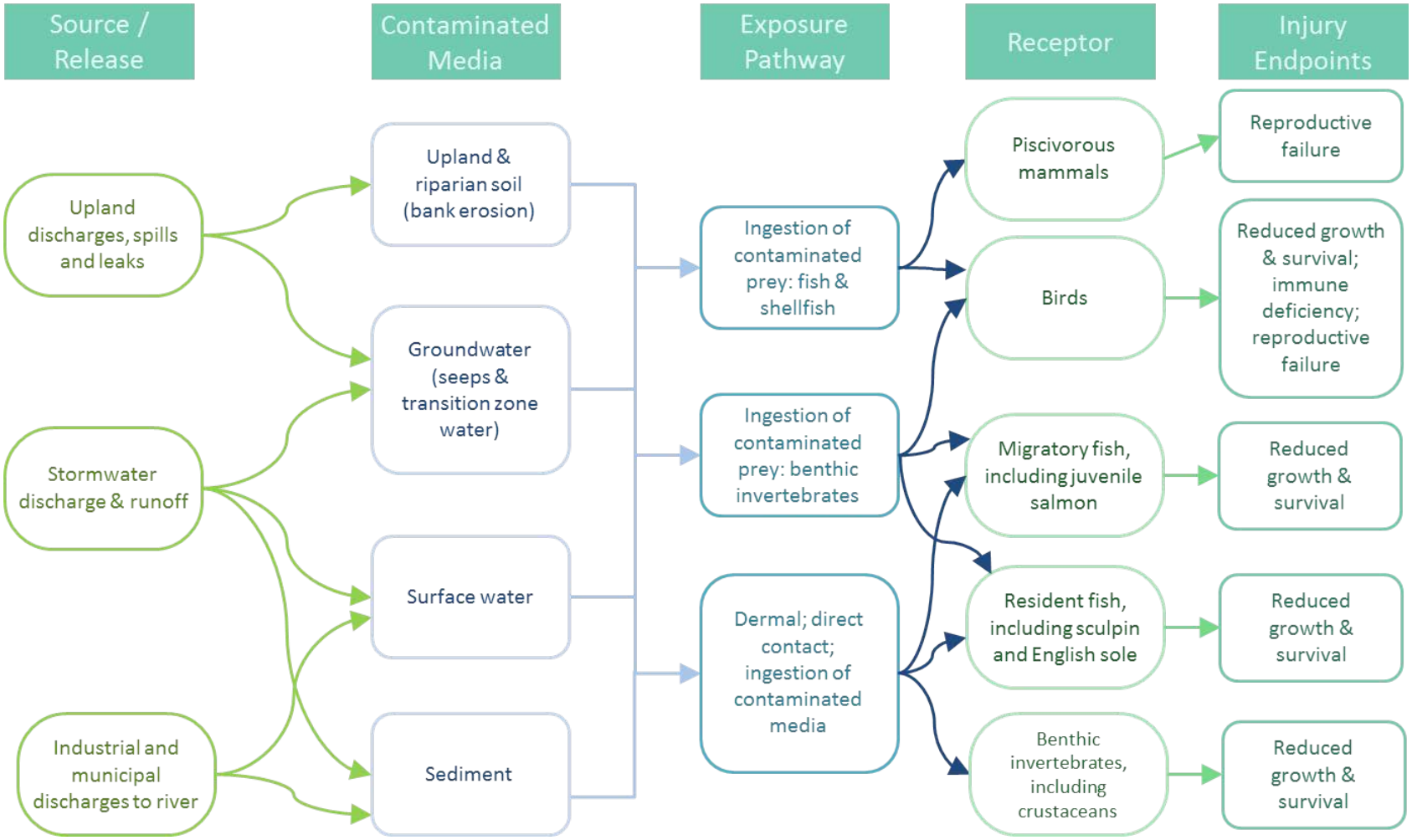
The Elliott Bay Trustees determined that pathways exist for resources in the Lower Duwamish River to be exposed to contaminants released from Site-related operations (NOAA 2009).

The Assessment Area has received and continues to receive contaminants from industrial activities along its banks and navigation within the waterway, as well as sources external to the Site (e.g., from upstream or global/regional air pollution). Common sources of contamination include shipyards, tank farms, lumber storage and milling yards, metal fabrication plants, food processing, cold storage, construction and cement companies, metal working facilities, machine shops, metal recyclers, chemical manufacturing, cargo transport terminals, motor vehicle and marine vessel maintenance, and aviation facilities. CSOs and storm drains also transport hazardous substances to the river during large storm events (NOAA 2009).

Hazardous substance releases occurred through permitted and non-permitted discharges, including but not limited to spills, storm water runoff, and discharge of contaminated groundwater (Ecology 2015, NOAA 2009, Ecology 2007). Historical industrial practices allowed for direct discharge to the Lower Duwamish River as well as disposal of waste on upland properties without sufficient containment. Hazardous substances that may have been released due to these activities include, but are not limited to, creosote and preservatives from lumber facilities, pilings, and docks (e.g., sulfate salts, copper, zinc, PAHs, and TBT), petroleum and its byproducts (PAHs), and manufacturing and metalworking operations (PCBs, sodium borate, acids, cyanide, zinc salts, chromium, copper, cadmium, nickel).

While a variety of mechanisms exist that have exposed natural resources in the Assessment Area to hazardous contaminants, at this time, the Elliott Bay Trustees are focusing on sediment and biological pathways. Direct contact with sediment may expose resources to contaminants. Food web transfer is also important due to the potential of some Site-related contaminants to biomagnify (e.g., PCBs). There is an extensive body of available information regarding contaminant fate and transport, both generally in aquatic systems and specific to the Assessment Area. The conceptual site model in Exhibit 3-1 summarizes the Elliott Bay Trustees' current focus on specific pathways, biological receptors, and endpoints of injury for the Lower Duwamish River NRDA. For example, spills, storage, and historic disposal activities can directly contaminate soils in upland areas and groundwater (e.g., through infiltration from underground storage tanks, contaminant holding ponds, and surface activities). Contaminated soils and groundwater can then enter the Lower Duwamish River through stormwater transport, aboveground seeps, or subaqueous pore water pathways. Direct discharge, spills, transport of upland contaminants along sub-surface channels or through CSOs or storm drains, and contributions from the other pathways (soil, groundwater) can contaminate surface water and sediment in the Lower Duwamish Waterway (EPA 2014). Natural resources are then exposed to and often accumulate these contaminants. As the NRDA proceeds, the Elliott Bay Trustees may identify additional pathways of concern.

EXHIBIT 3-1 CONCEPTUAL SITE MODEL



3.3.2 INJURY TO NATURAL RESOURCES

Following confirmation of exposure to hazardous substances and determination of pathway, the Elliott Bay Trustees will evaluate whether injury to natural resources has occurred. In this case, the Elliott Bay Trustees are specifically focused on assessing injury to biological resources using the aquatic habitat complex, including the recreational use and tribal services they provide. As defined in Section 2.3, biological resources include fish, wildlife, and other organisms. Injury has occurred if exposure to Site-related contaminants:

1) *"Cause[s] the biological resource or its offspring to have undergone at least one of the following adverse changes in viability: death, disease, behavioral abnormalities, cancer, genetic mutations, physiological malfunctions (including malfunctions in reproduction), or physical deformations"* (43 CFR §11.62(f)(i)). To determine whether injury has occurred, the Elliott Bay Trustees will focus on metrics that are relevant for a particular ecosystem, habitat, or resource. For example, Assessment Area-specific toxicity tests could indicate a significant reduction in survival or reproduction of a resource, which constitutes an injury to that resource under the CERCLA NRDA regulations.

2) *"Exceed[s] levels for which an appropriate State health agency has issued directives to limit or ban consumption of such organism"* (43 CFR §11.62(f)(iii)). Fish consumption advisories are in place along the Lower Duwamish River due to PCBs (WA DOH 2018), which constitute an injury under the CERCLA NRDA regulations. Crab, shellfish, and resident fish have a "do not eat" advisory, while salmonids have a weekly meal limit. Additionally, there is a statewide fish advisory due to mercury, which is especially important for women who might become pregnant, nursing mothers, and young children (WA DOH 2018).

The Elliott Bay Trustees will prioritize use of existing data and information to the fullest extent possible, including to establish metrics of injury. Additionally, the Elliott Bay Trustees will consider a phased approach for developing studies or analyses, as necessary, to address data gaps in the assessment. These are cost effective strategies that are expected to satisfy the definition and standard of reasonable cost described in 43 CFR §11.14(ee).

3.3.3 INJURY CAUSED BY REMEDIAL ACTIONS

Remedial actions often do not fully return natural resources and/or lost services to baseline conditions (i.e., the conditions that would have existed had the release of the hazardous substance not occurred) because remedial actions are designed to manage unacceptable risks to human health and the environment. Further, remedial actions that involve dredging and other physical alterations of the environment, may also result in unavoidable, additional injury that is compensable under the CERCLA NRDA regulations (43 CFR § 11.15(a)(1)). The Elliott Bay Trustees will identify and quantify the extent to which remediation affects natural resources by assessing both physical injuries and injuries resulting from residual contamination throughout the documented or

expected timeframe of recovery. This evaluation will be based on a review of remedial documents, when available, including documents that describe where remediation has been completed, or that reasonably estimate the result of the remedy (i.e., habitat condition and level of contamination; 43 CFR § 11.15(a)(1)).

Because in this case EPA has already issued Records of Decision for remedial actions for several operable units within the assessment area (Section 1.2), the Elliott Bay Trustees will use this information to identify potential remediation-related impacts. The Elliott Bay Trustees will also look for opportunities to coordinate remedial actions and restoration efforts. This will both increase efficiencies (i.e., cost and time) as well as benefit the natural resources within the Assessment Area. Restoration work conducted in conjunction with the remedy and proposed as compensation for natural resource injuries will be reviewed for approval by the Elliott Bay Trustees before compensation is accepted, and will also be reviewed by the public as part of restoration planning.[11]

3.4 SUMMARY OF INJURY DETERMINATION

Currently available data demonstrate that natural resources in the Assessment Area have been exposed to and injured by the release of Site-related hazardous substances (e.g., studies and analyses conducted as part of the remedial investigation, analyses completed in the context of settlement, other scientific research). The Elliott Bay Trustees have identified specific categories of injury and corresponding habitat and resources that will be the focus of NRDA studies to refine the determination of injury in the Assessment Area. Studies will build on existing information, and potentially include, but are not limited to:

- Comprehensive review of existing exposure and effects data;
- Documentation of the pathways from the Site-related source(s) of the COCs to the point at which biota are exposed to those contaminants;
- Documentation of the exposure of natural resources to COCs and corresponding injury, including through sample collection and analysis and laboratory tests;
- Determination of the type and extent of the public's use of Assessment Area resources.

As part of the injury determination process, study efforts will include the data collection and analyses necessary to further characterize baseline conditions (i.e., natural resource conditions but for the contamination; Section 4.5). Studies proposed by the Elliott Bay Trustees are further discussed in Chapter 5.

[11] Interested PRPs must obtain the approval of the Elliott Bay Trustees prior to project implementation in order for the project to be eligible to receive credit against potential liability.

CHAPTER 4 | INJURY QUANTIFICATION AND DAMAGE DETERMINATION

Once the Elliott Bay Trustees determine that injury to a natural resource has occurred, the CERCLA NRDA regulations state that:

> *the authorized official shall quantify for each resource determined to be injured and for which damages will be sought, the effect of the discharge or release in terms of the reduction from the baseline condition in the quantity and quality of services…provided by the injured resource* (43 CFR §11.70(a)(1)).

The purpose of the injury quantification step is to define the scope of natural resource injuries and lost services, and to allow for selection and scaling of restoration projects that will adequately and appropriately compensate the public for those injured resources and lost services. The Elliott Bay Trustees intend to quantify and value injuries through time, utilizing metrics and units that depend on the particular characteristics of the injury.

An important parameter in the injury quantification, per the CERCLA NRDA regulations, is a determination of the recovery period for the resources within the relevant geographical area (43 CFR §11.31(a)(2)). Recovery period, as defined in 43 CFR §11.14(gg), "means either the longest length of time required to return the services of the injured resource to their baseline condition, or a lesser period of time selected by the authorized official and documented in the Assessment Plan." The Elliott Bay Trustees will consider factors such as proposed or implemented remedial and restoration activities, natural attenuation, and species' habitat use and sensitivity to contaminants when estimating the recovery period in the Assessment Area. Due to the nature of the contaminants in the Assessment Area (e.g., chemicals with bioaccumulative properties), at this time the Elliott Bay Trustees anticipate that it will take many decades for some natural resources and resource services in the Assessment Area to reach baseline conditions. Other natural resource services may never return to baseline. The Elliott Bay Trustees will refine these estimates based on the results of relevant assessment studies.

Once injury is quantified, the Elliott Bay Trustees will determine the damages required to compensate the public for losses to natural resources and resource services. Damages can be measured as the cost to restore, replace, or acquire the equivalent of lost resources, or the lost value associated with the reduction in resource services (43 CFR §11.80). The CERCLA NRDA regulations require that during the damage determination phase, the Trustees produce their analysis of appropriate alternatives for restoration in the RCDP (43 CFR §11.81). The RCDP can be included in the Injury Assessment Plan; however, in this case the Elliott Bay Trustees have decided to gather more data and analysis regarding the

extent of injuries to natural resources before proceeding to the damage determination phase. Consequently, development of the RCDP will take place after completion of the injury determination and quantification phases (43 CFR §11.81(d)(1)). Once the Elliott Bay Trustees develop a draft RCDP, the draft will be released for public review and comment. (43 CFR §11.81(d)(2)). The RCDP will provide information concerning the amount of compensation required and identify the cost estimating and valuation methodologies used by the Elliott Bay Trustees to determine the compensable losses caused by the release of hazardous substances or oil. The RCDP will also provide the Elliott Bay Trustees' rationale for selection of those identified methodologies in a manner consistent with the criteria contained in the CERCLA NRDA regulations (43 CFR § 11.83). The methodologies identified for restoration and damages determination in the RCDP will vary by resource category, and are described in further detail below:

Ecological: Exposure to contamination can cause toxic effects on biota, resulting in a loss of resources and resource services. The Elliott Bay Trustees anticipate quantifying losses to the aquatic habitat complex based on the results of ecological studies of species of interest associated with the habitat, and will determine damages as the cost of implementing sufficient habitat restoration to generate resources equivalent to those lost.

- **Recreational (human use):** Contamination and associated fish consumption advisories can cause adverse changes to available services in terms of recreational quality, public access, or recreational demand. To assess the scope of losses, the Elliott Bay Trustees will rely on existing information and interviews with key informants and focus groups with recreationists, and may implement survey-based methods for quantifying recreational losses due to contamination. The Elliott Bay Trustees may base damages either on the lost value of recreational use services or the cost of implementing sufficient restoration such that the amount of recreational use value created is equivalent to the value lost.
- **Tribal lost services:** The Elliott Bay Trustees will quantify the change in services provided by natural resources and corresponding impacts to Tribal Trustee communities due to contamination of Assessment Area resources through a cultural assessment. The Elliott Bay Trustees will evaluate methods to refine their determination of tribal-related damages when more information on the types and scale of losses is available.

These anticipated approaches are discussed in greater detail in the sections below.

4.1 ECOLOGICAL INJURY QUANTIFICATION AND DAMAGE DETERMINATION APPROACH

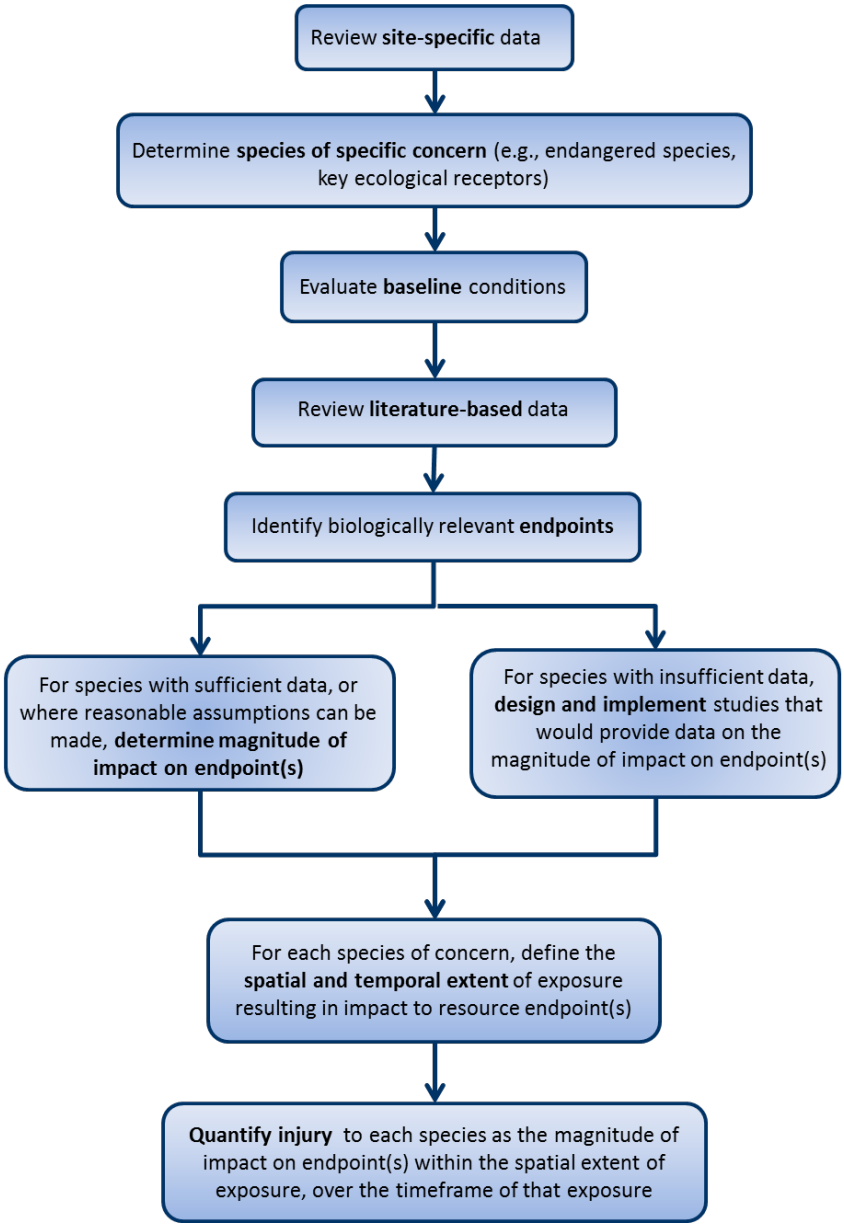
Consistent with the CERCLA NRDA regulations, the Elliott Bay Trustees anticipate quantifying injury to natural resources that utilize the aquatic habitat complex within the Assessment Area. Ecological losses may result from the direct (e.g., toxic) or indirect (e.g., physical disturbance as a result of contaminant-related remedial actions) effects of hazardous substances and oil on natural resources, including biological organisms. The

Elliott Bay Trustees will directly apply, or first modify the methods identified in the CERCLA NRDA regulations (43 CFR §11.83(c)(2)) to scale restoration projects to compensate for natural resource service losses.

The Assessment Area's aquatic habitat complex supports key species that are essential to habitat health, viability, and sustainability and are of specific concern for this assessment (Sections 2.3 and 2.4). For each species, the Elliott Bay Trustees will identify appropriate metrics to assess the degree of contaminant-related injury (e.g., percent reduction in growth or survival), and will identify the area of habitat over which the injury has occurred in the past and/or is expected to occur in the future. Existing data (e.g., developed under the remedy and related efforts), in combination with the studies described in Chapter 5, will generate data appropriate for quantifying losses for each species and metric over time. The Elliott Bay Trustees will consider each species/metric combination as independent indicators of the losses to the aquatic habitat complex. Studies will include field-based efforts (e.g., to confirm exposure to Site-related contaminants and assess the type and magnitude of injury resulting from that exposure), laboratory studies to confirm that Site-related contaminants cause the field-based observations on relevant endpoints, and studies to verify the completeness of contaminant pathways (Exhibit 4-1).

To determine the damages required to compensate for ecological injuries to the aquatic habitat complex, the Elliott Bay Trustees intend to calculate the quantity of habitat needed to generate in the future an equivalent quantity of the injured species. The benefits of habitat restoration projects (consistent with the Integrated Habitat Restoration Alternative in the RP/PEIS (NOAA 2013)) to each of the indicator species over time will be quantified using the same metrics as those used to quantify injury (e.g., productivity of fish per area over time). This comparison will inform the scale of required compensatory restoration. Because many of the potentially injured indicator species utilize or benefit from the same habitat type, the total quantity of required restoration will be determined by the species requiring the largest area of restoration of the ideal habitat type. The Elliott Bay Trustees will ensure that there is no "double-counting" of losses in the quantification process, as required in the CERCLA regulations (43 CFR §11.83(c)(2)). This approach will require the evaluation of whether restoration will also fully compensate for the losses associated with an indicator species requiring less restoration. Damages will be calculated as the cost to implement that restoration.

EXHIBIT 4-1 EXAMPLE INJURY QUANTIFICATION FOR HABITAT QUALITY INDICATORS (BY SPECIES)



4.2 RECREATIONAL USE INJURY QUANTIFICATION AND DAMAGE DETERMINATION APPROACH

There is a broad range of services that humans derive from natural resources. Recreational use loss is a common category of human use losses associated with releases of hazardous substances for which natural resource trustees typically seek compensation. Kayaking, boating, fishing, and beach use are common activities that people participate in and around the Assessment Area. While public access is generally restricted along the

banks of the river due to private industrial activity, there are existing access points and plans to create more (EPA 2013b). Current angler use on the Lower Duwamish River is characterized by salmon fishing, although fishing for resident species does occur.

Contamination may affect recreationists in a number of ways. Some recreationists may forgo visits due to the presence of hazardous substances. Others may proceed with a visit, but the visit may have a diminished value due to the presence of contaminants. The Elliott Bay Trustees' preliminary investigation of potential recreational losses indicates that recreational use losses have likely occurred as a result of hazardous substances releases to the Assessment Area (e.g., consumption advisories have been in place for the Lower Duwamish River for over 15 years; WA DOH 2018).

Under the CERCLA NRDA regulations, to the extent that the release of hazardous substances causes changes to available services in terms of recreational quality, public access, or recreation demand, these changes are compensable (43 CFR §11.71(e)). To assess the magnitude of this potential loss, the Elliott Bay Trustees plan to implement a phased approach, with the scope and implementation of each phase dependent on the results of the previous phase. Part 1 will consist of a comprehensive review of existing information. Part 2 will involve interviews with key informants and focus groups with recreationists, for which the Elliott Bay Trustees will develop specific questions and elicit feedback regarding recreational use and preferences in the Assessment Area. Based on the results of Parts 1 and 2, the Elliott Bay Trustees will determine whether further evaluation of recreational loss is appropriate. If so, they will likely implement a primary study of recreational activity using one of the survey-based methods listed in the CERCLA NRDA regulations (e.g., revealed preference or stated preference; 43 CFR §11.83), or complete a benefit transfer estimate of the value of lost recreational use.

4.3 TRIBAL LOSS QUANTIFICATION APPROACH

Tribal loss refers to a loss in natural resource services of importance to the governments or members of Tribal Trustee communities, for which separate natural resource restoration actions may be needed. Due to the differences in the nature and extent of services tribal members derive from natural resources and the corresponding impacts of those changes, the Elliott Bay Trustees will describe and quantify service losses to Tribal Trustee communities separately from service losses to the non-tribal general public. For example, the cultural significance of a particular natural resource, its traditional collection, and/or use may differ from that of the non-tribal general public. Thus, specific restoration actions may be required to fully compensate for losses in tribal services.

Examples of methods which have been applied to measure service losses to Tribal Trustee communities in the context of NRDA include:

- Assessment of changes in tribal services. This includes assessment and analysis of changes in levels of traditional knowledge, cultural practices, and relationships resulting from shifts in the use of natural resources caused by the presence of

hazardous substances. Such an analysis is generally based on anthropological and ethnographic protocols.

- Direct assessment of loss of resource use. This can involve application of revealed preference techniques, user surveys, and existing data. Data could include assessment of the number of individuals who previously utilized a site, the nature and frequency of that use, substitution or alternative behaviors, and the expected recovery period for the activity.
- Equivalency analyses. This involves the use of habitat (HEA) or resource (REA) equivalency analyses or similar measures to quantify losses given the assumption that ecological losses are a proxy measure of tribal service losses. For example, REA can be applied to estimate losses due to decreasing or eliminating collection of culturally important species due to consumption guidelines (43 CFR §11.62(f)(1)(iii)).
- Stated preference and other survey-based techniques. This involves the use of surveys to elicit tribal attitudes and preferences towards an injured resource.

These approaches may be used in combination to assess changes in services resulting from the release of hazardous contaminants to the environment.

4.4 TEMPORAL SCOPE

Injury quantification efforts will focus on the period beginning with the enactment of CERCLA on December 11, 1980 and continuing through reasonable expected recovery of resource services (in accordance with the promulgation of CERCLA). Specifically:

- For resources not expected to fully recover, injuries will be considered permanent.
- Where injuries pre- and post- CERCLA enactment are not distinguishable, injury will be quantified for all years that injury occurred in the past and is expected to occur in the future.
- For injured resources expected to fully recover to baseline conditions, interim losses will be quantified from the start of injury (or post-CERCLA enactment, whichever is later) until the year when the injured resources fully recover. To the extent that injuries pre- and post-CERCLA enactment are distinguishable, the incremental injury after the enactment of CERCLA will be quantified.
- Contaminant releases and associated damages occurring wholly before CERCLA was enacted will not be included in the injury assessment.

4.5 BASELINE

Baseline, as defined in 43 CFR §11.14(e), is;

> *the condition or conditions that would have existed at the assessment area had the discharge of oil or release of the hazardous substance under investigation not occurred.*

Baseline data should reflect expected conditions in the Assessment Area had the discharge of oil or release of hazardous substances not occurred, taking into account natural processes and changes that result from human activities (e.g., structural alterations). The Elliott Bay Trustees evaluated baseline conditions in the Assessment Area in the context of settlement using information on contaminant concentrations and other physical conditions in reference areas, data from study controls, and reasonable assumptions.

Under this Plan, the Elliott Bay Trustees plan to continue to refine their understanding of baseline conditions. In general, the characterization of baseline conditions will occur within the specific injury studies that are proposed (Chapter 5). In the context of ecological injury, the Elliott Bay Trustees will define resource-specific baseline conditions by selecting appropriate reference locations that differ as little as possible from the Assessment Area, except for the presence of contamination (43 CFR §11.72(d)). Additional studies and evaluations will likely be needed to understand whether other factors could be contributing to adverse effects observed in the Assessment Area. Baseline is also a consideration when quantifying recreational and Tribal Trustee service losses.

CHAPTER 5 | ONGOING AND PROPOSED STUDIES

The preceding chapters describe some of the key components of the Lower Duwamish River NRDA and discuss the framework and general approaches the Elliott Bay Trustees plan to apply. The NRDA itself will be comprised of a series of iterative analyses aimed at assessing the severity and magnitude of natural resource injury resulting from hazardous substance releases to the Assessment Area. Efforts will focus on natural resources that are commonly found in the Assessment Area and have likely been injured by the release of Site-related contaminants. These resources include, but are not limited to, benthic invertebrates (e.g., shellfish, amphipods, midges), resident bottom-dwelling fish (English sole); forage fishes (e.g., sculpin), Chinook salmon, birds, and mammals. In order to advance the injury assessment process outlined in Chapters 3 and 4, the Elliott Bay Trustees plan to undertake studies that will: 1) determine and quantify injury to natural resources and lost services resulting from Site-related contamination, and 2) assist in identifying and scaling restoration projects that will compensate for natural resource injuries (including the cost of such restoration).

This work will build on previous studies investigating the effects of contaminants on Assessment Area resources and associated recreational uses and tribal services. Previous research has documented the toxic effects of COCs in relevant natural resources, such as juvenile salmonids (e.g., Meador et al. 2002a, 2002b; Meador et al. 2006; Johnson et al. 2014; O'Neill et al. 2015); forage fishes (e.g., Kuzyk et al. 2005, Khan 2011); and other aquatic species. For instance, O'Neill et al. (2015) found that juvenile Chinook salmon residing and feeding in more urbanized and industrialized environments such as the Duwamish/Green River system, are exposed to higher concentrations of contaminants than salmon in less developed habitats. Arkoosh et al. (1998) reported that chemical contaminants in a polluted estuary in the Pacific Northwest with historical contamination of COCs, was linked to reduced immune response and survival of juvenile Chinook salmon. Meador (2013) also found that survival rates for juvenile Chinook out-migrating through contaminated estuaries were significantly lower than those utilizing relatively clean estuaries. Adverse effects, such as reduced growth, immunological impacts, and biochemical changes have been reported in salmonids exposed to PCBs and PAHs (Johnson et al. 2014), including wild juvenile Chinook salmon exposed to COCs in a contaminated estuary (Varanasi et al. 1993, Arkoosh et al. 1998). Exposure to PCBs has been associated with adverse physiological effects in juvenile and adult salmonids (Meador et al. 2002a), and Johnson et al. (2008) observed altered timing of spawning in both male and female English sole due to their exposure to estrogen-like compounds (e.g., PCBs) likely associated with industrial discharges, surface runoff, and combined sewer outfalls. The Ecological Risk Assessment portion of the RI for the Lower

Duwamish Waterway Superfund site also identified the potential for adverse effects (i.e., reduced survival, reduced growth, or impaired reproduction) on benthic invertebrates, fishes, and wildlife resulting from exposure to PCBs, PAHs, and TBT through multiple lines of evidence (Windward 2010).

As described in Section 2.4, natural resources that utilize habitat within the Assessment Area not only provide ecological services, but also provide human use services to both the general public and tribal members. For example, recreational fishing has been affected by the fish consumption advisories in place for the Lower Duwamish River. The importance of Assessment Area resources to tribal members, their connection to and use of those resources, and the impacts of contamination on tribal practices has also been documented. For example, salmon runs in the Duwamish River area are important to Native Americans for subsistence and ceremonial uses, and two Tribal Trustees hold treaty fishing rights in the Assessment Area. The Duwamish River is also utilized as a migration corridor for hatchery-raised salmon from upriver commercial operations, in which tribal members are involved, and tribal members participate in salmon net-pen operations in Elliott Bay (Section 2.4.3).

Future efforts based on the results of initial studies may include: 1) documenting that exposure of, and injury to, natural resources have occurred due to the release of hazardous substances to the Assessment Area; 2) quantifying injury to natural resources in terms of lost ecological, recreational, and tribal resources and services; and 3) determining damages (i.e., the amount of money sought by the Elliott Bay Trustees as compensation for injury) associated with the quantified losses. The Elliott Bay Trustees will then use the ecological damages collected from PRPs to plan and implement restoration projects consistent with the RP/PEIS (as described in Section 1.4) that will be documented in an RCDP. Potential damages from lost recreational and Tribal services will also be addressed in the RCDP. Additionally, the Elliott Bay Trustees may recognize on-going restoration projects and actions as appropriate compensation for natural resource injuries.

This Chapter describes the studies that the Elliott Bay Trustees are presently undertaking or considering at this time. These selected efforts represent the Elliott Bay Trustees' best understanding of the information that may be needed to further refine the determination and quantification of injury to Assessment Area natural resources and resource services. This Plan is not intended to limit additional or alternative studies that may be undertaken in the course of the assessment, as the Elliott Bay Trustees recognize that other studies may become necessary or advisable as the assessment proceeds and new information becomes available, or new data gaps are identified. To the extent possible, study development will be coordinated with ongoing efforts initiated by other entities (e.g., EPA and State of Washington). In addition, the inclusion of a study within this Plan does not guarantee that it will be undertaken. For example, the Elliott Bay Trustees may decide that some studies may not be needed if reasonable assumptions supported by expert opinion can be made, considering the cost of additional research or sampling against the expected gain in information from a particular study. As such, this Plan provides a

starting point from which the Elliott Bay Trustees will prioritize study efforts and implement the NRDA. As these efforts progress and additional information is generated, the Elliott Bay Trustees may provide amendments to this Plan for public review.

5.1 STUDY PRIORITIZATION

The Elliott Bay Trustees identified and prioritized a list of discrete assessment activities that are expected to assist in identifying and quantifying the scale of natural resource injury stemming from releases of hazardous substances to the Assessment Area. Study prioritization is based on:

- The review and use of existing information specific to the Assessment Area;
- Likely cost-effectiveness;
- Technical sequencing (e.g., an assessment activity may have a nearer-term priority if the analysis generates data or results upon which subsequent assessment efforts are based);
- Efforts that may be more likely to clarify the existence or extent of injury; and,
- Efforts most likely to contribute to the understanding of the appropriate scale and scope of required restoration.

Based on this prioritization, assessment activities are grouped into one of three categories:

1. Nearer-Term Priorities (Level 1). Ongoing efforts by the Elliott Bay Trustees and studies that provide prerequisite data for future studies.
2. Middle-Term Priorities (Level 2). Studies that build upon the data collected in Level 1 studies with the intent of more effectively determining injury are needed to clarify the extent of injury and connections to releases and assist in scaling restoration alternatives.
3. Longer-Term Priorities (Level 3). Studies that will be needed for later stages of the assessment process, depend largely on the completion of previous efforts, are expected to be subject to more difficult technical challenges, or are less certain of satisfying the CERCLA NRDA regulatory requirement for cost effectiveness at this time.

5.2 INJURY ASSESSMENT STUDY SUMMARY

The Elliott Bay Trustees' proposed studies are summarized in Exhibit 5-1 and presented in detail in this section. Each study description discusses the study objectives, the need/rationale for each study, and the general approach to conducting the study which will be developed further in collaboration with principal investigators (PIs). These studies will build on previous efforts, including remedial studies and other relevant investigations.

EXHIBIT 5-1 ONGOING AND PLANNED STUDIES

CATEGORY	STUDY NUMBER	PRIORITY	STUDY	OBJECTIVE	STATUS
Data Management	1	1	Development of database and data analysis protocols	Review and integrate data from available sources (e.g., remedial databases, relevant literature) into DIVER. Work with the Elliott Bay Trustees to finalize methods for handling sample results that report non-detects, lab replicates, field duplicates, and data qualifiers; and develop methodology to define and apply protocols for processing and use of the data to meet goals of the assessment.	Ongoing
Pathway	2	1	Review of existing pathway-related data	Review existing information on physical and chemical transport mechanisms within the Assessment Area to document contaminant pathways. Include spill histories and data on surface water, groundwater, flow-through infrastructure (e.g., outfalls), soil, and sediment.	Potential
	3	2	Analysis of media to support source and pathway analyses	Collection of Site-related soil, overland surface water runoff, outfall discharge, seeps, and/or groundwater. Analysis of COCs in these media and physical characteristics to assess connections between sources and Assessment Area resources.	Potential
Sediment	4	1	Review of existing sediment data	Based on the database (Study #1), evaluate the extent, quality, and appropriateness of available sediment chemistry data, information on physical parameters, and timing of relevant remedial actions to inform benthic invertebrate and fish injury assessment and assist in study design.	Ongoing
	5	1	Chemical analysis of Assessment Area sediment	Collection of sediments, as needed, to complement studies of benthic invertebrate and fish exposure and toxicity, and pathway. Analysis of COCs in Assessment Area sediments, and corresponding physical parameters, as compared to reference site sediments.	Potential
Benthic Invertebrates	6	1	Review of existing invertebrate data	Evaluate the extent, quality, and appropriateness of available contaminant chemistry and toxicity data associated with relevant benthic invertebrate species to inform the potential severity and magnitude of injury.	Ongoing
	7	1	Assess toxicity to shellfish	Conduct a laboratory and/or in situ study exposing shellfish (e.g., bivalves, shrimp, and/or crabs) to relevant COCs to confirm causality between contaminant exposure and effects on relevant endpoints.	Potential
	8	2	Compile benthic invertebrate baseline parameters	Compile and review existing information to determine baseline benthic invertebrate community characteristics (e.g., abundance of target species) and habitat extent within the Assessment Area.	Potential

CATEGORY	STUDY NUMBER	PRIORITY	STUDY	OBJECTIVE	STATUS
Fish	9	1	Review of existing fish data	Based on the database (Study #1), review the extent of available contaminant chemistry data measured in fish tissues and data related to fish toxicity studies to inform historic exposure and effects as well as the design of subsequent primary studies.	Ongoing
	10	1	Assess juvenile salmonid exposure and toxicity	Collect *in-situ* juvenile salmonids and assess the toxicity of Assessment Area-specific contaminant exposure. Analysis of COCs in field-collected juvenile salmonid tissues, stomach contents, and/or whole organisms to assess exposure to Site-specific contaminants.	Ongoing
	11	2	Complete juvenile salmonid laboratory toxicity testing	Conduct a laboratory study exposing juvenile salmonids to relevant COCs to confirm causality between contaminant exposure and effects on relevant endpoints.	Potential
	12	1	Assess forage fish exposure and toxicity	Collect resident forage fish (e.g., sculpin) and assess the toxicity of Assessment Area specific contaminant exposure. Analysis of COCs in field-collected resident fish tissues, stomach contents, and/or whole organisms to assess exposure to Site-specific contaminants.	Potential
	13	2	Complete forage fish laboratory-based toxicity testing	Conduct a laboratory study exposing bottom-dwelling resident forage fish (e.g., sculpin) to relevant COCs to confirm causality between contaminant exposure and effects on relevant endpoints.	Potential
	14	1	Assess bottom-dwelling fish exposure and toxicity	Collect resident bottom-dwelling fish (e.g., English sole) and assess the toxicity of Assessment Area-specific contaminant exposure. Analysis of COCs in field-collected resident fish tissues, stomach contents, and/or whole organisms to assess exposure to Site-specific contaminants.	Potential
	15	2	Complete bottom-dwelling fish laboratory-based toxicity testing	Conduct a laboratory study exposing resident bottom-dwelling fish (e.g., English sole) to relevant COCs to confirm causality between contaminant exposure and effects on relevant endpoints.	Potential
	16	3	Compile baseline migratory and resident fish characteristics	Determine baseline characteristics of migratory salmonids and resident forage and bottom-dwelling fish (e.g., abundance, community age structure, habitat use) within the Assessment Area.	Potential

CATEGORY	STUDY NUMBER	PRIORITY	STUDY	OBJECTIVE	STATUS
Birds	17	1	Review existing avian exposure, toxicity, life history, and habitat use data	Review existing data on avian exposure and toxicity, life history information, and habitat use data to determine if additional assessment is warranted.	Ongoing
Mammals	18	1	Review existing mammalian exposure, toxicity, life history, and habitat use data	Review existing data on mammalian exposure and toxicity, life history information, and habitat use data to determine if additional assessment is warranted.	Ongoing
Remedial Activities	19	2	Evaluate impacts of remedial activities	Compile information on remedial activities and evaluate the severity of impacts on the aquatic habitat complex. This includes the timing, location, spatial extent, and type of remedial activities.	Potential
Recreation	20	1	Review existing outdoor recreational use data and information	Review existing data and information on the types and levels of potentially affected recreational activities and values in the Lower Duwamish River through time. Review public information on and awareness of the contamination in the Lower Duwamish River, including via fish and shellfish consumption advisories and guidelines, news reports, and community information sources.	Ongoing
	21	2	Complete outdoor recreational use interviews and focus groups	Organize and implement interviews and focus groups with recreationists to gain information and insights into outdoor recreational use, including fishing, boating, and swimming in the Lower Duwamish River. Consider results along with previously collected information to scope a primary recreational use study.	Potential
	22	3	Conduct an outdoor recreational use survey	Based on results of Study #20, and #21 implement one or more surveys to quantify lost recreational use on the Lower Duwamish River potentially affected by the contamination, and/or complete a benefit transfer estimate of the value of lost recreation use	Potential
Tribal Loss	23	1	Assess changes in the tribal services provided by natural resources as a result of COCs	Further document the relationship between the Tribal Trustees and resources that utilize the Assessment Area. Identify natural resources and habitats of importance for which tribal members hold a different value than the general public, and assess changes in Tribal Trustees' connections to and use of resources as a result of contamination.	Potential

5.3 INJURY ASSESSMENT STUDY DESCRIPTIONS

The following descriptions expand on the studies presented in Exhibit 5-1 by discussing the study objectives, the need/rationale for each study, and the general approach to conducting each study, which will be developed further in collaboration with PIs.

DATA MANAGEMENT: DEVELOPMENT OF DATABASE AND DATA ANALYSIS PROTOCOLS (STUDY #1, PRIORITY 1)

Objectives: (1) Review and integrate relevant Assessment Area-related data (e.g., sediment, fish tissue) from available sources (e.g., remedial database, literature) into DIVER. (2) Finalize methods for handling sample results that report non-detects, lab replicates, field duplicates, and data qualifiers, and develop an analytical methodology to determine protocols for processing and use of the data to meet assessment goals.

Need/Rationale: A substantial amount of Assessment Area contaminant chemistry and bioassay data are available in a variety of media collected under a range of efforts. Compiling and standardizing the data into one database will enable more efficient analysis of existing data to inform gaps and structure targeted studies that fill those gaps and clearly allow other researchers to understand quality of the data.

Approach: The Elliott Bay Trustees will identify data repositories containing relevant data for the injury assessment (e.g., sediment, fish tissue). Qualifier codes, analytes, units, methods, sampling dates, depths, species, and other pertinent parameters will be standardized to be consistent with the DIVER format. Any metadata related to the original sources will be retained for reference, including available documents that explain field and analytical methodologies. Protocols and methods for processing and use of the data to meet goals of the assessment will be developed.

PATHWAY: REVIEW OF EXISTING SOURCE AND PATHWAY-RELATED DATA (STUDY #2, PRIORITY 1)

Objective: Review existing information on physical and chemical transport mechanisms within the Assessment Area to document contaminant pathways. Include spill histories and data on surface water, groundwater, flow-through infrastructure (e.g., pipelines, utility tunnels, outfalls), soil, and sediment.

Need/Rationale: The Elliott Bay Trustees intend to implement a cost-effective assessment and therefore will use existing data to the extent possible prior to undertaking primary studies. As such, it is prudent and necessary to identify and review existing pathway-related information. Documentation of a complete pathway is a requirement under the CERCLA NRDA regulations for natural resource injury determination (43 CFR §11.61(c)(3) and §11.63).

Approach: The Elliott Bay Trustees will review existing data sources that include, but are not limited to, information collected under EPA's remedial process (e.g., Windward 2010, AECOM 2012) and the State of Washington's upland source control process (Ecology 2012), outfall and other runoff-related information, and Site-specific hydrology, geology, topography, and bathymetry data. The Elliott Bay Trustees will assess the

availability, quality, and comprehensiveness of existing pathway information to refine their current understanding of Assessment Area pathways. This effort will enable the Elliott Bay Trustees to identify complete pathways as well as any data gaps that could inform additional data collection or studies.

PATHWAY: ANALYSIS OF MEDIA TO SUPPORT SOURCE AND PATHWAY ANALYSES (STUDY #3, PRIORITY 2)

Objective: Collect Site-related soil, overland surface water runoff, pipeline or outfall discharge, seep discharge, groundwater, and other physical media, and analysis of COCs in and physical characteristics of these media to assess connections between sources and Assessment Area resources.

Need/Rationale: To the extent possible, existing contaminant chemistry data in soil, surface water, groundwater, and other matrices/media, as well as physical information (e.g., groundwater flow, soil type) will be utilized to inform planning of primary studies, as well as the determination and quantification of natural resource injuries. However, additional sampling of these media may be necessary to link pathways of exposure to natural resource injuries in the Assessment Area. Documentation of a complete pathway is a requirement under the CERCLA NRDA regulations for natural resource injury determination (43 CFR §11.61(c)(3) and §11.63).

Approach: The Elliott Bay Trustees will use the data from Study #1, including contaminant chemistry data in soil, surface water, groundwater, and other media, and assess whether additional collection and subsequent chemical analysis of samples is necessary to characterize pathways of exposure from sources of contamination to natural resources in the Assessment Area. If sufficient high quality data do not exist with the appropriate characteristics and in the locations of interest (e.g., near known sources of a specific contaminant or proximate to proposed field collection sites for fish), then the Elliott Bay Trustees will conduct a primary study to collect and analyze these media.

SEDIMENT: REVIEW OF EXISTING SEDIMENT DATA (STUDY #4, PRIORITY 1)

Objective: Evaluate the extent, quality, and appropriateness of available sediment chemistry data, information on physical parameters, and timing of relevant remediation actions to inform benthic invertebrate (including shellfish) and fish injury assessments and assist in study design. Based on this review, identify data gaps and uncertainties upon which the Elliott Bay Trustees may choose to focus future primary studies.

Need/Rationale: A cost-effective assessment utilizes existing data to the extent possible prior to undertaking primary studies. As such, it is prudent and necessary to identify and review existing sediment chemistry data.

Approach: The Elliott Bay Trustees will use sediment chemistry data from Study #1. This study will involve a detailed and rigorous review of available information, specifically evaluating the use of these data in a NRDA context. For example, data will be reviewed for relevance to COCs, quality, spatial and temporal extent, and availability of associated physical parameters (e.g., total organic carbon) by which to evaluate

potential toxicity, fate, and transport of various contaminants. If sufficient high quality data with the appropriate characteristics and in the locations of interest (in the case of *in situ* work) do not exist, then the Elliott Bay Trustees will conduct a primary study.

SEDIMENT: CHEMICAL ANALYSIS OF ASSESSMENT AREA SEDIMENT (STUDY #5, PRIORITY 1)

Objective: Collect sediments, as needed, to complement studies of benthic invertebrate and fish exposure and toxicity, and pathway. Analyze COCs in Assessment Area sediments, and corresponding physical parameters, as compared to reference site sediments.

Need/Rationale: Sediment is both a primary sink for and source of contaminants in the Assessment Area, and is one of the main pathways through which natural resources are exposed to contaminants. To the extent possible, existing sediment data will be utilized to inform planning of primary studies. However, additional sediment sampling may be necessary to link pathways of exposure to natural resource injuries in the Assessment Area, document the extent and magnitude of exposure, and focus the design of other studies.

Approach: The Elliott Bay Trustees will use data from Studies #1 and #4 to assess what additional collection and subsequent chemical analysis of Assessment Area sediments is necessary, particularly in the context of the benthic invertebrate, fishes, and pathway studies outlined within this Plan. If sufficient high quality data do not exist with the appropriate characteristics and in the areas of interest (i.e., near proposed field collection sites for fish), then the Elliott Bay Trustees will implement a primary study to collect and analyze sediment for COCs. This study will be undertaken in tandem with the proposed field sampling efforts of studies listed below, to ensure the most relevant data are collected as efficiently as possible.

BENTHIC INVERTEBRATES: REVIEW OF EXISTING INVERTEBRATE DATA (STUDY #6, PRIORITY 1)

Objective: Evaluate the extent, quality, and appropriateness of available contaminant chemistry and toxicity data associated with relevant benthic invertebrate species (e.g., shellfish, midges, amphipods) to inform the potential severity and magnitude of injury as an indicator of habitat quality, as well as identification of data gaps and uncertainties.

Need/Rationale: A cost-effective assessment utilizes existing data to the extent possible prior to undertaking primary studies. As such, it is prudent and necessary to identify and review existing data related to benthic invertebrates in the Assessment Area. These data, including sediment contaminant concentrations, benthic invertebrate toxicity studies, and other benthic parameters, can directly inform injury determination and quantification.

Approach: The Elliott Bay Trustees will use the processed data from Study #1, remedial process documents, and other supplemental reports/studies for contaminant chemistry and toxicity data associated with relevant benthic invertebrate species (e.g., shellfish, midges, amphipods) and adverse effects endpoints. This study will involve a detailed and rigorous

review of available information, specifically evaluating the use of these data in a NRDA context. For example, the Elliott Bay Trustees will review data for species relevance, quality, spatial and temporal extent, contaminants of concern, and endpoints. If data are sufficient, the Elliott Bay Trustees will use those data to determine and quantify injury to benthic invertebrates within the Assessment Area.

BENTHIC INVERTEBRATES: ASSESS TOXICITY TO SHELLFISH (STUDY #7, PRIORITY 1)

Objective: Conduct studies to determine the toxicity of Site sediment to shellfish (e.g., bivalves, shrimp, crabs).

Need/Rationale: This effort will support an injury determination to shellfish (e.g., 43 CFR §11.62(b)(1)(v)), and may inform injury quantification efforts. Exposing important ecological, recreational and cultural species to Site-specific sediment will directly inform the severity and magnitude of contaminant-related injury to shellfish and recreational and Tribal harvesters.

Approach: This study will follow Study #6, which will review results of toxicity tests that have already been implemented (e.g., *in situ* and/or laboratory toxicity testing of bivalve species). If the results of that review indicate significant data gaps, then this primary study may be initiated. The Elliott Bay Trustees anticipate that this study will consist of two parts. (1) Sediment will be collected from the assessment area and reference locations as determined in the study design. The study will occur in a laboratory setting with appropriate test and control exposures, and will utilize test organisms (e.g., bivalves, shrimp, crabs), life stages, and exposure durations that best reflect these benthic invertebrate communities' exposure to hazardous substance releases from the Assessment Area. The bioassay(s) will be designed to subject the test organisms to exposure durations relevant to the organisms' life histories and site conditions. Endpoints may include but not be limited to survival, growth, development, and (or) reproduction. Sediment characteristics, including contaminant concentrations in sediment and pore water, will also be evaluated in field-collected samples. (2) *In situ* toxicity tests may be conducted as well, focusing on priority areas within the Assessment Area (e.g., areas with documented COC releases, and areas identified in other studies as toxic to benthic organisms). The *in situ* studies will assess similar endpoints and study durations as described for Part 1, through the use of caged or confined toxicity testing techniques.

BENTHIC INVERTEBRATES: COMPILE BENTHIC INVERTEBRATE BASELINE PARAMETERS (STUDY #8, PRIORITY 2)

Objective: Compile and review existing information to determine baseline benthic invertebrate community characteristics (e.g., abundance of target species) and habitat extent and quality within the Assessment Area.

Need/Rationale: Baseline data will inform the conditions and metric(s) against which the Elliott Bay Trustees will measure both injury (i.e., adverse effects resulting from exposure to Assessment Area contamination) and restoration (i.e., the benefits to a

species or species group resulting from habitat improvements). Understanding the baseline condition of injured natural resources is a component of the injury quantification process under the CERCLA NRDA regulations (43 CFR §11.70(a)(1)).

Approach: This study will be executed in two phases. (1) The Elliott Bay Trustees will utilize existing data, publicly available documents, and Site-specific and/or generic literature to establish characteristics such as benthic invertebrate abundance, community structure, and features of relevant habitat within the Assessment Area. (2) If the first phase reveals substantial data gaps, the Elliott Bay Trustees may conduct a primary study that will fill those data gaps.

FISH: REVIEW OF EXISTING FISH DATA (STUDY #9, PRIORITY 1)

Objective: Based on the DIVER database (Study #1), review the extent of available contaminant chemistry data measured in fish tissues and data related to fish toxicity studies to inform historic exposure and injuries as well as the design of subsequent primary studies. Focus on salmon, forage, and bottom-dwelling fishes.

Need/Rationale: Understanding the extent and magnitude of contaminant exposure to natural resources is an essential component of injury determination and quantification. A cost-effective assessment utilizes existing data to the extent possible prior to undertaking primary studies. As such, it is prudent and necessary to review existing, available data to enable efficient analysis, identification of data gaps, and determination of direction for potential future studies.

Approach: The Elliott Bay Trustees will use the data from Study #1 for contaminant chemistry and toxicity data associated with relevant species and locations within the Assessment Area, with a focus on salmon, forage fish, and bottom-dwelling fishes. This study will involve a detailed and rigorous review of available information, specifically evaluating the use of these data in a NRDA context using exposure metrics and toxicological response parameters. Examples of factors to consider in data usability include species relevance, data quality, spatial and temporal extent of information, contaminants of interest, and relevance of toxicological endpoints for assessing and quantifying injury.

FISH: JUVENILE SALMONID TOXICITY ASSESSMENT (STUDY #10, PRIORITY 1; STUDY #11, PRIORITY 2)

Objective: Assess the toxicity of COCs to juvenile salmonids (e.g., Chinook) through field assessments and laboratory testing.

Need/Rationale: Salmon are anadromous, meaning they are born in freshwater, migrate to the ocean to mature, and then return to their natal freshwater stream to spawn and die. Specifically within the Assessment Area, salmon (e.g., Chinook) use the aquatic habitat complex for salinity adjustments as juveniles, as a foraging area, and as a place of refuge from predation. Some salmonid species are also threatened or candidate species under the Washington State Department of Fish and Wildlife or the Federal Endangered Species Act, including Chinook salmon, coho salmon, chum salmon, and steelhead.

Salmon can have profound differences in susceptibility to chemicals at different life stages (e.g., juveniles versus spawning adults). Salmonid life history is an important determinant of chemical exposure and acute toxicity. Their extended residency in freshwater streams, particularly during a critical time of growth and development, make juvenile Chinook salmon particularly vulnerable to the effects of contaminants. In addition to direct, short-term impacts, contaminant exposure during the juvenile stage may also have long-term effects on the viability of that organism as an adult.

These studies will generate data to inform both injury determination and quantification. Field studies enable a direct measurement of the effects on salmon associated with exposure to contaminated media within the Assessment Area as compared to a reference site. Analysis of field-collected salmon tissues and stomach contents (as well as sediment concentrations from Study #4 and #5) documents exposure to the COCs. In addition, because laboratory studies are conducted in a controlled environment where many variables can be specifically defined and monitored, the proposed laboratory tests are intended to support field observations of the impact of relevant contaminants on the test organisms.

Approach: Toxicity testing of juvenile salmonids involves two interrelated studies, as well as review and analysis of the results of Study #1 (database of contaminant and toxicity data) and Study #9 (review of existing fish data). For Study #10, the Elliott Bay Trustees will design and implement a field-based study of juvenile salmonid health in the Assessment Area as compared to a reference site. Juvenile salmon will be collected from various locations throughout the Assessment Area and evaluated for selected endpoints such as growth patterns (e.g., as indicated by otolith accretion). COCs in field-collected juvenile salmonid tissue and stomach contents, as well as sediment (Study #1, #4, and #5), will be measured to assess salmonid exposure to COCs within the Assessment Area. Concentrations of COCs in fish tissues, stomach contents, and sediment will be compared to concentrations collected at an appropriate reference location. These data will be analyzed to evaluate the statistical association between exposure and injury. Study #11 will be a laboratory exposure study in which juvenile salmonids are exposed to individual or mixtures of COCs to assess the effects on selected endpoints, such as growth and survival. This study is intended to determine whether exposure to COCs at concentrations relevant to the Assessment Area is responsible for any observed adverse effects on chosen endpoints. Appropriate control organisms and laboratory conditions will be used. The data obtained in these studies will be used to quantify contaminant-related losses to salmon by using organism-based metrics that reflect an impact to the overall aquatic habitat complex (e.g., lost biomass).

FISH: FORAGE FISH TOXICITY ASSESSMENT (STUDY #12, PRIORITY 1; STUDY #13, PRIORITY 2)

Objective: Assess the toxicity of COCs to forage fish species (e.g., sculpin) through field assessments and laboratory testing.

Need/Rationale: Forage fishes are an essential component of the aquatic food web. They link benthic invertebrates (e.g., amphipods) and upper trophic level species (e.g., cormorants), and, in the case of species such as Pacific staghorn sculpin, are closely tied to sediment (a primary sink for and source of contaminants in the Assessment Area). Exposure and toxicity testing of forage fish species will complement the salmon studies proposed by the Elliott Bay Trustees and assist in determining whether forage fish species in the Assessment Area have been injured due to exposure of Site-related contaminants. These studies will generate data to inform both injury determination and quantification. Field studies enable a direct measurement of the effects to forage fishes as a result of exposure to contaminated media within the Assessment Area as compared to a reference site. Analysis of COCs in field-collected fish tissues and stomach contents (and sediment) documents exposure to the COCs. In addition, because laboratory studies are conducted in a controlled environment where many variables can be specifically defined and monitored, these laboratory tests are intended to support field observations of the impact of relevant contaminants on the test organisms.

Approach: Toxicity testing of forage fishes involves two interrelated studies, as well as review and analysis of the results of Study #1 (database of contaminant and toxicity data) and Study #9 (review of existing fish data). As part of Study #12, the Elliott Bay Trustees will design and implement a field-based study of sculpin health in the Assessment Area as compared to a reference site. Sculpin will be collected from various locations throughout the Assessment Area and evaluated for growth patterns (e.g., as indicated by otolith accretion). COCs in field-collected sculpin tissues, stomach contents, as well as sediment (Study #4 and #5), will be analyzed to assess exposure to COCs within the Assessment Area. Concentrations of COCs in fish tissues, stomach contents, and sediment will be compared to concentrations collected at an appropriate reference location. These data will be correlated to link exposure and injury. Study #13 will be a laboratory exposure study in which sculpin are exposed to individual or mixtures of COCs to assess the effects on selected endpoints, such as growth and survival. This study will confirm that exposure to COCs is responsible for any observed adverse effects on chosen endpoints. Appropriate control organisms and laboratory conditions will be used. The Elliott Bay Trustees will use data obtained in these studies to quantify contaminant-related losses to forage fishes, using organism-based metrics that reflect an impact to the overall aquatic habitat complex (e.g., lost biomass).

FISH: BOTTOM-DWELLING FISH TOXICITY ASSESSMENT (STUDY #14, PRIORITY 1; STUDY #15, PRIORITY 2)

Objective: Assess the toxicity of COCs to bottom-dwelling fish species (e.g., English sole) through field assessments and laboratory testing.

Need/Rationale: Bottom-dwelling fishes are an essential component of the aquatic food web. They link benthic invertebrates (e.g., marine worms) and upper trophic level species (e.g., blue heron, marine mammals), and, in the case of species such as English sole, are closely tied to sediment (a primary sink for and source of contaminants in the Assessment Area). Exposure and toxicity testing of bottom-dwelling fish species will complement the

salmon and forage fish studies proposed by the Elliott Bay Trustees and assist in determining whether bottom-dwelling fish species in the Assessment Area have been injured due to exposure of Site-related contaminants. These studies will generate data to inform both injury determination and quantification. Field studies enable a direct measurement of the effects to bottom-dwelling fishes as a result of exposure to contaminated media within the Assessment Area as compared to a reference site. Analysis of COCs in field-collected fish tissues and stomach contents (as well as sediment) documents exposure to the COCs. In addition, because laboratory studies are conducted in a controlled environment where many variables can be specifically defined and monitored, these laboratory tests are intended to support field observations of the impact of relevant contaminants on the test organisms.

Approach: Toxicity testing of bottom-dwelling fishes involves two interrelated studies, as well as review and analysis of the results of Study #1 (database of contaminant and toxicity data) and Study #9 (review of existing fish data). As part of Study #14, the Elliott Bay Trustees will design and implement a field-based study of English sole health in the Assessment Area as compared to a reference site. English sole will be collected from various locations throughout the Assessment Area and evaluated for growth patterns (e.g., as indicated by otolith accretion). COCs in field-collected English sole tissues, stomach contents, and/or whole organisms, as well as sediment (Study #4 and 5), will be analyzed to assess English sole exposure to COCs within the Assessment Area. Concentrations of COCs in fish tissues, stomach contents, and sediment will be compared to concentrations collected at an appropriate reference location. These data will be correlated to link exposure and injury. Study #15 will be a laboratory exposure study in which English sole are exposed to individual or mixtures of COCs to assess the effects on selected endpoints, such as growth and survival. This study will confirm that exposure to COCs is responsible for any observed adverse effects on chosen endpoints. Appropriate control organisms and laboratory conditions will be used. The Elliott Bay Trustees will use data obtained in these studies to quantify contaminant-related losses to bottom-dwelling fishes, using organism-based metrics that reflect an impact to the overall aquatic habitat complex (e.g., lost biomass).

FISH: COMPILE BASELINE MIGRATORY AND RESIDENT FISHES CHARACTERISTICS (STUDY #16, PRIORITY 3)

Objective: Determine the baseline characteristics of migratory salmonids, resident forage, and bottom-dwelling fishes (e.g., abundance, community age structure, habitat use) within the Assessment Area.

Need/Rationale: Baseline data will inform the conditions and metric(s) against which the Elliott Bay Trustees will measure both injury (i.e., adverse effects resulting from exposure to Assessment Area contamination) and restoration (i.e., the benefits to a species or species group resulting from habitat improvements). Determining and understanding the baseline condition of injured natural resources is a component of the injury quantification process under the CERCLA NRDA regulations (43 CFR §11.70(a)(1)).

Approach: The Elliott Bay Trustees will utilize existing data, publicly available documents, and Site-specific and/or generic literature to establish life history characteristics such as abundance and age structure of salmon, sculpin, and English sole within the Assessment Area, as well as ecological characteristics such as habitat use by these species. Information may be from the Assessment Area, a reference area, or other relevant areas. If substantial data gaps are identified, the Elliott Bay Trustees may implement a primary study that will provide necessary data.

BIRDS: REVIEW EXISTING AVIAN EXPOSURE, TOXICITY, LIFE HISTORY, AND HABITAT USE DATA (STUDY #17, PRIORITY 1)

Objective: Review existing data on avian exposure and toxicity, life history information, and habitat use data from relevant sources. This will inform assessment of exposure and effects as well as the need for and design of subsequent primary studies.

Need/Rationale: Birds utilize habitats within and adjacent to the Assessment Area and are key ecological receptors in those ecosystems. Understanding the extent and magnitude of contaminant exposure to natural resources is an essential component of injury determination and quantification. A cost-effective assessment utilizes existing data to the extent possible prior to undertaking primary studies. As such, it is prudent and necessary to review existing, available data on avian exposure and toxicity within the Assessment Area and other relevant locations. This review will allow for more efficient analysis of existing data to identify gaps and inform potential primary studies.

Approach: This study will involve a detailed and rigorous review of available data and information including contaminant exposures, life histories, habitat use, and toxicity which is relevant to bird species found in the Assessment Area, and specifically evaluating the use of these data in a NRDA context. The Elliott Bay Trustees will review information for species relevance, data quality, appropriateness of spatial and temporal extent, contaminants of interest, and relevance of endpoints. If sufficient high quality data do not exist with the appropriate characteristics, then the Elliott Bay Trustees will consider a primary study.

MAMMALS: REVIEW EXISTING MAMMALIAN EXPOSURE, TOXICITY, LIFE HISTORY, AND HABITAT USE DATA (STUDY #18, PRIORITY 1)

Objective: Review existing data on mammalian exposure and toxicity, life history information, and habitat use from relevant sources. This will inform an assessment of exposure and effects as well as the need for and design of subsequent primary studies.

Need/Rationale: Mammals utilize habitats within and adjacent to the Assessment Area and are key ecological receptors in those ecosystems. Understanding the extent and magnitude of contaminant exposure to natural resources is an essential component of injury determination and quantification. A cost-effective assessment utilizes existing data to the extent possible prior to undertaking primary studies. As such, it is prudent and necessary to review existing, available data on exposure and injury to mammals. This

review will allow for more efficient analysis of existing data to identify gaps and inform potential primary studies.

Approach: This study will involve a detailed and rigorous review of available data and information relevant to mammalian species within the Assessment Area, specifically evaluating the use of these data in a NRDA context. The Elliott Bay Trustees will review information for species relevance, data quality, relevance of spatial and temporal extent, contaminants of interest, and relevance of endpoints. If sufficient high quality data do not exist with the appropriate characteristics and in the areas of interest, then the Elliott Bay Trustees will consider whether a primary study is warranted.

REMEDIAL ACTIVITIES: EVALUATE IMPACTS OF REMEDIAL ACTIVITIES (STUDY #19, PRIORITY 2)

Objective: Compile information on remedial activities and evaluate the severity of impacts on the aquatic habitat complex. This will include timing, location, spatial extent, and type of remedial activities.[12]

Need/Rationale: Impacts due to remedial activities are compensatory under the CERCLA NRDA regulations (43 CFR §11.15(a)(1)). As such, understanding the extent, duration, and magnitude of these activities allows for a complete quantification of injury and need for compensation.

Approach: A timeline of remedial activities will be developed based on existing information. Location, duration, spatial extent, and type of remedial actions will be documented to the extent possible. While some remedial actions in the Site have been completed, many in-water remedial actions and upland source control actions have not yet been implemented. Therefore, the Elliott Bay Trustees will review previously conducted and anticipated remedial actions and any information related to those actions (e.g., timing, duration, area, type of remediation). This information may be used to spatially and temporally quantify injury to relevant natural resources.

RECREATION: REVIEW EXISTING OUTDOOR RECREATIONAL USE DATA AND INFORMATION (STUDY #20, PRIORITY 1)

Objective: Review existing data and information on the types and levels of potentially affected recreational activities in the Lower Duwamish River through time. Review public information on and awareness of the contamination in the Lower Duwamish River, including fish and shellfish consumption advisories and guidelines, news reports, and community information sources.

Need/Rationale: In order to understand the potential magnitude, extent, and duration of outdoor recreational use losses, it is necessary to review existing data and information on the types and levels of potentially affected recreational activity in the Assessment Area through time. A cost-effective assessment utilizes existing data to the extent possible

[12] This study focuses on the physical impacts of remedial actions. The potential injury resulting from residual contamination or physical injury post-remedy will be incorporated into the injury assessments for individual resources.

prior to undertaking primary studies, or to complete a benefit transfer estimate of the value of lost recreational use. As such, it is prudent and necessary to review existing, available data. This review will allow for more efficient analysis of existing data to identify gaps and inform primary studies.

Approach: The Elliott Bay Trustees will use existing information to identify the level and type of recreational activities conducted within the Assessment Area and how they may be affected by public awareness of the contamination. The Elliott Bay Trustees will review fish and shellfish consumption advisories and guidelines, human health risk assessments, news reports, community information resources, relevant recreational trip valuation literature, and other information sources to establish the geographic extent, nature, potential value and duration of any human use advisories that have been applied to the Lower Duwamish River and corresponding changes in recreational behavior. Depending on the results of this study, and/or if this effort reveals substantial data gaps, the Elliott Bay Trustees may implement one or more primary studies, or complete a benefit transfer estimate of the value of lost recreational use.

RECREATION: PRIMARY STUDIES OF OUTDOOR RECREATIONAL USE THROUGH INTERVIEWS, FOCUS GROUPS, AND SURVEYS (STUDY #21, PRIORITY 2; STUDY #22, PRIORITY 3)

Objective: Refine the Elliott Bay Trustees' understanding of and quantify the effects of Site-related contamination on outdoor recreational use of the Assessment Area and the role of consumption advisories and contamination on recreationist site choice and behavior.

Need/Rationale: Based on the results of Study #20, the Elliott Bay Trustees may determine that additional primary data collection regarding the potential extent of outdoor recreational use losses is appropriate. Information on outdoor recreation site choice and use/avoidance in the presence of contamination may be necessary to quantify injury and assess lost recreational use damages.

Approach: Should the results of Study #20 indicate that sufficient losses may have occurred and that information can feasibly be collected for a reasonable cost, a phased effort will be initiated. The first phase will involve organization and implementation of focus groups to gain specific feedback on outdoor recreational use on the Lower Duwamish River. Interviews with key informants (e.g., heads of fishing clubs or paddling organizations) and focus groups with recreationists will be conducted to collect information about current patterns of recreational use and potential behavioral impacts (e.g., substituting to alternative locations) due to contamination. The focus groups will be moderated, and brief surveys will be distributed to participants to provide a standardized framework for eliciting responses. The results of these interviews and focus groups will be considered along with similar information collected during earlier phases of the NRDA and other existing data to determine if the Elliott Bay Trustees should implement one or more comprehensive use and valuation surveys (e.g., revealed and/or stated preference). Any comprehensive use and valuation surveys will be implemented by the

Elliott Bay Trustees using an appropriate sample frame, sample mode, and other design features consistent with requirements of the NRDA regulations (43 CFR §11.83).

TRIBAL LOSS: ASSESS CHANGES IN THE TRIBAL TRUSTEE SERVICES PROVIDED BY NATURAL RESOURCES AS A RESULT OF COCS (STUDY #23, PRIORITY 1)

Objective: Document the relationship between the Tribal Trustees and natural resources in the Assessment Area, noting that tribes may value natural resources differently due to cultural significance, and evaluate changes in resource use as a result of contamination.

Need/Rationale: The cultural significance of certain natural resources is uniquely tied to tribal members' way of life in a manner that is distinctly separate from the non-tribal general public. Therefore, it is necessary to further understand the changes in tribal services provided by Assessment Area resources, including resource use (e.g., changes in frequency and/or location) due to Site-related contaminants. Natural resources provide a range of services to tribal communities. These services may have been diminished in quality or interrupted by the presence of contaminants released into the Assessment Area. This evaluation will ensure that the Elliott Bay Trustees are able to account for tribal losses of natural resource services of concern in both the injury assessment and subsequent restoration planning process.

Approach: The Elliott Bay Trustees will first compile and review existing information that describes tribal services, uses, and values associated with Assessment Area resources. This includes reports, interviews with tribal members and natural resource managers, and other information (e.g., history, culture). Building on this information review, the Elliott Bay Trustees will identify additional information sources to fill data gaps. For example, additional interviews could be conducted with a variety of tribal members to ascertain the historical and current uses (or desired uses) of Assessment Area resources. These interviews will identify the nature and extent of services provided by natural resources that are important to the health, welfare, economy, tradition, and culture of tribal members, in terms of both use and non-use services. The Tribal Trustees will then develop narratives that describe tribal members' relationship to natural resources found within the Assessment Area, providing a more complete picture of the natural resources important to tribal communities. This information ultimately will be used to support decision-making regarding the scale and scope of potential primary and compensatory restoration for lost tribal services.

5.4 SHARING DATA, SPLIT SAMPLES, AND ANALYTICAL RESULTS

Section 11.31(a)(4) of 43 CFR states that, "The Assessment Plan shall contain procedures and schedules for sharing data, split samples, and results of analyses, when requested, with any identified potentially responsible parties and other natural resource trustees."

If the Elliott Bay Trustees determine that a study should be implemented, that study will be developed into a full Quality Assurance Project Plan (QAPP) in collaboration with a PI and will be made available to the public. These QAPPs will include study objectives,

approaches for sharing and publishing data and analytical results with relevant parties and the public, and conditions and procedures for sharing split samples with PRPs.

5.5 QUALITY ASSURANCE

The CERCLA NRDA regulations require that trustees develop a QAPP that "satisfies the requirements listed in the National Contingency Plan and applicable EPA guidance for quality control and quality assurance plans" (43 CFR §11.31(c)(2)). The Elliott Bay Trustees recognize the importance of data quality, given the many management decisions involved in accomplishing the NRDA that ultimately require the use of environmental data. The collection, compilation, evaluation, and reporting of environmental data are necessary to perform the assessment. The Elliott Bay Trustees must therefore properly document the origin and quality of the data used to make decisions so that data limitations may be identified; and assessments of the severity, location, and extent of injury are accurate. This assists the Elliott Bay Trustees in making appropriate decisions regarding the type and scale of restoration actions necessary to compensate for natural resource injuries. Also relevant to this effort are the NOAA and U.S. Fish and Wildlife Service guidelines established under the Information Quality Act of 2001. All information developed and used in this NRDA will comply with these guidelines.

This Injury Assessment Plan includes studies that evaluate existing datasets as well as studies that generate new information. With respect to the evaluation of existing data, the PI for each study will carefully document the source(s) of all data, available information about quality assurance (QA)/quality control (QC) procedures used by the original investigator, and any data qualifiers or other information informing appropriate application of the data. This approach will also be applied to new data and analyses developed by Federal and state agencies, tribes, academics, and information developed under the auspices of other activities or programs that will be used in developing the NRDA. For new studies that are specifically undertaken to support the NRDA process, the Elliott Bay Trustees will develop appropriate study-specific QAPPs according to the general principles described below.

As stated by EPA (2001), QAPPs will "vary according to the nature of the work being performed and the intended use of the data" and as such, need to be tailored to match the specific data-gathering needs of a particular project (40 CFR §300.5). The NRDA will entail a variety of widely different data-gathering efforts; therefore, it is not appropriate to develop a single, detailed QAPP to cover all these activities. Instead, the Elliott Bay Trustees will ensure that individual study QAPPs adequately address project-specific QA issues. The discussion in this document therefore focuses on the required elements of an acceptable QAPP.

In general, a study-specific QAPP must provide sufficient detail to demonstrate that:

- The study's technical and quality objectives are identified and agreed upon;
- The intended measurements, data generation, or data acquisition methods are appropriate for achieving study objectives;

- Assessment procedures are sufficient for confirming that data of the type and quality needed and expected are obtained; and
- Any limitations on the use of the data can be identified and documented (EPA 2001).

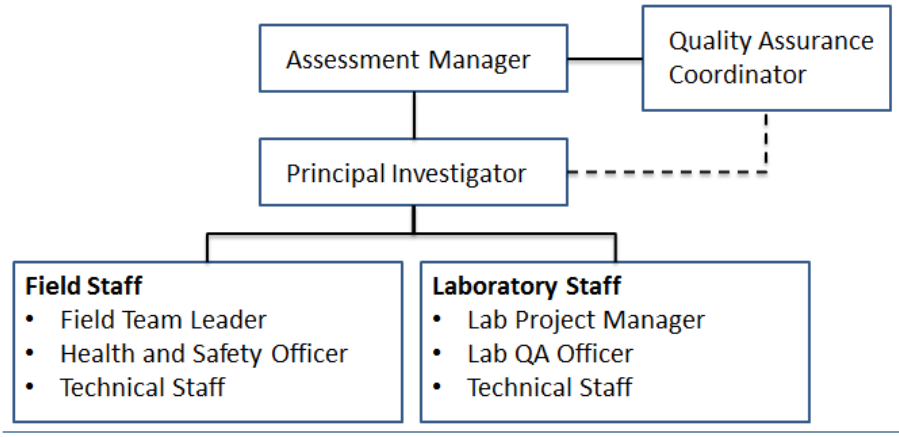
Accordingly, study-specific QAPPs developed for this assessment will include the four elements called for by EPA:

- Project Management – documents that the study has a defined goal(s), that the participants understand the goal(s) and the approach to be used, and that the planning outputs have been documented;
- Data Generation and Acquisition – ensures that all aspects of study design and implementation including methods for sampling, measurement and analysis, data collection or generation, data compiling/handling, and QC activities are documented and employed;
- Effectiveness Assessment and Oversight – assesses the effectiveness of the implementation of the study and associated QA and QC activities; and,
- Data Validation and Usability – addresses the QA activities that occur after the data collection or generation phase of the study is completed.

5.6 STUDY MANAGEMENT

Effective implementation of study objectives requires clear study organization, which includes carefully defining the roles and responsibilities of each study participant. Unambiguous personnel structures help ensure that each individual is aware of his or her specific areas of responsibility, as well as clarifying internal lines of communication and authority, which is important for decision-making purposes as studies progress. Individual and organizational roles and responsibilities may vary by study or task, but each person's role and responsibility should be clearly described in the study-specific QAPP. Exhibit 5-2 presents a generic personnel plan for a NRDA study.

EXHIBIT 5-2 PERSONNEL PLAN



The Assessment Manager is the designated Trustee representative with responsibility for the review and acceptance of the study-specific plan. This individual is also responsible for ensuring that the study's goals and design will meet the broader requirements of this NRDA. The Assessment Manager coordinates efforts with the Quality Assurance Coordinator and oversees the PI for the study.

The QA Coordinator oversees the overall conduct of the quality system. Appointed in consultation with the Elliott Bay Trustees, this individual's responsibilities include, but are not limited to: reviewing and assisting the PI with the development of study-specific QAPPs; conducting audits and ensuring implementation of both study-specific and overall plans; archiving samples, data, and all documentation supporting the data in a secure and accessible form; and reporting to the Elliott Bay Trustees. To ensure independence, the person serving as QA Coordinator will not serve either as the Assessment Manager or as a PI for any NRDA study.

Study-specific PIs oversee the design and implementation of particular NRDA studies. Each PI has the responsibility to ensure that all health, safety, and relevant QA requirements are met. If deviations from the QAPP occur, the PI (or his/her designee) will document these deviations and report them to the Assessment Manager and the QA Coordinator.

The Field Team Leader supervises day-to-day field investigations, including sample collection, field observations, and field measurements. The Field Team Leader generally is responsible for ensuring compliance with all field QA procedures defined in the study-specific QAPP. Similarly, the Laboratory Project Manager is responsible for monitoring and documenting the quality of laboratory work. The Health and Safety Officer (who may also be the Field Team Leader) is responsible for ensuring adherence to specified safety protocols in the field.

5.7 DATA GENERATION AND ACQUISITION

All studies under the direction of the Elliott Bay Trustees that are specifically undertaken in support of the NRDA will have a prepared QAPP prior to the initiation of any work. These QAPPs will be submitted to, and approved by, the QA Coordinator or designee and generally include:

- Study objectives;
- Rationale for generating or acquiring the data;
- Proposed method(s) for generating or acquiring the data, including descriptions of (or references to) standard operating procedures for all sampling or data-generating methods and analytical methods;
- Types and numbers of samples required;
- Analyses to be performed;
- Sampling locations and frequencies;

- Sample handling and storage procedures;
- Chain-of-custody procedures;
- Data quality requirements (for instance, with respect to precision, accuracy, completeness, representativeness, comparability, and sensitivity);
- Description of the procedures to be used in determining if the data meet these requirements;
- Description of the interpretation techniques to be used, including statistical analyses; and
- Split sample protocols and procedures for archiving samples and management of residuals.

In addition, to the extent practicable, laboratories will be required to comply with good laboratory practices. This includes descriptions and documentation of maintenance, instrument inspections, and acceptance testing of instruments, equipment, and their components, as well as the calibration of such equipment and the maintenance of all records relating to these exercises. Documentation to be included with the final report(s) from each study will include field logs for the collection or generation of the samples, chain of custody records, and other QA/QC documentation, as applicable.

5.8 EFFECTIVENESS ASSESSMENT AND OVERSIGHT

To ensure that the QAPP for each project is implemented effectively, the QA Coordinator will review QAPPs for all Trustee studies that generate data. The QA Coordinator or designee will also audit all such studies. Audits will include technical system audits (e.g., evaluations of operations) as well as scrutinizing data and reports (e.g., evaluations of data quality and adequacy of documentation).

If, in the professional opinion of the QA Coordinator, the results of an audit indicate a compromise in the quality of the collection, generation, analysis, or interpretation of the data, the QA Coordinator has the authority to stop work by oral direction. Within two working days of this direction, the QA Coordinator will submit to the Elliott Bay Trustees a written report describing the necessity for this direction. The Assessment Manager will consult with the Elliott Bay Trustees regarding measures to be taken in response to the QA Coordinator's report.

5.9 DATA VALIDATION AND USABILITY

In addition to the assessment and oversight activities described previously, analytical data will be considered for validation by an independent third party. Prompt validation of analytical data can assist the analyst or analytical facility in developing data that meet the requirements for precision and accuracy. If undertaken, it is expected that data validation will use the study-specific plans and EPA Guidance on Environmental Verification and Validation (EPA 2002).

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