UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
West Coast Region
1201 NE Lloyd Boulevard, Suite 1100
PORTLAND, OR 97232-1274

Refer to NMFS No:
WCRO-2023-01903

March 22, 2024

Calvin J. Terada
Director
United States Environmental Protection Agency, Region 10
1200 Sixth Avenue, Suite 155
Seattle, Washington 98101-3123

Re: Endangered Species Act Section 7(a)(2) Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Response for the Upper Reach of the Lower Duwamish Waterway Superfund Site Remedial Action, King County, Washington (6th Field HUC 171100130305).

Dear Mr. Terada:

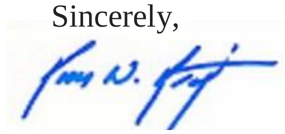
Thank you for your letter of August 11, 2023, requesting initiation of consultation with NOAA's National Marine Fisheries Service (NMFS) pursuant to section 7 of the Endangered Species Act of 1973 (ESA) (16 U.S.C. 1531 et seq.) for the U.S. Environmental Protection Agency's (EPA) proposed Upper Reach of the Lower Duwamish Waterway Superfund Site Remedial Action. In this opinion, NMFS concludes that the proposed action is not likely to jeopardize the continued existence of Puget Sound (PS) Chinook salmon and PS steelhead. The project is also not likely to result in the destruction or adverse modification of critical habitat designated for PS Chinook salmon and PS steelhead. This document also documents our conclusion that the proposed action is not likely to adversely affect southern resident (SR) killer whales and their designated critical habitat.

As required by section 7 of the Endangered Species Act, the NMFS provided an incidental take statement with the biological opinion. The incidental take statement describes reasonable and prudent measures the NMFS considers necessary or appropriate to minimize incidental take associated with this action. The take statement sets forth nondiscretionary term and conditions. Incidental take from actions that meet the term and condition will be exempt from the Endangered Species Act take prohibition.

NMFS also reviewed the likely effects of the proposed action on essential fish habitat (EFH) pursuant to section 305(b) of the Magnuson–Stevens Fishery Conservation and Management Act [16 U.S.C. 1855(b)], and concluded that the action would likely adversely affect the EFH of Pacific Coast salmon and Pacific Coast groundfish. Therefore, we have included the results of that review in Section 3 of this document.

Please contact Tyler Yasenak of the Oregon Washington Coastal Office at (206) 207-0092, or by email at tyler.yasenak@noaa.gov if you have any questions concerning this consultation, or if you require additional information.

Sincerely,



Kim W. Kratz, Ph.D
Assistant Regional Administrator
Oregon Washington Coastal Office

cc: Elly Hale, Environmental Protection Agency

Endangered Species Act (ESA) Section 7(a)(2) Biological Opinion and Magnuson–Stevens Fishery Conservation and Management Act Essential Fish Habitat Response for the

Upper Reach of the Lower Duwamish Waterway Superfund Site Remedial Action
King County, Washington

NMFS Consultation Number: WCRO-2023-01903

Action Agency: United States Environmental Protection Agency

Affected Species and NMFS' Determinations:

ESA-Listed Species	Status	Is Action Likely to Adversely Affect Species?	Is Action Likely to Jeopardize the Species?	Is Action Likely to Adversely Affect Critical Habitat?	Is Action Likely to Destroy or Adversely Modify Critical Habitat?
PS Chinook salmon (*Oncorhynchus. tshawytscha*)	Threatened	Yes	No	Yes	No
PS steelhead (*O. mykiss*)	Threatened	Yes	No	Yes	No
Killer whales (*Orcinus orca*) Southern resident (SR)	Endangered	No	No	No	No
Puget Sound/Georgia Basin Yelloweye Rockfish (*Sebastes ruberrimus*)	Threatened	No	No	No	No
Puget Sound/Georgia Basin Bocaccio (*S. paucispinis*)	Endangered	No	No	No	No

Fishery Management Plan That Identifies EFH in the Project Area	Does Action Have an Adverse Effect on EFH?	Are EFH Conservation Recommendations Provided?
Pacific Coast Salmon	Yes	Yes
Pacific Coast Groundfish	Yes	Yes

Consultation Conducted By: National Marine Fisheries Service, West Coast Region

Issued By:

Kim W. Kratz, Ph.D
Assistant Regional Administrator
Oregon Washington Coastal Office

Date: March 22, 2024

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LIST OF ACRONYMS

AOC – Administrative Order on Consent
ARAR – Applicable of Relevant and Appropriate Requirements
BA – Biological Assessment
BO – Biological Opinion
BODR – Basis of Design Report
BMP – Best Management Practices

CERCLA – Comprehensive Environmental Response, Compensation, and Liability Act
CHART – Critical Habitat Analytical Review
COC – Contaminant of Concern
cPAH – Carcinogenic Polycyclic Aromatic Hydrocarbon
CWA – Clean Water Act
CY – Cubic Yard
D/F – Dioxins/Furans
dB - Decibels
DO – Dissolved Oxygen
DPS – Distinct Population Segment
DQA – Data Quality Act
DSAY – Discounted-Service-Acre-Year
EFH – Essential Fish Habitat
ENR – Enhanced Natural Recovery
EPA – Environmental Protection Agency
ESA – Endangered Species Act
ESD – Explanation of Significant Differences
ESU – Evolutionarily Significant Unit
FNC – Federal Navigation Channel
HAT – Highest Astronomical Tide
HEA – Habitat Equivalency Analysis
ITS – Incidental Take Statement
LAA – Likely to Adversely Affect
LDW – Lower Duwamish Waterway
MLLW – Mean Lower Low Water
MNR – Monitored Natural Recovery
MPG – Multiple Population Grouping
MSA – Magnuson-Stevens Fishery Conservation and Management Act
NHVM – Nearshore Habitat Values Model
NMFS – National Marine Fisheries Service
NPDES – National Pollutant Discharge Elimination System
NTU – Nephlometric Turbidity Units
NWFSC – Northwest Fisheries Science Center
PAH – Polycyclic Aromatic Hydrocarbons
PBF – Physical or Biological Features
PCB – Polychlorinated Biphenyl
PCE – Primary Constituent Element
PDI – Pre-Design Investigation
PS – Puget Sound
PSNC – Puget Sound Nearshore Calculator
PTS – Permanent Threshold Shift
RAA – Remedial Action Areas
RAL – Remedial Action Levels
RAWP – Remedial Action Work Plan
RD – Remedial Design
RL – Received Level

RM – River Mile
RMC – Residuals Management Cover
ROD – Record of Decision
RPM – Reasonable and Prudent Measures
SEL – Sound Exposure Level
SL – Sound Level
SR – Southern Resident
TRT – Technical Recovery Team
TSS – Total Suspended Sediments
TTS – Temporary Threshold Shifts
U&A – Usual and Accustomed
WAC – Washington Administrative Code
WDFW – Washington Department of Fish and Wildlife
WDOE - Washington Department of Ecology
WQMP – Water Quality Monitoring Plan

1. INTRODUCTION

This Introduction section provides information relevant to the other sections of this document and is incorporated by reference into Sections 2 and 3, below.

1.1. Background

The National Marine Fisheries Service (NMFS) prepared the biological opinion (opinion) and incidental take statement (ITS) portions of this document in accordance with section 7(b) of the Endangered Species Act (ESA) of 1973 (16 U.S.C. 1531 et seq.), as amended, and implementing regulations at 50 CFR part 402.

We also completed an essential fish habitat (EFH) consultation on the proposed action, in accordance with section 305(b)(2) of the Magnuson–Stevens Fishery Conservation and Management Act (MSA) (16 U.S.C. 1801 et seq.) and implementing regulations at 50 CFR part 600.

We completed pre-dissemination review of this document using standards for utility, integrity, and objectivity in compliance with applicable guidelines issued under the Data Quality Act (DQA) (section 515 of the Treasury and General Government Appropriations Act for Fiscal Year 2001, Public Law 106-554). The document will be available at the NOAA Library Institutional Repository [https://repository.library.noaa.gov/welcome]. A complete record of this consultation is on file at NMFS Lacey Office.

1.2. Consultation History

This biological opinion is based on the information provided in the July 25, 2023, biological assessment (BA) and supporting documents. The U.S. Environmental Protection Agency (EPA) requested formal consultation on August 14, 2023. On September 15, 2023, NMFS initiated formal consultation. On November 28, 2023, NMFS requested additional information regarding the project effects. On December 10, 2023 EPA responded to NMFS's information request. A complete record of this consultation is on file at the Oregon Washington Coastal Office located in Lacey, Washington.

The EPA concluded that the proposed action is likely to adversely affect (LAA) Puget Sound (PS) Chinook salmon (*Oncorhynchus tshawytscha*) and PS steelhead (*Oncorhynchus mykiss*) and their critical habitats. NMFS concurs with the EPA's determination.

NMFS also reviewed the likely effects of the proposed action on EFH, and concluded that the action would adversely affect the EFH of Pacific Coast Salmon and Pacific Coast Groundfish.

On July 5, 2022, the U.S. District Court for the Northern District of California issued an order vacating the 2019 regulations that were revised or added to 50 CFR part 402 in 2019 ("2019 Regulations," see 84 FR 44976, August 27, 2019) without making a finding on the merits. On September 21, 2022, the U.S. Court of Appeals for the Ninth Circuit granted a temporary stay of the district court's July 5 order. On November 14, 2022, the Northern District of California issued an order granting the government's request for voluntary remand without vacating the

2019 regulations. The District Court issued a slightly amended order two days later on November 16, 2022. As a result, the 2019 regulations remain in effect, and we are applying the 2019 regulations here. For purposes of this consultation and in an abundance of caution, we considered whether the substantive analysis and conclusions articulated in the biological opinion and incidental take statement would be any different under the pre-2019 regulations. We have determined that our analysis and conclusions would not be any different.

1.3. Proposed Federal Action

Under the ESA, "action" means all activities or programs of any kind authorized, funded, or carried out, in whole or in part, by Federal agencies (see 50 CFR 402.02). Under MSA, federal action means any action authorized, funded, or undertaken, or proposed to be authorized, funded or undertaken by a federal agency (50 CFR 600.910).

The Puget Sound Salmon Recovery Plan (NMFS 2006) has identified remediation of the Lower Duwamish Waterway (LDW) as an important proposed action to address water quality and pollution. The Lower Duwamish Waterway Group, in coordination with the EPA and Washington State Department of Ecology, is implementing a cleanup remedy for the upper reach of the LDW Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA, or Superfund) site. For purposes of the ESA consultation, EPA is acting as the lead federal agency. The City of Seattle, King County, the Port of Seattle, and The Boeing Company, agreed to an Administrative order on Consent (AOC) to conduct remedial design (RD) for the upper reach under the fourth amendment to the AOC for the LDW, with oversight by EPA and Ecology.

The LDW Superfund Site extends 5 miles upstream from the southern tip of Harbor Island to Just upstream of the Turning Basin at river mile (RM) 5, a federally authorized and maintained navigation feature consisting of an area where ship traffic can turn around. The LDW Superfund Site has been divided into three reaches (lower, middle, and upper), which are undergoing separate RDs on staggered time frames. The upper reach comprises the furthest upstream two RMs: 3.0 to 5.0 and is the subject of this Biological Opinion (BO).

The project is proposed to clean up sediments that are a result of over a century of urbanization and industrial activity on the LDW consistent with the EPA Record of Decision (ROD; 2014), the carcinogenic polycyclic aromatic hydrocarbon (cPAH) Explanation of Significant Differences (ESD) (EPA 2021), and AOC4 (EPA 2018). The remedial technologies selected for cleanup include a combination of dredging, enhanced natural recovery (ENR), engineered capping and monitored natural recovery (MNR).

The proposed action consists of the overall remedial action for the upper reach of the LDW, as set forth in the ROD, fourth amendment to the AOC, and ESD (EPA 2014, 2018, 2021). The Preliminary (30 percent) RD for the upper reach identified areas of sediment that exceeded ROD-defined Remedial Action Level (RALs). The RAL exceedance areas were further developed into Remedial Action Areas (RAAs) (Figures 1-2 and Table 1) that have a larger footprint and encompass the RAL exceedance areas to account for engineering and constructability considerations, which provides a greater degree of confidence for removing sediment that exceeds the RALs. After the Preliminary (30 percent) RD submittal to EPA, Intermediate (60 percent) RD was completed and addressed comments received from EPA on the Preliminary (30 percent) RD. The BA uses the RAAs that were updated during Intermediate (60 percent) RD; the updated Intermediate (60 percent) RD Basis of Design Report (BODR) was submitted to EPA on February 20, 2023 (Anchor QEA and Windward 2023). Concurrent with Intermediate (60 percent) RD, additional Phase III pre-design investigation (PDI) data was collected in the upper reach and would be incorporated into the Pre-Final (90 percent) RD. Because the new Phase III PDI data may result in some revisions to RAA boundaries, the BA has included allowance (RAA surface area and volume contingencies in addition to the Intermediate (60 percent) RD). to assess the maximum anticipated impacted areas and volumes.

Remedial activities would be completed within the RAAs and include dredging; debris removal; engineered capping; clean material backfill placement for habitat area restoration, Residuals Management Cover (RMC), and ENR; and overwater/in-water structure modification. Dredged sediment and debris material would also require in-water transport by barge to a transloading facility, barge offloading, upland transport by rail or trucks, and disposal of dredged material and debris at a permitted commercial landfill. Clean material used for placement would also require barge transport to the upper reach. MNR is included as part of the remedy and requires monitoring rather than active remediation.

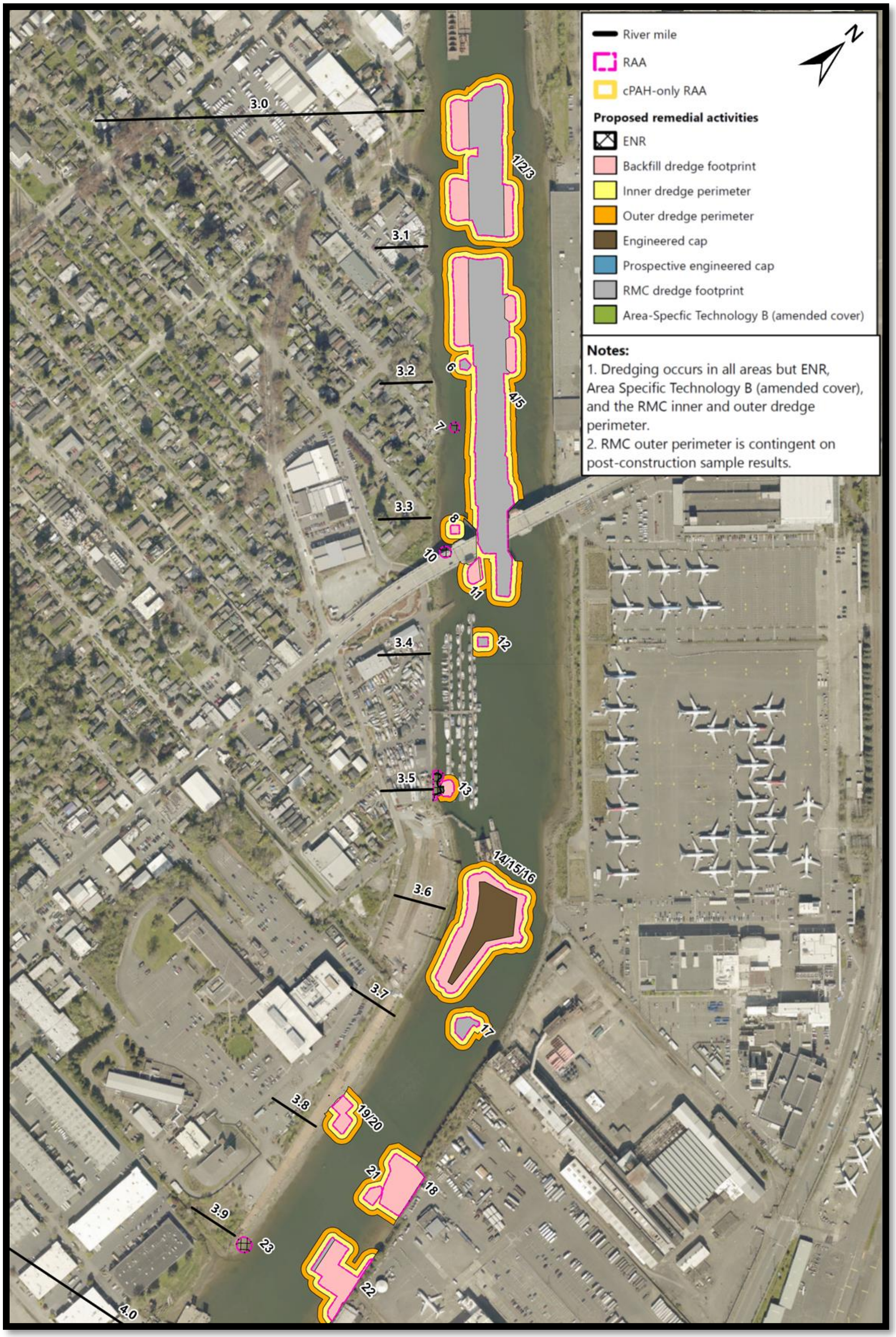

Figure 1. Remedial Action Areas and Proposed Activities between River Mile 3.0 and 4.0 of the Upper Reach of the Lower Duwamish Waterway.

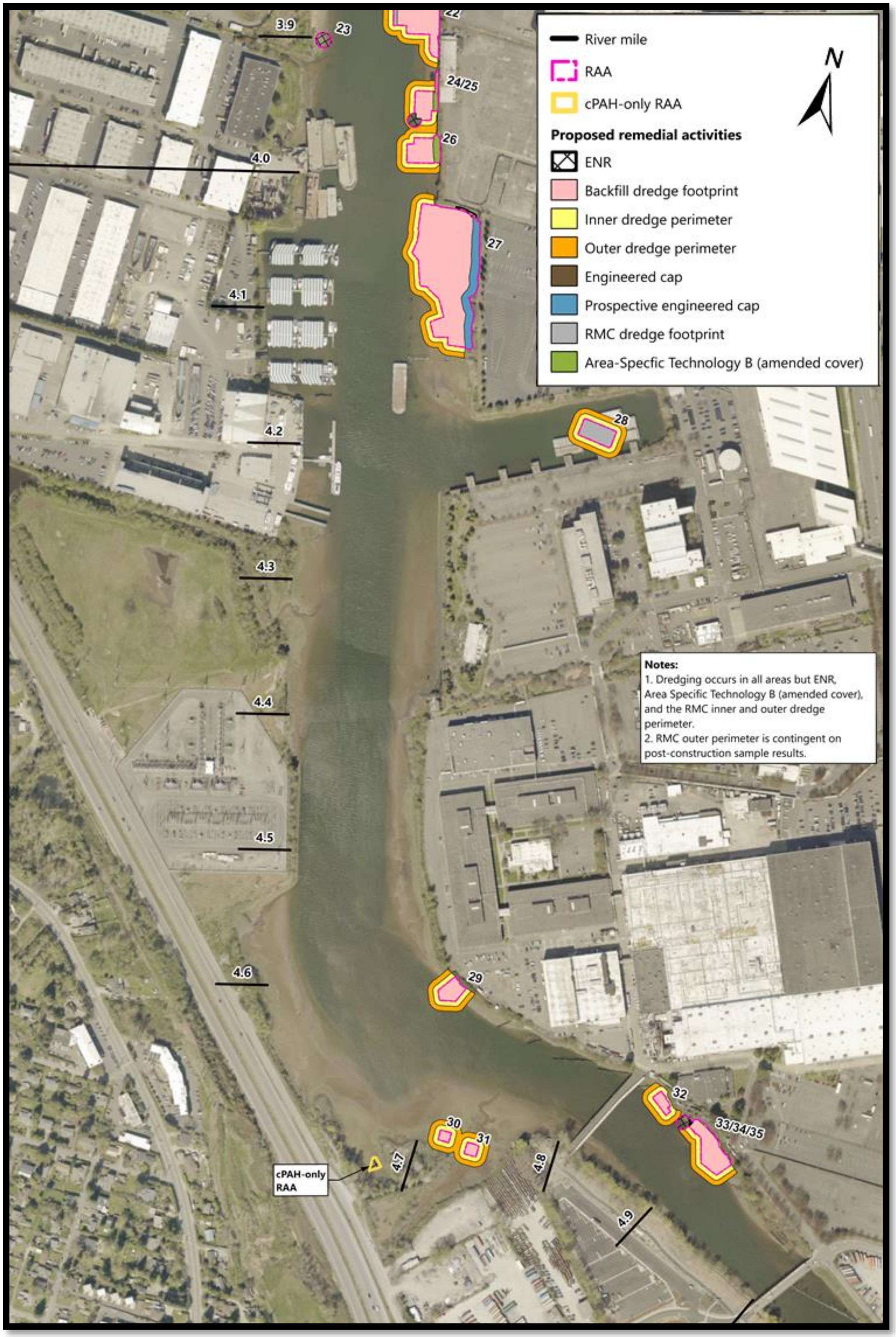

Figure 2. Remedial Action Areas and Proposed Activities between River Mile 4.0 and 5.0 of the Upper Reach of the Lower Duwamish Waterway.

Table 1. Remedial Design Technology Assignments by Remedial Action Area

Remedial Action Area	Area (acres)	Remedial Design Technology	Notes
1/2/3	2.42	Dredge and Backfill	Elevations shallower than -10 feet MLLW would be backfilled to grade.
1/2/3	2.42	Dredge	Elevations deeper than -10 feet MLLW would not be backfilled to grade, but RMC material would be placed
4/5	4.24	Dredge and Backfill	Elevations shallower than -10 feet MLLW and outside the federal navigation channel (FNC) would be backfilled to grade.
4/5	4.24	Dredge	Areas within the FNC or elevations deeper than -10 feet MLLW would not be backfilled to grade, but RMC material would be placed.
6	0.03	Dredge	Elevations deeper than -10 feet MLLW would not be backfilled to grade, but RMC material would be placed.
7	0.03	ENR	ENR material to be placed on existing mudline
8	0.03	Dredge and Backfill	Elevations shallower than -10 feet MLLW would be backfilled to grade.
9	N/A	N/A	RAA nine has been removed from the design package.
10	0.04	ENR	ENR material to be placed on existing mudline.
11	0.10	Dredge and Backfill	Elevations shallower than -10 feet MLLW and outside the FNC would be backfilled to grade.
12	0.03	Dredge	Areas within the FNC or elevations deeper than -10 feet MLLW would not be backfilled to grade, but RMC material would be placed.
13	0.07	Dredge	Areas within the South Park Marina would not be backfilled to grade, but RMC material would be placed.
13	0.09	ENR	ENR material would be placed over existing riprap slope.
14/15/16	1.2	Dredge and Backfill	Elevations shallower than -10 feet MLLW would be backfilled to grade.
14/15/16	1.2	Partial Dredge and Engineered Cap	Areas within the FNC would be treated with an engineered cap.
17	0.11	Dredge	Areas within the FNC or elevations deeper than -10 feet MLLW would not be backfilled to grade, but RMC material would be placed.
18	0.54	Dredge and Backfill	Elevations shallower than -10 feet MLLW would be backfilled to grade.
18	0.02	Area-Specific Technology: Amended Cover	Amended cover material would be placed on existing mudline in structural offset areas.
18	0.009	Slag Pile Removal	Slag pile would be removed.
19/20	0.16	Dredge and Backfill	Elevations shallower than -10 feet MLLW would be backfilled to grade.
21	0.007	Dredge and Backfill	Elevations shallower than -10 feet MLLW would be backfilled to grade.

Remedial Action Area	Area (acres)	Remedial Design Technology	Notes
22	0.62	Dredge and Backfill	Elevations shallower than -10 feet MLLW would be backfilled to grade.
		Dredge	Elevations deeper than -10 feet MLLW would not be backfilled to grade, but RMC material would be placed.
	0.41	Slag Pile Removal	Two large debris piles would be removed.
23	0.06	ENR	ENR material would be placed on existing mudline.
24/25	0.20	Dredge and Backfill	Elevations shallower than -10 feet MLLW would be backfilled to grade.
	0.03	Area-Specific Technology: Amended Cover	Amended cover material would be placed in structural offset area.
	0.08	ENR	ENR material would be placed on existing mudline.
26	0.22	Dredge and Backfill	Elevations shallower than -10 feet MLLW would be backfilled to grade
	0.07	Area-Specific Technology: Amended Cover	Amended cover material would be placed on existing riprap slope
27	1.88	Dredge and Backfill	Elevations shallower than -10 feet MLLW would be backfilled to grade
	0.35	Partial Dredge and Engineered Cap	Engineered cap may be placed along the bank slope.
28	0.22	Dredge	Berth areas would not be backfilled to grade.
29	0.15	Dredge and Backfill	Elevations shallower than -10 feet MLLW would be backfilled to grade.
30	0.04	Dredge and Backfill	Elevations shallower than -10 feet MLLW would be backfilled to grade.
31	0.05	Dredge and Backfill	Elevations shallower than -10 feet MLLW would be backfilled to grade.
32	0.07	Dredge and Backfill	Elevations shallower than -10 feet MLLW would be backfilled to grade.
33/34/35	0.05	ENR	ENR material would be placed on existing mudline.
	0.35	Dredge and Backfill	Elevations shallower than -10 feet MLLW would be backfilled to grade.
ENR (cPAH only) Areas	0.17	ENR	ENR material would be placed on existing mudline.

(1) Dredging

Where dredging and land-based excavation is the remedial technology used, sediment with chemical concentrations above the ROD-defined RALs would be removed. Dredging would occur in all the RAAs except for RAAs 7, 10, and 23, which would undergo ENR. Land-based excavation is expected to only occur in RAA 27. The anticipated dredging areas would cover approximately 13.2 acres. However, because RAA boundaries are being revised during Pre-Final (90 percent) RD based on new Phase III PDI data, an additional 2.0 acres of dredging has been assumed as a conservative contingency for evaluation purposes to bring the total potential dredge area to 15.2 acres. Overall, 98,000 cubic yards (cy) of material is anticipated to be dredged, plus an additional contingency re-dredge volume of 10,100 cy within the same dredging footprint. Contingency re-dredging may be implemented if the post-dredge survey indicates there is missed inventory or high concentrations of dredging residuals. Therefore, the total anticipated dredging volume is 108,100 cy. An additional 21,600 cy of dredged material has been assumed during the evaluation in case RAA boundary adjustments expand the overall dredge area based on new data. This brings the total dredge volume to 129,700 cy. Dredging or excavation required elevations or thickness vary based on the RAA location and would range from elevations of +20 feet mean lower low water (MLLW) where excavation may occur at top of banks, down to -25 feet MLLW, not including a 1-foot allowable overage tolerance.

All dredge areas would also include either backfilling to grade, placement of an engineered cap, or placement of RMC within the dredge footprint such that the entire dredge prism would have a cover of clean material post-construction. In addition, RMC would be placed within a 20- to 40-foot perimeter from the dredge footprint.

Dredging can be accomplished using mechanical dredging methods (e.g., mechanical cranes and barge-mounted excavators), hydraulic dredging methods, and land-based excavation methods. It would ultimately be up to the selected contractor to determine the specific dredging method(s) to be used during construction. As part of the construction activities, the work barges would be placing spuds and other anchors into the substrate to keep the barges stable while completing the work.

Mechanical dredging would be the primary dredging method. Although the contractor would ultimately select the appropriate equipment for dredging, it is anticipated that different sizes of dredge buckets (e.g., 5 to 10 cy) would be used for dredging in most locations. Mechanical dredges employ a bucket to retrieve sediment from the bed of the waterway, move the sediment up through the water column, and place the sediment into adjacent haul vessel (such as a barge) for transport and disposal. Two major categories of mechanical dredges are differentiated based on the method of bucket deployment. The first category uses a wire attached to a crane or derrick to lower the bucket to the bed and retrieve sediment. The second category deploys the bucket at the end of the arm of an excavator or backhoe and is sometimes referred to as an articulated fixed-arm mechanical dredge. Mechanical dredges are sometimes referred to by the type of bucket used, such as conventional open clamshell buckets or environmental buckets (Figure 3).

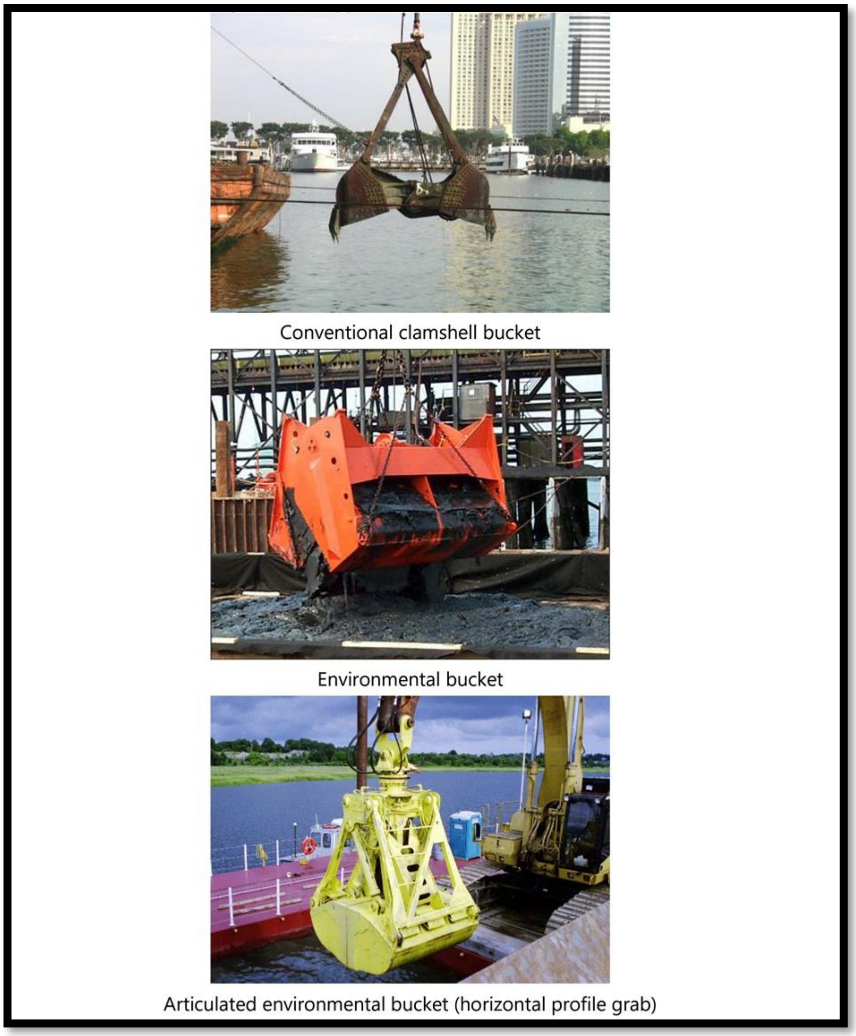

Figure 3. Different Mechanical Dredge Bucket Types.

The environmental (also known as closed) bucket is a sealed bucket (when complete bucket closure is possible) that has fewer bucket openings that allow sediment to escape when closed, as compared to the traditional open bucket. Environmental buckets are not watertight but do significantly reduce water and sediment loss from the bucket during dredging. Recent designs (e.g., Cable Arm) also incorporate a level-cut capability as compared to a circular-shaped cut for conventional buckets. However, minimizing the loss of sediment out of the bucket does not necessarily mean reducing suspended solids or lowering turbidity (Wang and Hotchkiss 2003). For example, in site conditions with significant debris, environmental buckets may not be able to fully close and tend to lose most or all of the dredged sediment from the bucket as it is raised through the water column. A standard clamshell digging bucket would be more effective at removing debris or dense substrate and be able to close tighter to prevent loss of dredged sediment when removing debris. Environmental buckets are also typically lightweight in construction and not suitable for digging denser or consolidated sediments, requiring multiple passes to remove the material or being ineffective at achieving the required dredge elevation and

grades. When used in unconsolidated sediments without significant debris, environmental buckets have been shown to be effective at reducing loss of sediment from the bucket.
The selection of dredge bucket and equipment is site-condition dependent- and contractor-specific and can vary depending on location-specific factors even for a single dredging project. The best equipment for one task may be unsuitable for another task. Dredging soft sediments in open water with minimal debris can be effectively accomplished with a conventional derrick crane and environmental and closed buckets, although the more closed the bucket is, the more sediment is expelled out the sides of the bucket into the water column as it closes. Constrained dredging in limited access areas may be more appropriately accomplished using an articulated bucket. When using closed environmental buckets (either wire-supported or fixed arm), debris can limit the efficiency of sediment removal by preventing the bucket from fully closing, which would unavoidably increase dredging residual and negate the benefits of the closed bucket. Although the contractor would ultimately select the appropriate equipment for dredging, the design specifications would require the contractor to use an environmental bucket to the extent practicable.

Hydraulic dredging is not anticipated to be used by the contractor during the upper reach remedial construction, but the contractor may propose its use in specific circumstances where site access for mechanical dredging is not feasible (e.g., under pier or riprap slope area) and the total amount of water generated would be small and controllable. As described in the Feasibility Study (AECOM 2012), hydraulic dredges remove and transport dredged material as a pumped sediment-water slurry. Large debris is typically removed by mechanical dredging methods prior to hydraulic dredging. Then, sediment is dislodged by mechanical agitation, cutterheads, or augers. In very soft sediment, it may be possible to remove surface sediment by straight suction or by forcing the intake into the sediment without first mechanically dislodging the sediment. Most of the loosened slurry is then captured by suction from pumps into an intake pipe and transported through a dredge discharge pipeline to handling and dewatering facility or a barge for dewatering. Hydraulic dredging impacts on sediment resuspension can be similar to mechanical dredging but typically observed near the sediment bed.

Dewatering of mechanical dredged materials would be initially performed on the haul barges. Initial dewatering would be accomplished by gravity separation of sediment solids from the water. Dredge return water would be filtered to remove suspended solids prior to discharging water from the haul barge. Water separated from sediment on the barges may be contained for transport to the transload facility or filtered and returned to the LDW, contingent upon meeting water quality standard criteria.

Debris piles are located within the dredging footprint of RAAs 18 and 22 covering 0.42 acre. There are three large piles (one in RAA 19 and two in RAA 22) that are presumed to be waste materials from former industrial activities that are identified for removal. Removal of the debris would require temporary shoring of the adjacent bulkhead walls (to counteract any loss of passive pressure associated with removal of the debris piles) and is expected to occur before dredging of the adjacent sediments within the RAA. The debris would be removed to the mudline plus 2 additional feet below the mudline.

Land-based (i.e., "in the dry") excavation may also be used in intertidal and bank areas but would be limited because of access limitations and duration of low tidal periods. It is expected to be used only in RAA 27 using a derrick crane, and a backhoe excavator, or a long-reach stick excavator and conventional land-based earth-moving equipment (e.g., excavators, backhoes, dozers, front-end loaders, and trucks). Excavation in these areas may be coordinated "in the dry" during periods of low tidal elevations; however, depending on weather, tides, scheduling, and contractor production, it may be necessary to conduct some intertidal excavation under water.

It is anticipated that materials removed from the intertidal and bank areas when using land-based equipment may need to be placed into temporary upland stockpile area or directly into trucks, depending on site access agreements and available upland space. Thus, any land-based work would require upland site access, staging areas, loading operations, and ground transportation. For RAA 27, staging and loading areas would occur in adjacent upland area, likely west of the existing interior fence. Above the top of bank currently consists of paved areas.

(2) Transport, Transloading, and Disposal of Dredged Material

Sediment and debris removed from the upper reach would be loaded onto haul barges, or directly into trucks during upland excavation activities, and transported to a transload facility where the material would be offloaded from barges and loaded onto trucks and/or railcars for transportation to a permitted disposal facility. The transload facility is anticipated to be located at a commercial transload facility either in the middle reach of the LDW or another facility located outside of the LDW Superfund Site. Specific transload facility and location would be determined by the selected contractor. The best management practices (BMPs) described below would avoid or minimize release of contaminated material or effluent associated with the transloading and transport of dredged material. Specifically, the following measures would be required to avoid impacts associated with the transport to the transload facility:

- The barges would be required to be watertight during transport (i.e., there would be no discharge of barge water during barge transport).
- The contractor is required to use a permitted facility to offload dredged materials (i.e., permitted for use as a waterfront facility that can offload bulk materials).
- Specifications require the contractor to implement BMPs to prevent spillage of sediment or barge water during offloading (e.g., install spill plates and impermeable liner to catch spillage from transfer operations over the water) and BMPs to control release of water and sediment from land stockpiles back into receiving waters (i.e., to comply with site's National Pollutant Discharge Elimination System (NPDES) or other permits, provide impermeable liner and perimeter barriers around upland stockpiles, and capture all stormwater and stockpile effluent).

Once offloaded to land at the transload facility, additional dewatering (including by gravity and/or amendment) would be performed if determined necessary by the transloading and disposal facilities. Any dredged return water generated by dewatering at the transload facility would be managed (contained and, if necessary, treated) and disposed of in accordance with the facility's permits (i.e., NPDES or other permits) and standards of wastewater disposal.

Dredged material would be transported in water to the transloading facility via haul barges, where it would be offloaded from the barge typically using a crane-mounted bucket and placed into a hopper/conveyor assembly or stockpiled area and prepared for upland transportation. Material would then be transported on land using rail or trucks to the permitted disposal facility. Rail transportation includes the transport of dewatered dredged material via railroad tracks using gondolas or containers. Rail transport is desirable when sediment is shipped over long distances, for example, to out-of-state disposal facilities. Truck transportation includes the transport of dewatered dredged material over public roadways using dump trucks, roll-off boxes, or trailers. The contractor would prepare its Remedial Action Work Plan (RAWP) that would describe construction methods and BMPs to comply with the plans and specifications; the contractor's RAWP would be reviewed and approved by EPA.

(3) Engineered Capping

RAA 27 has been identified for the potential placement of an engineered cap. In this area, existing debris, riprap (rock armor), and rubble are expected to be removed from the bank as well as the top several feet of armor material and sediment/soils, and the underlying sediments/soils are expected to be capped over an area of approximately 0.4 acre in the upper intertidal area for no net change in elevation or slope. There is no opportunity in this location to construct a flatter slope due to the location of a slurry cutoff wall that was constructed to support upland remediation requirements (around the inner fence line) that needs to be protected. The Intermediate (60 percent) RD for RAA 27 bank area may result in removal of all contaminated materials, but verification sampling in the bank area post-removal would be conducted to determine whether there are contaminated sediments/ soils that underly the planned removal thickness. The RAA 27 upper intertidal bank area has been designed as an engineered cap to be conservative.

Additionally, based on new Phase III PDI data, the Pre-Final (90 percent) RD would include an engineered cap in RAA 14/15/16 over an area of 1.0 acre. In this area, a portion of the federal navigation channel (FNC) is expected to require dredging (included in the anticipated overall dredging volume of up to 129,0700 cy) and then placement of an engineered cap. The top of the engineered cap surface would be below -19 feet MLLW (deep subtidal) as required by the ROD.

Overall, engineered caps are expected to cover up to 1.4 acres with a potential added area of 0.22 acre as contingency to account for additional engineered cap areas that could be identified in Pre-Final (90 percent) RD based on new Phase III data.

Engineered capping consists of the physical isolation or immobilization of contaminated sediments, which limits the potential exposure to and mobility of contamination. Sediment caps are designed to reduce potentially unacceptable risks by physical isolation of the contaminated sediment or soil to prevent exposure from direct contact, reduce the ability of burrowing organisms to move contaminants to the surface, provide erosion protection to prevent resuspension of the capped sediment, and/or chemical isolation of contaminated media to reduce exposure from contaminants.

An engineered cap typically consists of an erosion protection layer (e.g., gravel or large rock) overlying a filter material (coarse sand or gravel) overlying a chemical isolation layer (fine to medium sand). In addition, the ROD (EPA 2014) requires the top of the cap to contain suitable habitat material for caps that are at elevation -10 MLLW or shallower and 1.5 feet of suitable habitat material in intertidal clamming areas. Below the upper tidal area of RAA 27 is an intertidal clamming area; however, the upper intertidal area of RAA 27 is an existing steep and armored slope (2 horizontal to 1 vertical (2H:1V)) that is not suitable as a clamming area. An engineered cap is expected to be placed in RAA 27 to replace the existing steep armored slope only in the upper intertidal area that is not suitable for clamming; therefore, it is assumed that suitable habitat materials is not appropriate to place on top of the steep armored slope, and the steep armored slope portion of RAA 27 would have the same surface condition (riprap) post-construction. The toe elevation of the existing armored slope and the proposed engineered cap would be approximately at elevation +4 MLLW. The surface of the RAA 27 engineered cap below mean higher high water would likely be covered by naturally deposited sediment in the long term (i.e., 2 to 5 years). The deep subtidal engineered cap in RAA 14/15/16 is expected to be covered by naturally deposited sediment based on the depositional environment in the navigation channel. For both of these areas, the habitat surface is expected to return to conditions reflecting what is naturally deposited from upstream.

The engineered capping material and all import materials are expected to be transported either by land from the borrow quarry to the upper reach with dump trucks or by water on barges. The engineered cap material would then be placed over the impacted soil and sediments as follows:

- Chemical Isolation Layer: Minimum thickness of 12 inches up to 18 inches of medium- to coarse-grained sand
- Filter Layer: Minimum thickness of 6 inches up to 12 inches of angular gravel material
- Erosion Protection Layer: 12- to 18-inch layer of armor material (i.e., angular rock armor (quarry spalls to light, loose rip rap size))

For placement of imported materials (i.e., engineered cap, backfill, RMC, ENR, and amended cover materials), the specifications would identify performance criteria that the contractor must meet and provide flexibility for the contractor to choose the optimal means and methods that take advantage of their experience and equipment. The contractor would be required to place all materials in a manner that reduces resuspending potentially contaminated bed sediment. Additionally, material would be placed using methods that limit mixing of the placed materials with the bedded sediment as described below.

(4) Placement of Backfill, RMC, ENR, and Amended Cover Materials

Clean, imported material, including backfill, RMC, ENR material, and amended cover materials, would be placed in the RAAs as shown in Figures 1 and 2. Material placed in areas of existing elevations of -10 feet MLLW or shallower would consist of suitable habitat material (e.g., fish mix/habitat mix) but would need to balance constructability and availability needs. For example, clean imported material would primarily be sands and gravels. Obtaining and constructing stable slopes using clean silts, clays, and other fine materials is not practical. The surface of the placed materials would eventually be covered by naturally deposited sediment specific to each area placed, so in the long term (i.e., 1 to 5 years) the habitat surface would return to conditions reflecting what is naturally deposited from upstream.

Backfill material would be suitable habitat material consisting of a mix of sand and gravel. Backfill would be placed in dredge areas that are currently at elevation -10 feet MLLW and shallower to return those areas back to their pre-construction elevations and grades to maintain shallow water habitat. Backfill material is expected to be placed over 6.6 acres in the upper reach. However, due to the potential that the RAA boundaries may be revised during the Pre-Final (90 percent) RD based on new Phase III PDI data, an additional 1.1 acres backfill placement have been assumed for evaluation to bring the total potential backfill placement to be 7.7 acres.

Medium to coarse sand material would be placed in and around dredged areas as RMC and in ENR areas. A 6- to 12-inch layer of RMC would be placed after dredging is complete within each dredge area and around the perimeter of each dredge area out to 20 feet (or 30 feet in the downstream direction only) from the dredge area (inner dredge perimeter) and may be placed up to 40 feet (or 60 feet in the downstream direction only) from the dredge area (outer dredge perimeter) depending on post dredge confirmation sampling. RMC thickness on side slopes would consist of a 2-foopt layer. RMC would address the thin layer of residuals generated during the dredging operations and provide a new surface substrate of clean sediments.

Residuals refer to the thin layer of disturbed contaminated sediment that remains of the post-dredge surface due to material loss during dredging or due to the inability of the dredge to fully remove the material disturbed during the excavation process. This material generally exhibits very high water content and very slow shear strength. Additional dredge passes are typically ineffective at capturing generated residuals. The purpose of residuals management is to provide as clean post-remedial action surface condition with concentrations that are all below surface RALs. Residual contamination can remain within the dredge prism and be resuspended to settle out close to the dredge areas in adjacent sediments. Placing RMC is an effective and standard approach to manage generated residuals. Where sufficiently thin and low-concentration residuals are present, short- and long-term mixing of the clean RMC material into underlying residuals would support attainment of the cleanup criteria. The placement of a clean cover layer accelerates the natural recovery process in the biologically active zone.

RMC is expected to be placed over 12.6 acres (5.2 acres within the dredge footprint and 7.4 acres in the inner and outer dredge perimeter) in the upper reach. This assumes 25 percent of the outer dredge perimeter would receive RMC based on post-dredge confirmation sampling. An additional 0.7 acre of RMC is assumed as a contingency within the dredge footprint, and 4.7 acres of RMC in the inner and outer dredge perimeter is assumed as a contingency. This assumes 100 percent of the outer dredge perimeter would receive RMC based on post-dredge confirmation sampling. The overall total potential RMC placement area is 18 acres.

ENR includes placing a thin layer (i.e., 6 to 12 inches) of clean sand or sand and gravel material over the existing mudline to accelerate natural recovery processes. The proposed action would implement ENR in areas that meet the necessary criteria based on contaminant of concern (COC) concentrations that are above the ROD-defined RALs but below a maximum threshold to use

ENR per the ROD. ENR provides a new surface substrate of clean sediments that reduces concentrations in the biologically active zone below the RALs. This cleaner surface material would generally mix with the underlying material through mechanisms such as bioturbation (the disturbance of sediments by organisms). ENR reduces contaminant concentrations in surface sediments more quickly that would happen by natural sedimentation processes alone.

ENR material is expected to be placed over 0.41 acre in the upper reach. An additional 0.21 acre of ENR material placement is assumed as a contingency for evaluation purposes, for a total potential ENR placement area of 0.62 acre.

Amended cover material would be placed in portions of RAAs 18, 24, and 26 that are adjacent to existing structures or armored slopes and where dredging offsets are required (i.e., dredging is not possible due to structural or stability concerns). A 6- to 12-inch layer of cover material consisting of sand and gravel assumed to be amended with 1.5 percent of granulated active carbon (by weight) would be placed to reduce the bioavailability of polychlorinated biphenyl (PCBs) at the surface of the cover over a 100-year period. Amended cover materials is expected to be placed over 0.12 acre. An additional 0.06 acre of amended cover placement is assumed as a contingency for evaluation purposes, for a total potential amended cover area of 0.18 acre.

For placement of backfill, RMC, ENR, and amended cover materials, the specifications would identify performance criteria that the contractor must meet and provide flexibility for the contractor to choose the optimal means and methods that take advantage of their experience and equipment. The contractor would be required to place all materials in a manner that reduces resuspending potentially contaminated bed sediment. Additionally, material would be placed using methods that limit mixing of the placed materials with the bedded sediment. These include using a barge-mounted, crane-operated clamshell or spreader box (‘skip box”), or variable-speed telebelt (Figure 4). The material would be placed with sufficient control to meet the design thickness and required backfill elevations for each type of material.

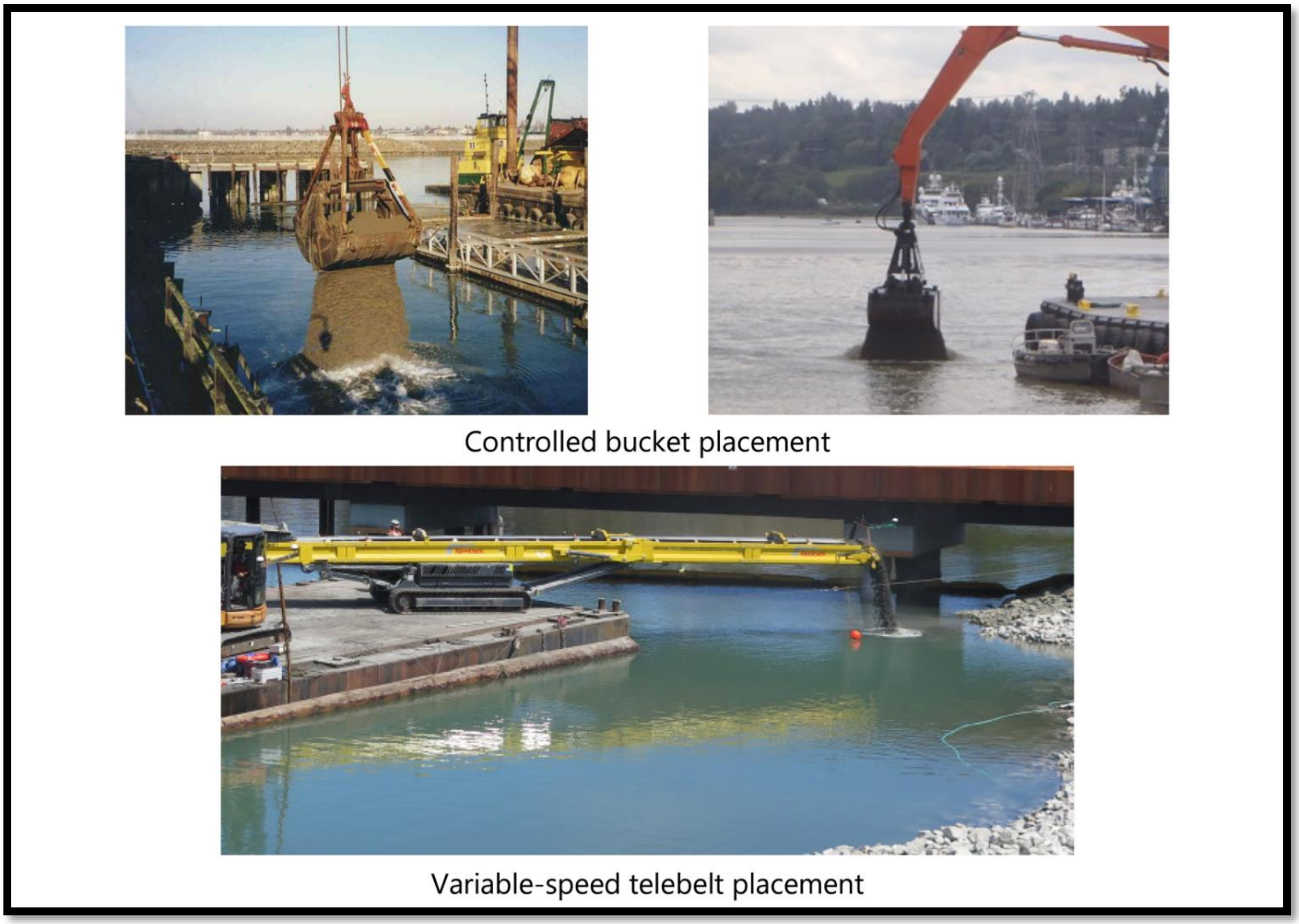

Figure 4. In-water placement of clean material using typical marine equipment.

(5) Monitored Natural Recovery

MNR relies on natural processes, such as burial of low to moderately contaminated sediments by cleaner sediments from upriver on the cleanup site. Per the ROD, MNR relies on natural processes to reduce ecological and human health risks to acceptable levels while monitoring recovery of sediments over time to determine remedy success. Within the LDW, natural burial of contaminants through sedimentation from upstream is the primary natural recovery mechanism. MNR would be used in all areas of the upper reach below ROD-defined RALs (i.e., that are not remediated through engineered capping, dredging, or ENR). For all areas where MNR is used, long-term monitoring of surface sediments (top 10 cm) would be implemented to evaluate whether cleanup levels are being achieved.

No construction activities are associated with MNR technology.

(6) In-Water Structure Modifications

Piles are anticipated to be removed and replaced with vibratory hammer to facilitate access for dredging at some locations. Any piles that are removed that support Tribal net fishing would also be replaced and designed to resist forces imposed by the nets, which would be evaluated in coordination with Tribal fishers. The need for vertically loaded replacement piles has not been identified within the upper reach. Piles are assumed to be replaced to provide "in kind" functions to piles that are removed; however, because timber piles require chemical treatments to limit decay, timber piles would be replaced with steel piles during replacement. There may also be a need for isolated removal for derelict piles that do not have an identified current or future use but may be inhibiting access for nearby remediation. The following pile removal and/or replacement are anticipated to occur:

- Between RAAs 24/25 and 26, two 10-inch diameter timber piles would be removed, and one would be replaced with a 14-inch steel pile. These activities would occur in the intertidal zone.
- In RAA 27, one timber dolphin consisting of three 10-inch timber piles would be removed and not replaced. One single 10- timber pile would be replaced with a 14-inch steel pipe pile for Tribal fishing use. These activities would occur in the intertidal zone.
- In RAAs 30 and 31, nine 10-inch creosote-treated timber piles would be removed from the LDW and not replaced. These activities would occur in the intertidal zone.
- In RAA 32, two 10-inch timber piles would be removed and not replaced in the intertidal zone.
- In RAA 33/34/35, at least thirteen 10-inch timber piles would be removed and not replaced in the intertidal zone.

For conservative evaluation purposes, it is assumed that approximately ten 36-inch steel pipe piles could be installed temporarily during construction for contractor's vessel moorage in deep subtidal areas outside of the FNC. These may be installed by the contractor and used to tie equipment up to when not in use.

Shoring would be needed to reinforce an existing bulkhead wall in RAA 22. Three options are being considered for shoring existing bulkhead wall:

- Tieback Anchors: The anchors would be installed above the water level and would not result in a loss of habitat.
- Bracing Piles: Eight to sixteen piles of 8- to 10-inch diameter would be installed along the existing bulkhead wall.
- Shoring Sheetpile Wall: If tieback anchors or bracing are not feasible or sufficient to be used as shoring along RAA 22, a shoring sheetpile would be driven along a 160-foot section of shoreline approximately 1.5 feet waterward of the existing bulkhead. The area between the existing and replacement wall would be filled with import material.

Shoring is needed to keep the existing bulkhead wall stable during removal of the debris pile. For the purpose of this analysis, it is assumed that a shoring sheetpile would be used to reinforce the existing bulkhead wall because this option would represent the greatest impact to intertidal habitat.

Existing outfall discharge locations may need to be armored or supported on splash pads/aprons or other flow energy dissipator systems to protect the bank from erosion due to the outfall flow discharge. It is assumed that bank protection material would cover an area of 540 square feet and is anticipated to be used on one outfall each in RAAs 13, 18, 26, and 33/34/35, for a total of 2,160 square feet (0.05 acre).

Piles would be removed using vibratory extraction methods, direct-pull methods or would be cut at or below the mudline. Piling removal is expected to be conducted with a crane mounted on a barge. If a pile is unable to be completely removed using the vibratory or pulling methods, the pile would most likely be cut approximately 2 feet below the mudline. Temporary piles would be removed using vibratory methods.

Piles would be installed using vibratory methods, which is suitable for the substrate conditions within the LDW. An impact hammer would not be required to drive piles to design depths and would not be used to proof any piles.

Bracing piles or sheetpile wall that may be used to reinforce the existing bulkhead wall in RAA 22 would be installed using vibratory methods. If tieback anchors were used to reinforce the existing bulkhead wall in RAA 22, the construction would be completed with drilling equipment above the waterline.

Outfall bank protection materials would be placed using typical earthwork equipment (excavator) at low tide in the dry.

(7) Construction Access

Construction access is expected to occur from the waterside for most of the proposed remedial activities. However, RAA 13 and RAA 27 are anticipated to required construction access from the upland. Upland access to RAA 13 (if used) is expected to be through the South Park Marina. For RAA 27, existing vegetation that may be disturbed for access to implement remedial activities includes 1,800 square feet of trees that line the parking lot. Currently, non-native shrubs, such as Himalayan blackberry (*Rubus armeniacus*) and butterfly bush (*Buddleia davidii*), are set back from the channel at the top of the riprap along RAA27. In addition, there are similar non-native shrubs at the top of the existing bulkhead wall at RAA 22 that may be disturbed during reinforcement of the bulkhead wall. Any shoreline vegetation disturbed from implementation of remedial actions from the landside would be replaced with native vegetation species to the extent feasible based on site access agreements.

(8) Summary of Remedial Activities

Overall, approximately 28.1 acres of approximately 132-acre upper reach could be impacted by remedial activities, including dredging, engineered capping, and placement of backfill, RMC, ENR and amended cover materials, as summarized in Table 2. Additionally, up to thirty 10-inch timber piles are expected to be removed, and up to two 14-inch steel pipe piles are expected to be installed as replacements (Table 3). Fifteen of the 10-inch timber piles that are expected to be removed are assumed to be creosote-treated. This results in a net gain of 14.22 square feet of intertidal habitat from the permanent decrease in pile area coverage. Approximately 10 36-inch steel pipe temporary piles may be installed during construction for moorage in deep subtidal areas outside of the FNC. For the purpose of this analysis, reinforcement of the existing bulkhead wall is assumed to be a new sheetpile wall and result in a loss of 240 square feet of intertidal habitat. Finally, 0.05 acre of bank protection are expected to be permanently placed at outfalls to protect the remediated bank from erosion. These areas would be within the areas of dredging and/or material placement, so they would not be new areas of construction impact. Overall, 2,386 square feet (net) would be impacted by in-water structure modifications.

Table 2. Summary of Area of Impact for Dredging and Material Placement Activities

Habitat Type	Area of Impact – Dredging or Excavation and Material Placement[1] (acres)	Contingency[2] Area of Impact – Dredging or Excavation and Material Placement (acres)	Area of Impact – Partial Dredging and Engineered Cap (acres)	Contingency[2] Area of Impact – Partial Dredging and Engineered Cap (acres)	Area of Impact – Material Placement[3] (acres)	Contingency[2] Area of Impact – Material Placement (acres)	Total Area of Impact (including contingency) (acres)
Riparian (higher than +11.3 feet MLLW	0.004	0.001	0.3	0	0.2	0.1	0.6
Intertidal (-4 to +11.3 feet MLLW)	4.2	0.6	0.1	0	2.9	1.9	9.7
Shallow Subtidal (-10 to -4 feet MLLW)	1.3	0	0	0.22	1.8	1.1	4.4
Deep Subtidal (deeper than -10 feet MLLW)	6.3	1.2	1.0	0	3.0	1.9	13.4
Total	11.8	1.8	1.4	0.22	7.9	5.0	28.1

Notes:

1. Each dredging and material placement area would be covered with either RMC (5.2 acres (0.7 acre of contingency)) or backfill material (6.6 acres (1.1 acres of contingency)) after dredging is complete; therefore, dredging and material placement is combined in these areas to avoid double counting area of impact. Partial dredging and engineered cap areas may receive an engineered cap after dredging. The total dredging area is equal to the dredging and material placement area plus the partial dredging and engineered cap area (13.2 acres (2.0 acres of contingency)).
2. Contingency areas are estimated to account for the potential that the RAA boundaries may be revised during the Pre-Final (90%) RD based on new Phase III PDI data.
3. Material placement includes placement of ENR material over 0.41 acre, placement of amended cover over 0.12 acre, and 7.4 acres of RMC outside of the dredge area in the inner dredge perimeter that automatically receives RMC and the outer dredge perimeter that may receive RMC depending on the results of post-dredge confirmation sampling. For area of impact, it is assumed that 25% of the outer perimeter would require RMC. Contingency material placement material includes placement of ENR material over 0.21 acre, placement of amended cover over 0.06 acre, and 4.7 acres of RMC outside of the dredge area in the inner dredge perimeter that automatically receives RMC and the outer dredge perimeter that may receive RMC depending on the results of post-dredge confirmation sampling. For contingency area of impact, it is assumed that 100% of the outer dredge perimeter would require RMC.

Table 3. Summary of Permanent In-Water Structure Installation and Removal

RAA	Piles to Be Removed			Piles to Be Installed			Outfall Bank Protection Splash Pad[1]	Existing Structure Reinforcement				Net Aquatic Area Impacted (ft^2)
	Number and Size	Type	Aquatic Area Opened Up (ft^2)	Number and Size	Type	Aquatic Area Impacted (ft^2)	Aquatic Area Impacted (ft^2)	Length to be Removed (feet)	Length to be Installed (feet)	Offset[2] (feet)	Aquatic Area Impacted (ft^2)	
22	0	0	0	0	N/A	0	0	0	160	1.5	240	240
24/25, 26	2 10 inches	Timber[3]	1.09	1 14 inches	Steel pipe	1.07	0	0	0	0	0	-0.02
27	3 10 inches	Timber[3]	1.63	0	N/A	0	0	0	0	0	0	-1.63
27	1 10-inches	Timber[3]	0.55	1 14-inches	Steel pipe	1.07	0	0	0	0	0	0.52
30/31	9 10-inches	Timber[3]	4.91	0	N/A	0	0	0	0	0	0	-4.91
32	2 10-inches	Timber[3]	1.09	0	N/A	0	0	0	0	0	0	-1.09
33/34/35	13 10-inches	Timber[3]	7.09	0	N/A	0	0	0	0	0	0	-7.09
13, 18, 26, 33/34/35	N/A	N/A	N/A	N/A	N/A	N/A	2,160	0	0	0	0	2,160
Total	30	N/A	16.36	2	N/A	2.14	2,160	0	160	1.5	240	2,386

Notes:

1) Up to four outfall bank protection splash aprons are expected to be installed, each consisting of an area of 540 ft^2.
2) Waterward offset from existing bulkhead. The installation of a shoring sheetpile wall represents the greatest loss of habitat of the three options presented above.
3) Timber piles in RAAs 24/25, 26, 27, and 30/31 are assumed to be creosote-treated. Timber piles in RAAs 32 and 33/34/35 are not creosote treated.

Project Timing

Project construction for the upper reach remedial action is expected to begin in the fall 2024 and require three consecutive construction windows (2024 to 2025, 2025 to 2026, and 2026 to 2027) to complete. In-water construction activities would occur during in-water work window designated for the LDW (October 1 to February 15) that are set to protect migrating juvenile salmonid species and Washington Department of Fish and Wildlife (WDFW) priority species.

Construction start dates each season would be coordinated with applicable Tribes to minimize interruption of Tribal netfishing in their Usual and Accustomed (U&A) area. Mobilization would take place prior to the start of the in-water work season, and demobilization would occur after the end of each in-water work season. Construction activities would generally move from upriver to downriver, but the selected contractor would be allowed to move between areas as necessary to complete remedial construction efficiently.

Best Management Practices

Impact avoidance and minimization measures apply to remedial technologies implemented as part of the proposed action, including dredging; barge loading and dewatering; transport and transloading of dredged material; engineered capping; placement of backfill, RMC, ENR, and amended cover materials; pile removal/installation; and any associated in-water work. The avoidance impacts to the aquatic environment, but where impacts may be unavoidable, measures to minimize the impacts are proposed.

(1) General

The following impact avoidance and minimization measures would apply to all in-water construction activities, including dredging; engineered capping; placement of backfill, RMC, ENR, and amended cover materials; and in-water structure removal and installation:

- All in-water work would be conducted during a regulatory in-water work window when juvenile salmonids and WDFW priority species are expected to either not be present or present in low numbers. The in-water work window designated for the LDW is October 1 to February 15. The work window requirement is expected to apply to activities occurring in the water that have the potential to impact listed species. Coordination with federal and state resource agencies and co-managers would occur to ensure any deviations in the timing of fish runs are accounted for in work start and end dates to aid in balancing the overall impact of the work to be performed (e.g., a small extension of the window to avoid an entire additional field season of work for a particular area may be of an overall lesser impact and preferred). Work that is expected to result in limited impacts would not be completed during the in-water work window. This type of work includes transport and transloading of dredged material, removal and placement of structures (except of pile removal and/or installation), and activities occurring in the dry or over the water with proper measures in place to prevent construction materials from entering the water.
- Water quality in the action area would be monitored and compared against applicable water quality standards (Washington Administrative Code (WAC) 173-201A-210). This

includes required limits measured in the water column for turbidity, dissolved oxygen (DO), pH, and temperature, and for select COC criteria (e.g., PCBs) pursuant to the Clean Water Act (CWA) Section 404 Applicable of Relevant and Appropriate Requirements (ARAR) Memorandum that would be issued by the EPA prior to the implementation and the Water Quality Monitoring Plan (WQMP) completed as part of the Pre-Final (90 percent) RD and Final (100 percent) RD.

- Operational Controls would be used for control of turbidity and resuspended sediment. For example, construction activities can be progressively slowed to minimize sediment suspension until turbidity exceedances are no longer detected outside of the compliance boundary, or dredging cycle times can be increased to decrease turbidity plumes until suspended sediment settles.
- A spill containment and control plan would be kept on site during construction activities and would contain notification procedures, specific cleanup and placement instructions for different products, quick response containment and cleanup measures that would be available, proposed methods for placement of spilled materials, and employee training for spill containment.

(2) Dredging:

- Removal of large debris, if practicable, would be required prior to dredging in identified debris areas. Debris caught in dredging equipment can cause additional resuspension and release of contaminated sediments. Note, this operational control is not appropriate for buried debris below the mudline; debris removal itself generates turbidity. Practicability of debris removal would depend on field conditions.
- Multiple bites by the dredge bucket on the sediment bed before the bucket is raised would be prohibited so that bed disturbance by the bucket is reduced.
- "Sweeping" (i.e., dragging a bucket or beam), or leveling of the sediment bed by pushing bottom sediments around with the dredge bucket to knock down high spots to achieve required dredge elevations, would be prohibited. Instead of leveling to remove high spots, the contractor may be required to make additional dredging pass to remove high spots that are identified during progress surveys.
- Interim underwater stockpiling of dredge material would be prohibited (i.e., taking small dredge cuts and temporarily stockpiling material at the mudline in a mound to allow the dredge operator to grab a fuller bucket). Such action could create a pile of loose sediment that can easily be resuspended.
- Overfilling of conventional clamshell and environmental buckets would be prohibited. When the dredge bucket penetrates soft sediment, there is the potential for the bucket to penetrate beyond the designed digging depth of the bucket. If the bucket is overfilled, a portion of the dredge material cannot be contained within the bucket and may be lost and resuspended in the water column as the bucket is raised. If bucket overloading is observed, measures would be taken to reduce this potential (e.g., decrease the maximum cut depth).
- The contractor would be required to use an environmental bucket as the primary method for dredging. However, the contractor may propose to use a standard clamshell digging bucket when site conditions are not appropriate for the environmental bucket (i.e., buried debris or dense sediment conditions).

- Specific dredging procedures (e.g., shallow top-to-bottom cuts) would be specified to prevent the potential for slope failures and slope movement that would cause excessive sediment resuspension.
- Additional BMPs to reduce sediment resuspension that may be employed as needed to manage water quality and meet turbidity criteria include the following:
    - The rate of dredge bucket descent and ascent would be slowed down; however, this BMP needs to be carefully implemented based on the physical characteristics of the sediment being removed (e.g., soft sediments verses hard digging, presence of debris, or water depths) because limiting the velocity of the descending bucket in dredge operations may reduce the volume of sediment that is picked up by the bucket, thus requiring multiple bites to remove the project sediment and increasing the overall project duration and associated duration of short-term water quality impacts.
    - After dredged sediment is placed into the haul barge, the opened bucket would be held open for a short period of time above the barge to allow residual materials from the bucket to fall into the barge.
    - Use of low power for tug operations in the shallow subtidal and intertidal zones would be recommended during barge relocation, movement for maritime traffic, and dredge/material barge replacements to reduce sediment resuspension.
- If hydraulic dredging methods are used, the following measures would be implemented to reduce the probability of entrainment:
    - The dredge would not be operated when the cutter or suction head is off the river bottom.
    - The cutter or suction head would be placed on the bottom of the water column or a maximum of 3 feet from the bottom when necessary.
    - The pumps would only be turned on when necessary.

(3) Barge Loading and Dewatering

Measures that would be required to reduce the potential for spillage of dredged material during haul barge filling and dewatering include the following:

- Uneven filling or overfilling of barges would be prohibited to prevent spillage of sediment and unfiltered dredge return water from barges.
- Haul barges would be loaded evenly to maintain barge stability.
- Once the barge is loaded and stabilized, it would be inspected for sediment adhered to the outside of the barge that could fall off the barge during transport. Contractor personnel would conduct a visual inspection around the entire barge deck area to remove such sediment before moving the barge out of the dredging site.
- For dredged sediment dewatering occurring on haul barges, the dredge return water would be discharged back into LDW within the active dredging work zone. The contractor would be required to equip the barges with appropriate BMPs (e.g., filtering all water prior to discharge to remove suspended solids from the dredge return water) to maintain compliance with water quality criteria.

(4) Transport and Transloading of Dredged Material

Measures would be required to reduce the potential loss of dredged material during transport, transloading of dredged materials off the barge (at the transload facility) or from a temporary upland stockpile area (if intertidal sediment and shoreline bank soil excavation occurs). Measures would also be required during transport of dredged/excavated material from the transload facility to the approved disposal facility. Such measures include the following:

- All barges transporting dredged materials would be certified as seaworthy by a marine inspector prior to barge use, and no unfiltered dredge return water would be allowed to discharge into the LDW in transit to the transload facility.
- Any effluent generated by dewatering at the transload facility, or via hydraulic or land-based dredging, would be managed (contained and, if necessary, treated) and disposed of in accordance with facility permits or authorizations for wastewater disposal.
- To prevent dredged material spillage when transloading materials between the haul barge and transload facility, spill aprons would be set up and used to direct bucket spillage back into the barges or onto the uplands and not into the adjacent water.
- Inside the transload facility, material captured by spill aprons would land on secondary containment areas outside the area typically traveled by trucks or railcars to avoid tracking material on tires or wheels.
- The bucket swing path from the haul barge to the upland transload facility would not be allowed to occur over open water. The contractor would need to swing the offloading bucket over either the derrick barge or a “spanning” barge that would capture any spillage from the offloading bucket.
- Visual monitoring would be performed by the contractor to determine if the transport of dry dredged/excavated materials creates a dust concern, and if so, dust suppression controls would be employed (e.g., covering the haul truck or containers).
- When wet materials are transported over land, haul trucks or railcar containers would be lined or sealed to reduce the chance of sediment or water release during transport.
- For dredge material transfer from a temporary upland stockpile area, truck loading would occur within the transfer area, and the trucks would be decontaminated and inspected within a designated contained footprint before they leave the transfer area.
- Trucks or railcars would not be overloaded to prevent loss due to spilling.
- Truck loading areas would be swept frequently to reduce the probability of truck tracking contaminated materials outside of the loading areas.
- The trucks, truck loading area, and access route would be visually inspected to confirm there is no loss of material from the trucks prior to releasing the truck from the transload facility to public roads.
- Tires and truck or railcar bodies would be cleaned to remove sediment, if necessary, before leaving the site (e.g., dry brushing and tire/wheel washing).
- Containment areas would be designed so that fluids from transloading operations can be collected.
- The effluent collected from transloading operations would be disposed of with the other waste generated from the site (including with the sediment for disposal) or sampled, treated, and discharged in accordance with approved permits of the transload facility or disposed at a permitted commercial facility.

(5) Placement of Engineered Cap, Backfill, RMC, ENR, and Amended Cover Materials

Impact avoidance and minimization measures and conservation measures that may be applied to this work include the following:

- A sand and gravel habitat layer (e.g., fish/habitat mix) would be placed on top of the cap armor layer in areas at elevation -10 feet MLLW or shallower (except in RAA 27) to enhance substrate for benthic invertebrates, which are prey for juvenile salmonids.
- The specifications for the imported material would include a requirement for the materials to consist of clean, granular material free of roots, organic material, contaminants, and all other deleterious material. This requirement would minimize the amount of fines being placed and reduce the potential for elevated turbidity during placement.
- Place engineered cap, backfill, or RMC material as soon as possible after dredging to minimize recontamination risk from dredge residuals.
- To ensure proper material placement, import materials would be placed in a controlled and accurate manner.
- The following methods are typical placement methods for engineered caps, or combination of methods, that the contractor may use to limit disturbance of the bottom sediments during engineered cap material placement operations:
    - Placing individual engineered cap layers by lowering the cap material close to the sediment bed surface and slowly opening the bucket to provide more accurate placement of each discrete cap layer.
    - Placing larger armoring layer material from near the sediment bed instead of from the surface of the water column.
    - On slopes, placing materials from the bottom of the slope and working up the slope to reduce the potential for slope sloughing.
    - Placing materials using land-based earthwork equipment from the shoreline if site access is feasible.
    - In intertidal areas, working at low tides in the dry when possible to limit potential water quality impacts and better control placement accuracy.
- The following methods are typical backfill, RMC, ENR, and amended cover placement methods, or combination of methods, that the contractor may use to limit disturbance of the bottom sediments during placement operations:
    - Placing materials with a barge-mounted, crane-operated clamshell or a spreader box (“skip box”).
    - The clamshell placement method involves slightly opening the bucket and slowly releasing the sand from the bucket slightly below or above the water surface as the operator moves the bucket in a sweeping motion from side to side, allowing the sands to fall through the water column, which helps spread out the placed materials and help reduce the energy of the placed material hitting the bed.
    - Placing materials from a barge with a variable-speed telebelt, which would project material over the placement area at a controlled speed to reduce the energy of the placed material hitting the bed.
- Bathymetric surveying may be used in deeper water depth areas to verify adequate placement coverage during and following material placement.

- Engineered cap, backfill, ENR, RMC, and amended cover materials must be approved before use; therefore, testing of the borrow source material would be required of the contractor to demonstrate that the source material meets specifications (i.e., chemical and physical criteria).

(6) Pile Installation and Removal

The following measures would be implemented during pile installation activities, to the extent practicable:

- Piles would be installed using vibratory methods and are suitable for the substrate conditions within the LDW. Vibratory methods are typically preferred because they reduce impacts to salmon, steelhead, and bull trout.
- An impact hammer would not be required to drive piles to design depths and would not be used to proof any piles.
- Hydraulic jetting devices would not be used to install pilings.
- All pile removal work would be confined to within a floating containment boom.
- When possible, removal of treated wood piles would occur in the dry or during low water conditions. Doing so increases the chances of retrieval if piles are broken.
- The crane operator would remove piles slowly. This would minimize turbidity in the water column and sediment disturbance.
- The operator would minimize overall damage to treated wood piles during removal. In particular treated wood piles must not be broken off intentionally be twisting, bending, or other deformation. This would help reduce the release of wood-treating compounds (e.g., creosote) and wood debris to the water column and sediments.
- Upon removal from the substrate and water column, piles would be moved into containment area for processing and disposal at an approved off-site upland facility.
- Piles would not be shaken, hosed off, stripped, scraped off, left hanging to drip, or any other action intended to clean or remove adhering material from the piles.
- The operator would make multiple attempts to remove a pile before resorting to cutting.
- Vibratory extraction would be used because it is the preferred method of pile removal; it causes the least disturbance to the riverbed and typically results in the complete removal of the pile from the aquatic environment.
- The operator would “wake up” the pile by vibrating it to break the skin friction/suction bond between the pile and the sediment. This bond-breaking avoids pulling out a large block of sediment and possibly breaking off the pile in the process.
- Excavation of sediment from around the base of a pile may be required to gain access to portions of the pile that are sound and to allow for extraction using direct-pull methods. Excavation may be performed in the dry at low tide or in the water using divers. Hydraulic jetting devices would not be used to move sediment away from piles to minimize turbidity and releases to the water column and surrounding sediments.
- If necessary, piles would be cut at or below mudline, with consideration given to the mudline elevation, slope, and stability of the site. Hand excavation of sediment (with divers in subtidal areas) is needed to gain access for cutting equipment. To minimize turbidity and releases to the water column and surrounding sediments, hydraulic jetting would not be used to move sediment away from the pile.

We considered, under the ESA, whether or not the proposed action would cause any other activities and determined that it would not.

1.4. Action Area

"Action area" means all areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action (50 CFR 402.02).

The remedial action footprint consists of an area of 28.1 acres of the approximate 132-acre upper reach (Figures 1 and 2). As described in Section 2.5, project-related effects around remedial activity would be the stressor with the greatest range of effect for fish. Those effects are expected to include the waters and substrates of the upper reach of LDW and 1,522 feet (or line-of-sight for in-water noise) beyond the project boundary (Figure 5). However, trophic connectivity between PS Chinook salmon and the SR killer whales that feed on them extends the action area to the marine waters of Puget Sound. Project effects outside of the yellow boundary in Figure 5 are limited to prey availability for SR killer whales (i.e., PS Chinook salmon initial survival contributing to future prey availability) and will be discussed in Section 2.10. The described area overlaps with the geographic ranges of the ESA-listed species and the boundaries of their designated critical habitats. Therefore, the action area for the project also includes the geographic area likely to be affected by the remedial activities. Potential impacts from the remedial actions include underwater noise, turbidity, entrainment, and changes to prey distribution and abundance. The action area is also EFH for Pacific Coast Salmon and Pacific Coast Groundfish (EFH analysis provided in Section 3).

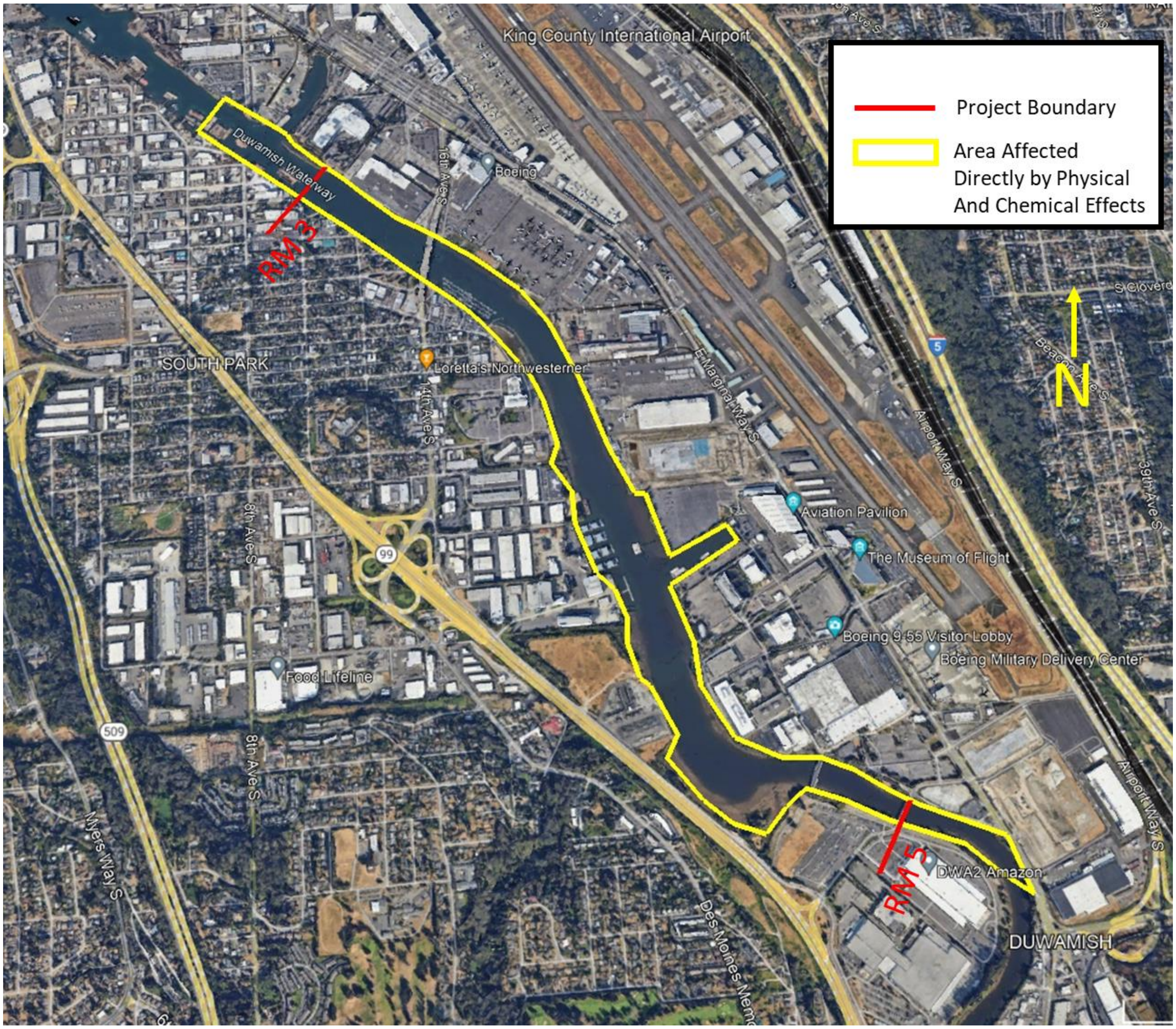

Figure 5. Google satellite image of the upper reach LDW remediation project area with direct physical and chemical effects. The full action area extends to the marine waters of the Puget Sound due to potential forage effects for SR killer whale.

2. ENDANGERED SPECIES ACT BIOLOGICAL OPINION AND INCIDENTAL TAKE STATEMENT

The ESA establishes a national program for conserving threatened and endangered species of fish, wildlife, plants, and the habitat upon which they depend. As required by section 7(a)(2) of the ESA, each Federal agency must ensure that its actions are not likely to jeopardize the continued existence of endangered or threatened species or to adversely modify or destroy their designated critical habitat. Per the requirements of the ESA, Federal action agencies consult with NMFS, and section 7(b)(3) requires that, at the conclusion of consultation, NMFS provide an opinion stating how the agency's actions would affect listed species and their critical habitats. If incidental take is reasonably certain to occur, section 7(b)(4) requires NMFS to provide an ITS that specifies the impact of any incidental taking and includes reasonable and prudent measures (RPMs) and terms and conditions to minimize such impacts.

The EPA determined the proposed action is not likely to adversely affect Southern Resident (SR) killer whale (*Orcinus orca*), Puget Sound/Georgia Basin yelloweye rockfish (*Sebastes ruberrimus*), Puget Sound/Georgia Basin bocaccio (*Sebastes paucispinis*), and sunflower sea star (*Pycnopodia helianthoides*). Our concurrence is documented in the "Not Likely to Adversely Affect" Determinations section (Section 2.10).

2.1. Analytical Approach

This biological opinion includes both a jeopardy analysis and an adverse modification analysis. The jeopardy analysis relies upon the regulatory definition of "jeopardize the continued existence of" a listed species, which is "to engage in an action that reasonably would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing the reproduction, numbers, or distribution of that species" (50 CFR 402.02). Therefore, the jeopardy analysis considers both survival and recovery of the species.

This biological opinion also relies on the regulatory definition of "destruction or adverse modification," which "means a direct or indirect alteration that appreciably diminishes the value of critical habitat as a whole for the conservation of a listed species" (50 CFR 402.02).

The designation(s) of critical habitat for Puget Sound Chinook and Puget Sound steelhead uses the term primary constituent element (PCE) or essential features. The 2016 final rule (81 FR 7414; February 11, 2016) that revised the critical habitat regulations (50 CFR 424.12) replaced this term with physical or biological features (PBFs). The shift in terminology does not change the approach used in conducting a "destruction or adverse modification" analysis, which is the same regardless of whether the original designation identified PCEs, PBFs, or essential features. In this biological opinion, we use the term PBF to mean PCE or essential feature, as appropriate for the specific critical habitat.

The ESA Section 7 implementing regulations define effects of the action using the term "consequences" (50 CFR 402.02). As explained in the preamble to the final rule revising the definition and adding this term (84 FR 44976, 44977; August 27, 2019), that revision does not change the scope of our analysis, and in this opinion we use the terms "effects" and "consequences" interchangeably.

We use the following approach to determine whether a proposed action is likely to jeopardize listed species or destroy or adversely modify critical habitat:

- Evaluate the rangewide status of the species and critical habitat expected to be adversely affected by the proposed action.
- Evaluate the environmental baseline of the species and critical habitat.
- Evaluate the effects of the proposed action on species and their critical habitat using an exposure–response approach.

- Evaluate cumulative effects.
- In the integration and synthesis, add the effects of the action and cumulative effects to the environmental baseline, and, in light of the status of the species and critical habitat, analyze whether the proposed action is likely to: (1) directly or indirectly reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing the reproduction, numbers, or distribution of that species; or (2) directly or indirectly result in an alteration that appreciably diminishes the value of critical habitat as a whole for the conservation of a listed species.
- If necessary, suggest a reasonable and prudent alternative to the proposed action.

As part of EPA's analysis for the BA, they evaluated the proposed action using a Habitat Equivalency Analysis (HEA)[1] and the Puget Sound Nearshore Habitat Values Model (NHVM) adapted from Ehinger et al. 2015. NMFS developed an input calculator ("conservation calculator") that serves as an interface to simplify model use. Ecological equivalency that forms the basis of HEA is a concept that uses a common currency to express and assign a value to functional habitat loss and gain. Ecological equivalency is traditionally a service-to-service approach where the ecological functions and services for a species or group of species lost from an impacting activity are fully offset by the services gained from a conservation activity. In this case, we use this approach to calculate the "cost" and "benefit" of the proposed action, as well as the impacts of the existing environmental baseline, using the NHVM.

NMFS developed the NHVM based specifically on the designated critical habitat of listed salmonids in Puget Sound, scientific literature, and our best professional judgement. The model, run by inputting project specific information into the conservation calculator, produces numerical outputs in the form of conservation credits and debits. Credits (+) indicate positive environmental results to nearshore habitat quality, quantity, or function. Debits (-) on the other hand indicate a loss of nearshore habitat quality, quantity, or function. Since the proposed project is a remediation project, the credits/debits analysis is only used as habitat analysis and would not be carried over to any future project. The model can be used to categorize habitat changes for nearshore development projects and restoration projects, in the past we have used this approach in the Structures in Marine Waters Programmatic consultation (NMFS 2016). More recently, on June 29, 2022, NMFS issued the Salish Sea Nearshore Programmatic biological opinion (NMFS 2022) for over- in- and near-shore projects in the marine shoreline of Puget Sound. That programmatic uses the NHVM to establish a credit/debit target of no-net-loss of critical habitat functions.

The NHVM is also used to assess critical habitat impacts resulting from dredging. The NHVM quantifies the number of and extent to which PCE's are impacted by the proposed dredging.

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[1] A common "habitat currency" to quantify habitat impacts or gains can be calculated using Habitat Equivalency Analysis (HEA) methodology when used with a tool to consistently determine the habitat value of the affected area before and after impacts. NMFS selected HEA as a means to identify section 7 project related losses, gains, and quantify appropriate mitigation because of its long use by NOAA in natural resource damage assessment to scale compensatory restoration (Dunford et al. 2004; Thur 2006) and extensive independent literature on the model (Milon and Dodge 2001; Cacela et al. 2005; Strange et al. 2002). In Washington State, NMFS has also expanded the use of HEA to calculate conservation credits available from fish conservation banks (NMFS 2008, NMFS 2015), from which "withdrawals" can be made to address mitigation for adverse impacts to ESA species and their designated CH.

After dredging, the dredged area starts to silt back in and the habitat functions of the migratory corridor gradually increase. The NHVM only assesses the temporal impacts of critical habitat impacts. Short-term effects, like elevated suspended sediments and re-suspended contaminants are addressed qualitatively in Section 2.4 (Effects of the Action), below.

2.2. Rangewide Status of the Species and Critical Habitat

This opinion examines the status of each species that would be adversely affected by the proposed action. The status is determined by the level of extinction risk that the listed species face, based on parameters considered in documents such as recovery plans, status reviews, and listing decisions. This informs the description of the species' likelihood of both survival and recovery. The species status section also helps to inform the description of the species' current "reproduction, numbers, or distribution" as described in 50 CFR 402.02. The opinion also examines the condition of critical habitat throughout the designated area, evaluates the conservation value of the various watersheds and coastal and marine environments that make up the designated area, and discusses the current function of the essential PBFs that help form that conservation value.

One factor affecting the status of ESA listed species considered in this opinion, and aquatic habitat at large, is climate change. Climate change is likely to play an increasingly important role in determining the abundance and distribution of ESA listed species, and the conservation value of designated critical habitats, in the Pacific Northwest. These changes will not be spatially homogeneous across the Pacific Northwest. Major ecological realignments are already occurring in response to climate change (IPCC WGII 2022). Long-term trends in warming have continued at global, national and regional scales. Global surface temperatures in the last decade (2010s) were estimated to be 1.09 ℃ higher than the 1850-1900 baseline period, with larger increases over land ~1.6 ℃ compared to oceans ~0.88 (IPCC WGI, 2021). The vast majority of this warming has been attributed to anthropogenic releases of greenhouse gases (IPCC WGI 2021) Globally, 2014-2018 were the 5 warmest years on record both on land and in the ocean (2018 was the 4th warmest) (NOAA NCEI 2022). Events such as the 2013-2016 marine heatwave (Jacox et al. 2018) have been attributed directly to anthropogenic warming in the annual special issue of Bulletin of the American Meteorological Society on extreme events (Herring et al. 2018). Global warming and anthropogenic loss of biodiversity represent profound threats to ecosystem functionality (IPCC WGII 2022). These two factors are often examined in isolation, but likely have interacting effects on ecosystem function.

Updated projections of climate change are similar to or greater than previous projections (IPCC WGI 2021). NMFS is increasingly confident in our projections of changes to freshwater and marine systems because every year brings stronger validation of previous predictions in both physical and biological realms. Retaining and restoring habitat complexity, access to climate refuges (both flow and temperature) and improving growth opportunity in both freshwater and marine environments are strongly advocated in the recent literature (Siegel and Crozier 2020). Climate change is systemic, influencing freshwater, estuarine, and marine conditions. Other systems are also being influenced by changing climatic conditions. Literature reviews on the impacts of climate change on Pacific salmon (Crozier 2015, 2016, 2017, Crozier and Siegel 2018, Siegel and Crozier 2019, 2020) have collected hundreds of papers documenting the major themes relevant for salmon. Here we describe habitat changes relevant to Pacific salmon and steelhead, prior to describing how these changes result in the varied specific mechanisms impacting these species in subsequent sections.

Forests

Climate change will impact forests of the western U.S., which dominate the landscape of many watersheds in the region. Forests are already showing evidence of increased drought severity, forest fire, and insect outbreak (Halofsky et al. 2020). Additionally, climate change will affect tree reproduction, growth, and phenology, which will lead to spatial shifts in vegetation. Halofsky et al. (2018) projected that the largest changes will occur at low- and high-elevation forests, with expansion of low elevation dry forests and diminishing high-elevation cold forests and subalpine habitats.

Forest fires affect salmon streams by altering sediment load, channel structure, and stream temperature through the removal of canopy. Holden et al. (2018) examined environmental factors contributing to observed increases in the extent of forest fires throughout the western U.S. They found strong correlations between the number of dry-season rainy days and the annual extent of forest fires, as well as a significant decline in the number of dry-season precipitation, combined with increases in air temperature, will likely contribute to the existing trend toward more extensive and severe forest fires and the continued expansion of fires into higher elevation and wetter forests (Alizedeh 2021).

Agne et al. (2018) reviewed literature on insect outbreaks and other pathogens affecting coastal Douglas-fir forests in the Pacific Northwest and examined how future climate change may influence disturbance ecology. They suggest that Douglas-fir beetle and black stain root disease could become more prevalent with climate change, while other pathogens will be more affected by management practices. Agne et al. (2018) also suggested that due to complex interacting effects of disturbance and disease, climate impacts will differ by region and forest type.

Freshwater Environments

The following is excerpted from Siegel and Crozier (2019), who present a review of recent scientific literature evaluating effects of climate change, describing the project impacts of climate change on instream flows:

Cooper et al. (2018) examined whether the magnitude of low river flows in the western U.S., which generally occur in September or October, are driven more by summer conditions or the prior winter’s precipitation. They found that while low flows were more sensitive to summer evaporative demand than to winter precipitation, interannual variability in winter precipitation was greater. Malek et al. (2018), predicted that summer evapotranspiration is likely to increase in conjunction with declines in snowpack and increased variability in winter precipitation. Their results suggest that low summer flows are likely to become lower, more variable, and less predictable.

The effect of climate change on ground water availability is likely to be uneven. Sridhar et al. (2018) coupled a surface-flow model with a ground-flow model to improve predictions of surface water availability with climate change in the Snake River Basin. Projections using Representative Concentration Pathways 4.5 and 8.5 emission scenarios suggested an increase in water table heights in downstream areas of the basin and a decrease in upstream areas.

As cited in Siegel and Crozier (2019), Isaak et al. (2018), examined recent trends in stream temperature across the Western U.S. using a large regional dataset. Stream warming trends paralleled changes in air temperature and were pervasive during the low-water warm seasons of 1996-2015 (0.18-0.35°C/decade) and 1976-2015 (0.14-0.27°C/decade). Their results show how continued warming will likely affect the cumulative temperature exposure of migrating sockeye salmon (*O. nerka*) and the availability of suitable habitat for brown trout (*Salmo trutta*) and rainbow trout (*O. mykis*). Isaak et al. (2018) concluded that most stream habitats will likely remain suitable for salmonids in the near future, with some becoming too warm. However, in cases where habitat access is currently restricted by dams and other barriers salmon and steelhead will be confined to downstream reaches typically most at risk of rising temperatures unless passage is restored (FitzGerald et al. 2020, Meyers et al. 2018).

Streams with intact riparian corridors and that lie in mountainous terrain are likely to be more resilient to changes in air temperature. These areas may provide refuge from climate change for a number of species, including Pacific salmon. Krosby et al. (2018), identified potential stream refugia throughout the Pacific Northwest based on a suite of features thought to reflect the ability of streams to serve as such refuges. Analyzed features include large temperature gradients, high canopy cover, large relative stream width, low exposure to solar radiation, and low levels of human modification. They created and index of refuge potential for all streams in the region, with mountain area streams scoring highest. Flat lowland areas, which commonly contain migration corridors, were generally scored lowest, and thus were prioritized for conservation and restoration. However, forest fires can increase stream temperatures dramatically in short time spans by removing riparian cover (Koontz et al. 2018), and streams that lose their snowpack with climate change may see the largest increases in stream temperature due to removal of temperature buffering (Yan et al. 2021). These processes may threaten some habitats that are currently considered refugia.

Marine and Estuarine Environments

Along with warming streams temperatures and concerns about sufficient groundwater to recharge streams, a recent study projects nearly complete loss of existing tidal wetlands along the U.S. West Coast, due to sea level rise (Thorne et al. 2018). California and Oregon showed the greatest threat to tidal wetlands (100 percent), while 68 percent of Washington tidal wetlands are expected to be submerged. Coastal development and steep topography prevent horizontal migration of most wetlands, causing the net contraction of this crucial habitat.

Rising ocean temperatures, stratification, ocean acidity, hypoxia, algal toxins, and other oceanographic processes will alter the composition and abundance of a vast array of oceanic species. In particular, there will be dramatic changes in both predators and prey of Pacific salmon, salmon life history traits and relative abundance. Siegel and Crozier (2019) observe that changes in marine temperature are likely to have a number of physiological consequences on fishes themselves. For example, in a study of small planktivorous fish, Gliwicz et at. (2018)

found that higher ambient temperatures increased the distance at which fish reacted to prey. Numerous fish species (including many tuna and sharks) demonstrate regional endothermy, which in many cases augments eyesight by warming the retinas. However, Gliwicz et al. (2018) suggest that ambient temperatures can have a similar effect on fish that do not demonstrate this trait. Climate change is likely to reduce the availability of biologically essential omega-3 fatty acids produced by phytoplankton in marine ecosystems. Loss of these lipids may induce cascading trophic effects, with distinct impacts on different species depending on compensatory mechanisms (Gourtay et al. 2018). Reproduction rates of many marine fish species are also likely to be altered with temperature (Veilleux et al. 2018). The ecological consequences of these effect and their interactions add complexity to predictions of climate change impacts in marine ecosystems.

Perhaps the most dramatic change in physical ocean conditions will occur through ocean acidification and deoxygenation. It is unclear how sensitive salmon and steelhead might be to the direct effects of ocean acidification because of their tolerance of a wide pH range in freshwater (although see Ou et al. 2015 and Williams et al. 2019), however, impacts of ocean acidification and hypoxia on sensitive species (e.g., plankton, crabs, rockfish, groundfish) will likely affect salmon indirectly through their interactions as predators and prey. Similarly, increasing frequency and duration of harmful algal blooms may affect salmon directly, depending on the toxins (e.g., saxitoxin vs domoic acid), but will also affect their predators (seabirds and mammals). The full effects to these ecosystem dynamics are not known but will be complex. Within the historical range of climate variability, less suitable conditions for salmonids (e.g., warmer temperatures, lower streamflows) have been associated with detectable declines in many of these listed units, highlighting how sensitive they are to climate drivers (Ford 2022, Lindley et al. 2009, Williams et al. 2016, Ward et al. 2015). In some cases, the combined and potentially additive effects of poorer climate conditions for fish and intense anthropogenic impacts caused the population declines that led to these population groups being listed under the ESA (Crozier et al. 2019).

Climate change effects on salmon and steelhead

In freshwater, year-round increases in stream temperature and changes in flow will affect physiological, behavioral, and demographic processes in salmon, and change the species with which they interact. For example, as stream temperatures increase, many native salmonids face increased competition with more warm-tolerant invasive species. Changing freshwater temperatures are likely to affect incubation and emergence timing for eggs, and in locations where the greatest warming occurs may affect egg survival, although several factors impact intergravel temperature and oxygen (e.g., groundwater influence) as well as sensitivity of eggs to thermal stress (Crozier et al. 2020). Changes in temperature and flow regimes may alter the amount of habitat and food available for juvenile rearing, and this in turn could lead to a restriction in the distribution of juveniles, further decreasing productivity through density dependence. For migrating adults, predicted changes in freshwater flows and temperatures will likely increase exposure to stressful temperatures for many salmon and steelhead populations, and alter migration travel times and increase thermal stress accumulation for evolutionarily significant units (ESUs) or distinct population segments (DPSs) with early returning (i.e., spring- and summer-run phenotypes associated with longer freshwater holding times (Crozier et al.

2020, FitzGerald et al. 2020). Rising river temperatures increase the energetic cost of migration and the risk of *en route* or pre-spawning mortality of adults with long freshwater migrations, although populations of some ESA-listed salmon and steelhead may be able to make use of cool-water refuges and run-timing plasticity to reduce thermal exposure (Keefer et al. 2018, Barnett et al. 2020).

Marine survival of salmonids is affected by a complex array of factors including prey abundance, predator interactions, the physical condition of salmon within the marine environment, and carryover effects from the freshwater experience (Holsman et al. 2012, Burk et al. 2013). It is generally accepted that salmon marine survival is size dependent, and thus larger and faster growing fish are more likely to survive (Gosselin et al. 2021). Furthermore, early arrival timing in the marine environment is generally considered advantageous for populations migrating through the Columbia River. However, the optimal day of arrival varies across years, depending on the seasonal development of productivity in the California Current, which affects prey available to salmon and the risk of predation (Chasco et al. 2021). Siegel and Crozier (2019) point out the concern that for some salmon populations, climate change may drive mismatches between juvenile arrival timing and prey availability in the marine environment. However, phenological diversity can contribute to metapopulation-level resilience by reducing the risk of a complete mismatch. Carr-Harris et al. (2018), explored phenological diversity of marine migration timing in relation to zooplankton prey for sockeye salmon (*O. nerka*) from the Skeena River of Canada. They found that sockeye migrated over a period of more than 50 days, and populations from higher elevation and further inland streams arrived in the estuary later, with different populations encountering distinct prey fields. Carr-Harris et al. (2018) recommended that managers maintain and augment such life-history diversity.

Synchrony between terrestrial and marine environmental conditions (e.g., coastal upwelling, precipitation and river discharge) has increased the spatial scale causing the highest levels of synchrony in the last 250 years (Black et al. 2018). A more synchronized climate combined with simplified habitats and reduced genetic diversity may be leading to more synchrony in the productivity of populations across the range of salmon (Braun et al. 2016). For example, salmon productivity (recruits/spawner) has also become more synchronized across Chinook populations from Oregon to the Yukon (Dorner et al. 2018, Kilduff et al. 2014). In addition, Chinook salmon have become smaller and younger at maturation across their range (Ohlberger 2018). Other Pacific salmon species (Stachura et al. 2014) and Atlantic salmon (Olmose et al. 2020) also have demonstrated synchrony in productivity across a broad latitudinal range.

At the individual scale, climate impacts on salmon in one life stage generally affect body size or timing in the next life stage and negative impacts can accumulate across multiple life stages (Healey 2011, Wainwright and Weitkamp 2013, Gosselin et al. 2021). Changes in winter precipitation will likely affect incubation and/or rearing stages of most populations. Changes in the intensity of cool season precipitation, snow accumulation, and runoff could influence migration cues for fall, winter and spring adult migrants, such as coho and steelhead. Egg survival rates may suffer from more intense flooding that scours or buries redds. Changes in hydrological regime, such as a shift from mostly snow to more rain, could drive changed in life history, potentially threatening diversity within an ESU (Beechie et al. 2006). Changes in summer temperature and flow will affect both juvenile and adult stages in some populations especially those with yearling life histories and summer migration patterns (Crozier and Zabel 2006, Crozier et al. 2010, Crozier et al. 2019).

At the population level, the ability of organisms to genetically adapt to climate change depends on how much genetic variation currently exists within salmon populations, as well as how selection on multiple traits interact, and whether those traits are linked genetically. While genetic diversity may help populations respond to climate change, the remaining genetic diversity of many populations is highly reduced compared to historic levels. For example, Johnson et al. (2018), compared genetic variation in Chinook salmon from the Columbia River Basin between contemporary and ancient samples. A total of 84 samples determined to be Chinook salmon were collected from vertebrae found in ancient middens and compared to 379 contemporary samples. Results suggest a decline in genetic diversity, as demonstrated by a loss of mitochondrial haplotypes as well as reduction in haplotype and nucleotide diversity. Genetic losses in this comparison appeared larger for Chinook from the mid-Columbia than those from the Snake River Basin. In addition to other stressors, modified habitats and flow regimes may create unnatural selection pressures that reduce the diversity of functional behaviors (Sturrock et al. 2020). Managing to conserve and augment existing genetic diversity may be increasingly important with more extreme environmental change (Anderson et al. 2015), through the low levels of remaining diversity present challenges to this effort (Freshwater et al. 2019). Salmon historically maintained relatively consistent returns across variation in annual weather through the portfolio effect (Schindler et al. 2015), in which different populations are sensitive to different climate drivers. Applying this concept to climate change, Anderson et al. (2015) emphasized the additional need for populations with different physiological tolerances. Loss of the portfolio increases volatility in fisheries, as well as ecological systems, as demonstrated for Fraser River and Sacramento River stock complexes (Freshwater et al. 2019, Munsch et al. 2022).

Status of the Critical Habitat

This section describes the status of designated critical habitat affected by the proposed action by examining the condition and trends of the essential physical and biological features of that habitat throughout the designated areas. These features are essential to the conservation of the ESA listed species because they support one or more of the species' life stages (e.g., sites with conditions that support spawning, rearing, migration and foraging).

For most salmon and steelhead, NMFS's critical habitat analytical review teams (CHARTs) ranked watersheds within designated critical habitat at the scale of the fifth-field hydrologic unit code (HUC5) in terms of the conservation values they provide to each ESA listed species that they support (NMFS 2005). The conservation rankings were high, medium, or low. To determine the conservation value of each watershed to species viability, the CHARTs evaluated the quantity and quality of habitat features, the relationship of the area compared to other areas within the species' range, and the significance to the species of the population occupying that area. Even if a location had poor habitat quality, it could be ranked with a high conservation value if it were essential due to factors such as limited availability, a unique contribution of the population it served, or serving another important role.

A summary of the status of critical habitats, considered in this opinion, is provided in Table 4.

Table 4. Critical habitat, designation date, federal register citation and status summary for critical habitat.

Species	Designation Date and Federal Register Citation	Critical Habitat Status Summary
Puget Sound Chinook salmon	9/02/05 70 FR 52630	Critical habitat for Puget Sound Chinook salmon includes 1,683 stream miles, 41 square mile of lakes, and 2,182 miles of nearshore marine habitat in Puget Sound. The Puget Sound Chinook salmon ESU has 61 freshwater and 19 marine areas within its range. Of the freshwater watersheds, 41 are rated as high conservation value, 12 low conservation value, and 8 received a medium rating. Of the marine areas, all 19 are ranked with high conservation value.
Puget Sound steelhead	2/24/16 81 FR 9251	Critical habitat for PS steelhead includes 2,031 stream miles. Nearshore and offshore marine waters were not designated for this species. There are 66 watersheds within the range of this DPS. Forty-one watersheds are rated as high conservation value, 9 watersheds received a low conservation value rating, and 16 received a medium rating to the DPS.

Status of the Species

Table 5 provides a summary of listing and recovery plan information, status summaries and limiting factors for the species addressed in this opinion. More information can be found in recovery plans and status reviews for these species. Acronyms appearing in the table include DPS, ESU, Multiple Population Grouping (MPG), Northwest Fisheries Science Center (NWFSC), and Technical Recovery Team (TRT).

Table 5. Listing classification and date, recovery plan reference, most recent status review, status summary, and limiting factors for each species considered in this opinion.

Species	Listing Classification and Date	Recovery Plan Reference	Most Recent Status Review	Status Summary	Limiting Factors
Puget Sound Chinook salmon	Threatened 6/28/05	Shared Strategy for Puget Sound 2007 NMFS, 2006	NWFSC 2015; Ford 2022	This ESU comprises 22 populations distributed over 5 geographic areas. Most populations within the ESU have declined in abundance over the past 7 to 10 years, with widespread negative trends in natural-origin spawner abundance, and hatchery-origin spawners present in high fractions in most populations outside of the Skagit watershed. Escapement levels for all populations remain well below the TRT planning range for recovery, and most populations are consistently below the spawner-recruit levels identified by the TRT as consistent with recovery.	• Degraded floodplain and in-river channel structure • Degraded estuarine conditions and loss of estuarine habitat • Degraded riparian areas and loss of in-river large woody debris • Excessive fine-grained sediment in spawning gravel • Degraded water quality and temperature • Degraded nearshore conditions • Impaired passage for migrating fish • Severely altered flow regime
Puget Sound steelhead	Threatened 5/11/07	NMFS, 2019	NWFSC 2015: Ford 2022	This DPS comprises 32 populations. The DPS is currently at very low viability, with most of the 32 populations and all three population groups at low viability. Information considered during the most recent status review indicates that the biological risks faced by the Puget Sound steelhead DPS have not substantively changed since the listing in 2007, or since the 2011 status review. Furthermore, the Puget Sound steelhead TRT recently affirmed that the DPS was at very low viability, as were all three of its constituent MPGs, and many of its 32 populations. In the near term, the outlook for environmental conditions affecting Puget Sound steelhead is not optimistic. While harvest and hatchery production of steelhead in Puget Sound are currently at low levels and are not likely to increase substantially in the foreseeable future, some recent environmental trends not favorable to Puget Sound steelhead survival and production are expected to continue.	• Continued destruction and modification of habitat • Widespread declines in adult abundance despite significant reduction in harvest • Threats to diversity posed by use of two hatchery steelhead stocks • Declining diversity in the DPS, including the uncertain but weak status of summer-run fish • A reduction in spatial structure • Reduced habitat quality • Urbanization • Dikes, hardening of banks with riprap, and channelization

2.3. Environmental Baseline

The "environmental baseline" refers to the condition of the listed species or its designated critical habitat in the action area, without the consequences to the listed species or designated critical habitat caused by the proposed action. The environmental baseline includes the past and present impacts of all Federal, State, or private actions and other human activities in the action area, the anticipated impacts of all proposed Federal projects in the action area that have already undergone formal or early section 7 consultations, and the impact of State or private actions which are contemporaneous with the consultation in process. The consequences to listed species or designated critical habitat from ongoing agency activities or existing agency facilities that are not within the agency's discretion to modify are part of the environmental baseline (50 CFR 402.02).

The LDW is the downstream portion of the Duwamish River and is located along a major shipping route for bulk and containerized cargo. This portion of the Duwamish River is estuarine, where freshwater from the river mixes with the salt water of the Puget Sound Estuary. Habitat conditions for the listed salmonids in the action area are degraded. In the early 1900s, the waterway was filled to create uplands that were subsequently developed for industrial and commercial operations, including the dredging and straightening of the original watercourse (Ecology 2013).

Throughout the 1900s the watershed area and flow volumes to the Duwamish River were reduced by approximately 70 percent as a result of the diversion of the river's tributaries (Kerwin and Nelson 2000). In 1906, the White River was diverted to the Puyallup River to help control flooding (Harper-Owes 1983). In 1916, the Black River, which was fed by the Cedar River and Lake Washington was lowered through the construction of the Lake Washington Ship Canal, and the Cedar River was subsequently diverted to Lake Washington (Harper-Owes 1983). Today, the Green River is the primary source of water for the Duwamish River. The Duwamish River originates at the confluence of the Green and Black rivers near Tukwila, Washington, and flows northwest for approximately 12 miles prior to discharging into Elliot Bay in Puget Sound. The project is located within the Duwamish estuary, where aquatic conditions consist of marine waters from Elliot Bay transitioning with freshwater from the Green-Duwamish Rivers.

For more than a century, the LDW has facilitated industrial and commercial operations such as shipping and handling of bulk materials, concrete manufacturing, paper and metals fabrication, marine construction, boat manufacturing, marina operations, food processing, and airplane parts manufacturing. The LDW was added to the EPA's National Priorities List in 2001 and to the Washington State Hazardous Sites List in 2002. The LDW Waterway Group has and continues to conduct an ongoing Remedial Investigation and Feasibility Study of the LDW to assess risks to human health and the environment and to evaluate cleanup alternatives. The proposed project is a result of this effort.

The LDW receives contaminant inputs from industrial activities and other sources, much of which has ended up in the sediments. Discharges and releases of oil and hazardous substances into the waterway resulted from current and historical industrial and municipal activities and processes since the early 1900s. Facilities released materials through permitted and non-permitted discharges, spills during cargo transfer and refueling, stormwater runoff through contaminated soils at upland facilities, and discharge of contaminated groundwater. The primary exposure pathways of a contaminant from media to receptors are via contaminants that accumulate in the sediments. The sediments in the estuary are contaminated with metals, petroleum products, and other organic materials. The organisms that live in and on the sediments, and that are exposed to sediment contamination, form the base of the food web upon which most of the fish, birds, and other wildlife that use the LDW environment depend. Contamination of the sediments affects nearly all aspects of the LDW ecosystem. Contaminants have been found in tissues of benthic invertebrates and fish in the Duwamish Waterway, indicating that contamination from the sediments is being accumulated by organisms. This suggests that juvenile and adult forage, including aquatic invertebrates and fishes, may inadequately support growth and maturation of juvenile Chinook Salmon.

The LDW is also part of Tribal U&A fishing areas. The Muckleshoot Indian Tribe currently conducts seasonal netfishing operations in the LDW for commercial, ceremonial, and subsistence purposes. The Suquamish Tribe actively manages resources north (downstream) of the Spokane Street Bridge, located just north of the LDW (EPA 2014). The Duwamish Tribe uses Herring's House Park and other parks along the Duwamish for cultural gatherings.

The remediation site is located between LDW river miles 3.0 and 5.0, which is largely an industrial/commercial area, but also includes the South Park residential neighborhood. The action area and much of the neighboring properties were constructed primarily on fill from dredged material when the LDW was straightened during the early 1900s. The public also use the river for fishing, recreation and wildlife habitat appreciation.

Elliott Bay has a surface area of about 7.7 (20 km^2) square miles. Shoreline depths range from 0 feet relative to ordinary high water mark in areas where armoring hasn't occurred, to approximately -30 feet (-9 m) relative to MLLW along some of the bulkheads that line much of the Seattle waterfront. Near the center of the bay, depths approach 500 feet (152 m). The average tidal fluctuation in 113 feet (3.4 m), and a generally counter-clockwise, low velocity circulation pattern exists in the bay. The bay opens toward the west and is exposed to wind-driven waves and wakes from large ocean-going vessels that regularly operate in the bay. The substrate along the shoreline of the bay consists of a mix of shell hash, scattered cobbles and boulders, and silts and clays that slope relatively gently varying distances before steepening and falling to depths exceeding 300 feet near the center of the bay (NOAA 2018).

The bay and the surrounding upland areas have been heavily impacted by more than 100 years of development. The southern half of the bay is occupied by the Port of Seattle, and many other waterfront users. Nearly continuous and heavy urban and industrial development extends to the waterline from the Duwamish Waterway. A narrow green belt of trees and shrubs runs along much of the shoreline from the western boundary to the marina to West Pont. Inland areas are covered nearly continuous residential and commercial properties. And supporting roads for miles north and south of the bay. Water and sediment quality within the bay have been impaired by decades of urban and industrial discharges. These include sewage discharges from wastewater treatment facilities, such as the nearby West Point Wastewater Treatment Plant, and numerous point and non-point stormwater discharges around the bay.

The populations of PS Chinook salmon and PS steelhead most likely to be exposed to effects of the proposed action are Green/Duwamish River fall Chinook and Green/Duwamish River (winter and summer run) steelhead.

2.4. Effects of the Action

Under the ESA, "effects of the action" are all consequences to listed species or critical habitat that are caused by the proposed action, including the consequences of other activities that are caused by the proposed action (see 50 CFR 402.02). A consequence is caused by the proposed action if it would not occur but for the proposed action and it is reasonably certain to occur. Effects of the action may occur later in time and may include consequences occurring outside the immediate area involved in the action (see 50 CFR 402.17). In our analysis, which describes the effects of the proposed action, we considered the factors set forth in 50 CFR 402.17(a) and (b).

2.4.1 Effects on Critical Habitat

As mentioned in Section 2.2.1, critical habitat for PS Chinook salmon and PS steelhead occur within the action area. The NMFS reviews effects on critical habitat affected by a proposed action by examining how the PBFs of critical habitat would be altered, and the duration of such changes.

Chinook Salmon and Steelhead Critical Habitat:
The NMFS reviews the effects on critical habitat affected by the proposed action by examining changes caused by the project to the condition and trends of physical and biological features identified as essential to the conservation of the listed species. Critical habitat includes the stream channels within the proposed stream reaches, and includes a lateral extent as defined by the ordinary high-water line (33 CFR 319.11). In areas where the ordinary high-water line has not been defined, the lateral extent would be defined by the bankfull elevation. Bankfull elevation is the level at which water begins to leave the channel and move into the floodplain and is reached at a discharge which generally has a recurrence interval of 1 to 2 years on the annual flood series. areas critical habitat is proposed to include areas contiguous with the shore line from the line of extreme high water out to a depth of no greater than 30 meters relative to mean lower low water. In the action area, river and estuary/nearshore habitats are expected to be affected. While the action area does extend to the waters of Puget Sound, this is due to the trophic interactions between Chinook salmon and SR killer whales; therefore, other habitat effects are not expected for nearshore or offshore marine areas.

It should be noted that the lowermost 4.6 miles of the Duwamish River, including the action area, are located within an estuary where saltwater from the sound and freshwater from the river mix. Water levels and salinity here fluctuate with the tide and amount of water in the river.

The salmonid PBFs present in the action area are presented below, with the affected features in bold:

> Freshwater rearing sites with water quantity and floodplain connectivity to form and maintain physical habitat conditions and **support juvenile growth and mobility; water quality and forage supporting juvenile development**; and natural cover such as shade

submerged and overhanging large wood, log jams and beaver dams, **aquatic vegetation**, large rocks and boulders, side channels, and undercut banks.

Freshwater migration corridors free of obstruction and excessive predation with **water** quantity **and quality** conditions and natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, side channels, and undercut bank supporting juvenile and adult mobility and survival.

Estuarine areas free of obstruction and excessive predation with: (i) **Water quality**, water quantity, and **salinity conditions supporting juvenile and adult physiological transitions between fresh- and saltwater**; (ii) Natural cover such as submerged and overhanging large wood, and aquatic vegetation, large rocks and boulders, side channels; and (iii) **Juvenile and adult forage, including aquatic invertebrates** and fishes, supporting growth and maturation.

This project would cause temporary effects to physical and biological features of critical habitat for PS Chinook salmon and PS steelhead. Those effects are:

1. Water Quality/Turbidity and DO – Remedial activity would degrade water quality in the berth and a 150-foot (acute) and 300-foot (chronic) area surrounding the berth by elevating suspended sediments for up to 264 working days within three consecutive in-water work windows. Conditions would return to baseline levels within hours after work ceases. Conditions for juvenile maturation would be disrupted by the water quality degradation. Remedial activities would cause no measurable changes in water temperature and salinity, but mobilized contaminants and suspended sediments into the water column, can reduce DO. Both turbidity and DO are expected to return to baseline within hours (turbidity) to days (DO) after work ceases. Based on these factors, the impairment of this PBF would not reduce the conservation value of the habitat for salmonids.
2. Water Quality/Pollutants – Increased levels of PAHs, PCBs, and other contaminants re-suspended in the water column would co-occur with the dredging and pile removal activities and following briefly after the commencement of activity. This aspect of water quality degradation could temporarily impair the value of critical habitat for growth and maturation of juvenile salmonids by exposing them to pollutants with both immediate and latent health effects, and could incrementally impair forage/prey communities that are exposed to the contaminants, delaying the speed that these communities re-establish after being physically disrupted by remediation activities. However, the purpose of the project is to significantly remove existing pollutants from the sediments. While the action may result in some resuspension of pollutants during project implementation, the long-term risk of significant future exposure would be reduced.
3. Forage and Prey/Reduced Prey Abundance from Dredging – Removing sediments and placing materials would remove/bury the benthic communities that live within those sediments, reducing prey availability in the footprint of the activity. Among prey fishes, short-term and intermittent exposure to reduced water quality could result in minor reductions in forage species via gill damage of forage fishes. Suspended sediments would eventually settle in the area adjacent to the dredge prism, which can disrupt benthic prey

species and if the sediments are contaminated (and not covered by RMC), then sublethal toxicity of benthic prey species could occur within 150 feet of the remediation activities. The limited duration of the in-water dredging (159 working days spread over three work windows), and material placement (105 working days spread over three work windows) and low intensity of these effects, and the prompt return to baseline levels (expected to be several months for forage availability), indicated that the prey reduction is not detrimental over the long term to conservation values of the critical habitat in the action area. Furthermore, the implementation of this project would result in improved riverbed chemical attributes while largely maintaining its near shore physical characteristics. As a result, the quality of forage and abundance of prey would improve rapidly upon completion of the proposed project.

Critical Habitat Summary. The LDW in the vicinity of the project includes degraded critical habitat with water quality conditions that somewhat support salmonid transitions between fresh and saltwater. The project is located in a heavily industrialized portion of the LDW that includes steep slopes, riprap armoring, and creosoted piling; poor riparian and marsh vegetation conditions; and a lack of complex shoreline habitat. Fish presence is expected to be transitory as conditions don't support robust forage or shelter opportunities.

The proposed action temporarily degrades water quality and prey communities (the most enduring effect begins to recover in months, but may take up to 3 years to fully regain complex diversity) caused by the remediation activities in the habitat. The proposed action would adversely affect some features, but it would not cause any loss of critical habitat in the action area, as all diminished features are affected in a limited footprint, and would return to baseline within hours (water quality) or months (prey communities).

The temporary effects would be briefly reduced forage value of the habitat, but the peak reduction would occur at a time when migration use is expected to be quite low, making the influence of the reduction limited. The enduring adverse effects would be completely offset by the remediation aspects of the proposed project. Therefore, the conservation role of the habitat is considered retained.

2.4.2 Effects on Listed Species

Species Presence and Exposure

Each of the following species uses the action area with variable presence. In order to determine effects on species, we must evaluate when species would be present and the nature (duration and intensity) of their exposure to those effects of the action in their habitat, which were described above. It should be noted; an effect exists even if only one individual or habitat segment may be affected (Fish and Wildlife Service and National Marine Fisheries Service 1998). Work is expected to occur during three consecutive work windows, and is allowed to occur at any time within the October 1 to February 15 work window. Life history behaviors influence which life stages could be present during that work window. This section will address effects in the area described in Figure 5. The project effects that extend into the marine environment only affect SR killer whales and these effects will be discussed in Section 2.10.

Puget Sound Chinook Salmon: Chinook salmon presence is documented within the LDW, and juveniles and adults migrate in the action area (WDFW 2018). Chinook salmon in the action area would primarily be of Green River (Duwamish) stock, although fish from other stocks do use the same area (Nelson et al. 2004).

For these reasons, it is expected that adult and juvenile Chinook salmon may be present in the action area as follows: adults reside in Puget Sound year-round and are most plentiful when ocean-going adults return to spawn, adults are then expected to occur in the deep-water areas in the vicinity of the action area during the summer and fall during their upstream migration, and juveniles may occur in the shallow nearshore during typical outmigration periods between February and July. Thus, adults may be exposed in the autumn portion of the work window, and juveniles in the winter portion of the work window.

Puget Sound Steelhead: Steelhead that would be present in the action area are winter- or summer-run steelhead from the Green River (Duwamish) stock (WDFW 2018). Run timing for adult Green River winter steelhead is generally from December through mid-March, with spawning generally from early March through December with spawning generally from mid-January through mid-March. Juvenile steelhead would be expected to outmigrate between mid-March and early June. A tagging study was conducted from 2006 – 2009 in this watershed and wild steelhead smolts were observed moving through the action area at a rate of 41 km/day (hatchery smolts were slightly slower) with no long-term rearing occurring in the area described in Figure 5 (Goetz et al. 2014). Furthermore, the majority of steelhead smolts migrate directly to the open ocean and do not rear extensively in the estuarine or coastal environments (Burgner et al. 1992; Goetz et al. 2014).

For these reasons, it is expected that adult steelhead may be present in the action area as follows: adults are expected to occur in the deep-water areas in the vicinity during the summer, fall, and winter of their upstream spawning migration, overlapping the work window. The general steelhead life history and available research suggests that steelhead use of the action area is lowest in the winter. Juvenile outmigration starts in March so we do not expect them to be present when work occurs.

<u>Elevated Noise</u>

Exposure to construction-related noise would cause minor effects on PS Chinook salmon and PS steelhead. Elevated in-water noise at levels capable of causing detectable effects in exposed fishes would be caused by the in-water vibratory pile driving, dredging, and vessel operations, including spud deployment.

The effects of fishes' exposure to noise vary with the hearing characteristics of the exposed fish, the frequency, intensity, and duration of the exposure, and the context under which the exposure occurs. At low levels, effects may include the onset of behavioral disturbances such as acoustic masking (Cordarin et al. 2009), startle responses and altered swimming (Neo et al. 2014), abandonment or avoidance of the area of acoustic effect (Mueller 1980; Picciulin et al. 2010; Sebastianutto et al. 2011; Xie et al. 2008) and increased vulnerability to predators (Simpson et al. 2016). At higher intensities and/or longer exposure durations, the effects may rise to include temporary hearing damage (a.k.a. temporary threshold shift or TTS, Scholik and Yan 2002) and increased stress (Graham and Cooke 2008). At even higher levels, exposure may lead to physical injury that can range from the onset of permanent hearing damage (a.k.a. permanent threshold shift or PTS) and mortality. The best available information about the auditory capabilities of the fish considered in this Opinion suggest that their hearing capabilities are limited to frequencies below 1/500 Hz, with peak sensitivity between about 200 and 300 Hz (Hastings and Popper 2005; Picciulin et al. 2010; Scholik and Yan 2002; Xie et al. 2008).

The NMFS uses two metrics to estimate the onset of injury for fish exposed to high intensity impulsive sounds. The metrics are based on exposure to peak sound level and sound exposure level (SEL), respectively. Both are expressed in decibels (dB). The metrics are: 1) exposure to 206 dB_{peak}; and 2) exposure to 187 dB SEL_{cum} for fish 2 grams or larger, or 183 dB SEL_{cum} for fish under 2 grams. Any received level (RL) below 150 dB_{SEL} in considered “Effective Quiet”. The distance from that source where the RL drops to 150 dB_{SEL} is considered the maximum distance from that source where fishes can be affected by the noise, regardless of accumulation of the sound energy (Stradler and Woodbury 2009). Therefore, when there is a difference between the ranges to the isopleths for effective quiet and SEL_{cum}, the shorter range shall apply. The discussion in Stadler and Woodbury (2009) makes it clear that the thresholds likely overestimate the potential effects of exposure to impulsive sounds. Further, the assessment did not consider non-impulsive sound because it is believed to be less injurious to fish than impulsive sound. Therefore, any application of the criteria to non-impulsive sounds is also likely to overestimate the potential effects in fish. However, this assessment applies to criteria to both impulsive and non-impulsive sounds for continuity, and as a tool to gain a conservative idea of the sound energies that fish may be exposed to during the majority of this project.

Vibratory Pile Driving: Elevated in-water noise at levels capable of causing detectable effects in exposed fish would be caused by the in-water use of vibratory pile installation and boat operations. The estimated in-water source levels (SL, sound level at 1 meter from the source) used in this assessment are based on the best available information, as described in recent acoustic assessments for similar projects (NMFS 2017b, 2018), and in other sources (Blackwell and Greene 2006, CalTrans 2015; Richardson et al. 1995). The best available information supports the understanding that all of the SLs from vibratory pile driving would be below the 206 dB_{peak} threshold for the onset of instantaneous injury in fish for vibratory pile driving of up to ten 36-inch steel piles, two 14-inch steel piles and 160 feet of sheet piles. Vibratory extraction may also be used to remove thirty 10-inch timber piles. Based on previous studies and the proposed number and size of piles, it is likely that the radius of the 150 dB_{SEL} isopleths would extend no more than 1,522 feet from the work area. None of the proposed piles would be proofed, thus there would be no impact pile driving.

PS Chinook salmon and PS steelhead that remain outside of the 150 dB_{SEL} isopleths for these sources would be unaffected by the noise. However, fish within the 150 dB_{Sel} isopleth are likely to experience a range of effects that would depend on their distance from the source and the duration of their exposure. All juveniles that are within the 150 dB_{SEL} isopleth, are likely to experience behavioral disturbance, such as acoustic masking, startle responses, altered swimming patterns, avoidance, and increased risk of predation. It is doubtful that any individual would approach close enough and remain long enough to accumulate sound energy in excess of

183dB Sel_{cum} threshold. However, if any do, they may also experience some level of auditory- and non-auditory tissue injury, which could reduce their likelihood of their long-term survival.

Dredging Activity: Noise generated from dredging is not anticipated to exceed typical background noise in the project area. The proposed dredging would occur in and near an active marine transportation zone and industrial facilities.

Entrainment or Bucket Strike

The likelihood of PS Chinook salmon and PS steelhead exposure to dredging- and material placement related entrainment or bucket strike is extremely low. The EPA's contractors would conduct 159 days (12-hour days) of dredging (145 planned and 14 as contingency) with an environmental or clamshell bucket between RM 3 and 5 of the Lower Duwamish River between October 1 and February 15. There would also be 105 days of placement of backfill, RMC, ENR, and Amended Cover Material, which would use similar equipment. This work would be spread over three work windows.

Any fish that become captured within the digging bucket (entrainment) or that are struck by the bucket as it descends would likely be killed. However, the documented occurrence of these events for mobile fish species are extremely rare. In the Southeast Region of the US, where closely monitored heavy dredging operations occur regularly in areas inhabited by sturgeon and sea turtles, only two live sturgeon (NMFS 2012) and two live sea turtles (NMFS 2011) were known to have been taken (harm) by clamshell dredging in over 20 years of monitoring (1990-2010).

The rarity of these occurrences is likely due to a combination of factors. In order to be entrained in a clamshell bucket, a fish must be directly under the bucket when it drops. The relatively small size of the bucket, compared against the scattered and low-density distribution of the fish across the available habitat within the project area strongly suggest that the potential for overlap between fish and bucket presence is very low, and that potential would decrease after the first few bucket cycles because mobile organisms such as salmonids are likely to move quickly away from the noise and turbid water. Further, mechanical dredges typically stay within an area limited to the range of the crane/excavator arm for many minutes to several hours before moving to an adjacent area. The risk of entrainment and bucket strike during the planned dredging would be lowered further by conducting the work during a period when very few individuals are likely to be present anywhere within the action area. Therefore, based on the best available information, the NMFS considers it extremely unlikely that any PS Chinook salmon or PS steelhead be entrained or struck by the bucket during the planned maintenance dredging.

Hydraulic dredging is not anticipated to be used by the contractor during the upper reach remedial construction, but the contractor may propose its use in specific circumstances where site access for mechanical dredging is not feasible (e.g., under pier or riprap slope areas) and the total amount of water generated would be small and controllable. In the unlikely event that hydraulic dredging is used for dredging, there is a risk of entrainment of juvenile PS Chinook salmon in the cutterhead. This risk is expected to be low because the contractor performing the work would implement conservation measures to reduce the probability of entrainment, including the following: 1) not operation the dredge when the cutterhead is off the river bottom; 2) keeping the cutterhead on the bottom of the water column or a maximum of 3 feet from the bottom when necessary; and 3) turning on the suction pumps only when necessary. The risk is also expected to be low due to the timing of the construction, which is expected to occur when the lowest numbers of listed fish species are expected to be in the action area.

Degraded Water Quality

As described above, water quality will be temporarily reduced. Water quality in the action area would be monitored and compared against applicable water quality standards (Washington Administrative Code (WAC) 173-201A-210). This includes required limits measured in the water column for turbidity, dissolved oxygen (DO), pH, and temperature, and for select COC criteria (e.g., PCBs) pursuant to the Clean Water Act (CWA) Section 404 Applicable of Relevant and Appropriate Requirements (ARAR) Memorandum that would be issued by the EPA prior to the implementation and the Water Quality Monitoring Plan (WQMP) completed as part of the Pre-Final (90 percent) RD and Final (100 percent) RD. Water quality monitoring will be implemented to track that chemical concentrations above acute and chronic water quality standards are achieved within 150 feet and 300 feet, respectively, of the dredge area. Operational controls will be used for control of turbidity and resuspended sediment. For example, construction activities can be progressively slowed to minimize sediment resuspension until turbidity exceedances are no longer detected outside of the compliance boundary, or dredging cycle times can be increased to decrease turbidity plumes until the suspended sediment settles.

Exposure to construction-related degraded water quality would cause sublethal effects in PS Chinook salmon and PS steelhead. As stated above, EPA's contractors would conduct 159 days (12-hour days) of dredging (145 planned and 14 as contingency) with an environmental or clamshell bucket between RM 3 and 5 of the Duwamish River between October 1 and February 15. There would also be 105 days of placement of backfill, RMC, ENR, and Amended Cover Material, which would use similar equipment. This work would be spread over three work windows. This work would also include the operation of barges in relatively shallow-water areas. This work would affect water quality through reduced DO concentrations, and through the introduction of toxic materials from the mobilized sediments and from equipment-related spills and discharges.

Turbidity: Dredging and project-related propeller wash would mobilize bottom sediments and cause turbidity plumes with relatively low concentrations of total suspended sediments (TSS). The intensity of turbidity is typically measured in Nephelometric Turbidity Units (NTU) that describe the opacity caused by the suspended sediments, or by the concentration of TSS as measured in milligrams per liter (mg/L). A strong positive correlation exists between NTU values and TSS concentrations. Depending on the particle sizes, NTU values roughly equal the same number of mg/L for TSS (i.e., 10 NTU = ~ 10mg/L TSS, and 1,000 NTU = ~ 1,000 mg/L TSS) (Campbell Scientific Inc. 2008, Ellison et al. 2010). Therefore, the two units of measure are easily compared.

Water quality is considered adversely affected by suspended sediments when turbidity is increased by 20 NTU for a period of 4 hours or more (Berg and Northcote 1985, Robertson et al.

2006). The effects of turbidity on fish are somewhat species and size dependent. In general, severity typically increases with sediment concentration and duration of exposure, and decreases with the increasing size of the fish. Bjornn and Reiser (1991) report that adult and larger juvenile salmonids appear to be little affected by the high concentrations of suspended sediments that may be mobilized during storm and snowmelt runoff episodes. However, empirical data from numerous studies report the onset of minor physiological stress in juvenile and adult salmonids after on hour of continuous exposure to suspended sediment concentration levels between about 1,100 and 3,000 mg/L, or to three hours of exposure of 400 mg/L, and seven hours of exposure to concentration levels as low as 55 mg/L (Newcombe and Jensen 1996). The authors reported that serious non-lethal effects such as major physiological stress and reduced growth were reported after seven hours of continuous exposure to 400 mg/L and 24 hours of continuous exposure to concentration levels as low as about 150 mg/L.

Mechanical dredging in areas containing high levels of fine-grained material is likely to cause suspended sediment plumes that could extend 200 to 500 feet down-current from the point of dredging, and may take hours after work has stopped to return to background levels. LaSalle et al. (1991) reported suspended sediment concentrations of about 700 mg/L at the surface, and 1,100 mg/L near the bottom, and about 300 feet from clamshell dredging in areas containing high levels of fine-grained material. During monitored clamshell dredging of inner Grays Harbor, the suspended sediment concentrations exceeded 500mg/L in 23 of 600 samples, and seven of those samples were for tests of ambient conditions (COE 2011). The single highest reported concentration was 3,000 mg/L when the ambient TSS concentration was 700 mg/L.

Hydraulic dredging is not anticipated to be used by the contractor during the upper reach remedial construction, but the contractor may propose its use in specific circumstances where site access for mechanical dredging is not feasible (e.g., under pier or riprap slope areas) and the total amount of water generated would be small and controllable. Hydraulic dredging impacts on sediment resuspension are expected to be similar to mechanical dredging but typically is observed near the sediment bed.

Material placement activities for engineered capping, backfilling, RMC placement, ENR placement, and amended cover placement could also result in increases in turbidity as the material is transported through the water column due to the presence of some fines within the clean material. However, the specifications for the imported materials would include a requirement for the materials to consist of clean, granular material free of roots, organic material, contaminants, and all other deleterious material. This requirement would minimize the amount of fines being placed and reduce the potential for elevated turbidity during placement. If elevated turbidity does occur during material placement, this condition is expected to be temporary and localized, and the activity would be monitored for water quality exceedances. The duration of elevated turbidity, if it occurs, is expected to be limited to a few hours and to be intermittent.

Vibratory removal of hollow 30-inch steel piles in Lake Washington mobilized sediments that adhered to the piles as they were pulled up through the water column (Bloch 2010). Much of the mobilized sediments likely included material that fell out of the hollow piles. Turbidity reached a peak of about 25 NTU (~25 mg/L) above background levels at 50 feet from the pile, and about 5

NTU (~5mg/L) above background at 100 feet. Turbidity returned to background levels within 30 to 40 minutes. Pile installation created much lower turbidity.

Propeller wash would also mobilize bottom sediments. The intensity and duration of the resulting turbidity are uncertain, and would depend on a combination of the vessels thrust, the water depth under it, and the type of substrate. The higher the thrust and the finer the sediment, the more sediment that is likely to be mobilized. Fine material (silt) remains mobilized longer than coarse material (sand). The shallower the water, the more thrust energy that would reach the substrate. A recent study described the turbidity caused by large tugboats operating in Navy harbors (ESTCP 2016). At about 13 minutes, the plume extended about 550 yards (500m), where the TSS concentration was about 80 mg/L. The plume persisted for hours and extended far from the event, but the TSS concentration fell to 30 mg/L within 1 hour and to 15 mg/L within 3 hours. At its highest concentration, the plume was below the concentrations required to elicit physiological responses reported by Newcombe and Jensen (1996). The exact extent of turbidity plumes from vessel operations for this project are unknown, but it is extremely unlikely that would exceed those described above. Based on that information, and on the consultations for similar projects in the region, sediment mobilization from propeller wash would likely consist of relatively low-concentration plumes that would extend to about 300 feet (WQMP compliance is required) from the vessel, and last a short time (hours) after the disturbance.

The EPA's contractors would be required to comply with the WQMP for this project, and to monitor and limit turbidity such that at points of compliance, 150 (acute) and 300 (chronic) feet from the dredge turbidity would not exceed 5 NTU (~5mg/L) above background levels of 50 NTU or less, and to 10 percent above background for background levels above 50 NTU or higher.

Dissolved Oxygen (DO): Habitat and prey resources may be affected through temporary decreases in DO contemporaneous with the increased suspended sediment (Mitchell et al. 1999) "Suspended sediments absorb heat energy thereby raising water temperatures … Turbidity can reduce light transmission through the water and decrease photosynthesis by aquatic plants, consequently affecting dissolved oxygen levels …" (Kjelland et al. 2015), internal citations omitted). Reductions in DO would likely be short lived, if they occur at all. Because the window for the dredging operation is between October and February, we anticipate both that water temperatures are likely to remain cold, and inflow from the freshwater environment would be strong, both of which should limit reductions in DO. Fish exposure to decreased DO is therefore not expected to have either an intensity or duration that would be expected to injure fish.

Mobilized Pollutants: Due to the highly industrialized nature of the project area, numerous sites containing hazardous substances exist and are specifically targeted as the remediation sites. Contaminants in sediments and dissolved in-water can have varying levels of toxicity, most often occurring as sub-lethal effects. The LDW was listed as a federal Superfund Site in 2001 (EPA 2014). At least 41 different hazardous chemicals have been found in LDW sediments (Ecology 2023). Elevated concentrations of mercury, polycyclic aromatic hydrocarbons, bis(2-ethylhexyl) phthalate, PCBs, and dioxins/furans (D/Fs) have been measured in sediments associated with portions of this source control area (Ecology 2013). Because concentration of PAHs, PCBs, and

D/Fs exceeded screening levels, the potential effects of those contaminants are discussed in more detail below. Some of the effects of these contaminants to salmonid species include:

- Sublethal effects to fish include external injury such as damage to the skin, fins, and eyes as well as internal organ problems such as liver tumors from exposure to PAH contaminated sediments and water. Gill tissues are highly susceptible to damage because they actively pass large volumes of water and are thereby exposed to PAHs present in water (SHNIP 2016). Most non-benthic fish tissue contain relatively low concentrations of PAH, and accumulation is usually short term because these organisms can rabidly metabolize and excrete them (Lawrence and Weber 1984 and West et al. 1984, as cited in Eisler 1987).
- Many studies have reported the nature of PAHs in aquatic environment and their metabolism in fishes. Fish exposure to PAHs has been linked to a wide range of physiological dysfunctions in fish, including neoplasia, endocrine disruption, immunotoxicity, and transgenerational impacts (Tierney et al. 2014)
- Exposure of fish to PAHs is generally associated with narcosis, resulting in a general depression of biological and physiological activities (Van Brummelen et al. 1998). These effects may be linked to reduced immune function, increased mortality after disease challenge, and reduced growth (Karrow et al. 1999; Varanasi et al. 1989; Arkoosh et al. 1991, 1998)
- PAHs have been found to reduce fitness and have potential to kill juvenile salmonids through the effect of "toxicant-induced starvation" in which lipid stores and biomass are reduced (Meador et al. 2006). Impacts of PAHs on the reproduction and development of wild Puget Sound salmon have not been well characterized, although some laboratory studies have shown abnormal behavioral effects during early development of coho salmon exposed to PAHs (Ostrander et al. 1988). Dioxins exposure can cause detrimental but sublethal effects, described above, among juvenile salmonids. Dioxin toxicity varies dramatically across fish species with salmonids exhibiting the highest sensitivity. Recent studies have shown negative effects to eggs and dry but little is known about toxicity levels of adult salmonids that might be found in the action area (King-Heiden et al. 2011). The period of potential exposure to these contaminants is during the 159 days of dredging over three work windows.
- Dioxin and dioxin-like PCBs act similarly on salmonids and other fish species. Reported effects on juvenile salmonids include a wide range of sub-lethal outcome including impaired growth and reproduction, hormonal alterations, enzyme induction, alterations to behavior patterns, and mutagenicity (Meador 2002, SHNIP 2016). Eisler (1986) stated that in general, toxicity increased with increasing exposure, crustaceans and younger developmental stages were the most sensitive groups tested, and lower chlorinated biphenyls were more toxic than higher chlorinated biphenyls.
- Exposure to dioxins can result in developmental or reproductive toxicity in fish, birds, and mammals. Fish larvae are among the most sensitive vertebrates to the toxic effects of dioxins/furans (Peterson et al. 1993); and exhibit similar signs of toxicity as other vertebrates including decreased food intake, wasting syndrome, and delayed mortality. Adult fish are less susceptible to dioxin-induced toxicity adverse effects (Lanham et al. 2012; Peterson et al. 1993; Walker and Peterson 1992, 1994).

Resuspension of contaminated sediments are proportional to the amount of dredging and the local levels of contamination. Assuming a three percent sediment resuspension rate (SHNIP 2016), approximately 3,891 cy (3,243 cy from planned dredging and 648 cy as contingency) of material would be resuspended over the three-year project. In addition, disturbance of the substrate would increase contaminant concentrations by resuspending particulates, thereby allowing more contaminants to transport into the water column. However, measures to limit suspended sediment, such as the dredging techniques, would reduce disturbance of substrate particles and contaminants (SHNIP 2016). Contaminant concentrations would be increased for up to 159 days (145 days from planned dredging and 14 days as contingency) during three consecutive work windows (October 1 to February 15), with potentially harmful acute increases contained within the 150-foot compliance boundary. Which species and life stages have the most exposure would be determined by the actual date of in-water work, which at this time is unspecified. Ultimately, once the contaminated sediment has been removed, the concentration of contaminated material in the surrounding environment would decrease and the pathway of exposure for fish through contamination of prey would be reduced in perpetuity. However, the project has residual management elements. The purpose of residuals management is to provide a clean post-remedial action surface condition with concentrations that are all below surface RALs. Residual contamination can remain within the dredge prism and be resuspended to settle out close to the dredge areas in adjacent sediments. Placing RMC is an effective and standard approach to manage generated residuals. Where sufficiently thin and low-concentration residuals are present, short- and long-term mixing of the clean RMC material into underlying residuals would support attainment of the cleanup criteria. The placement of a clean cover layer accelerates the natural recovery process in the biologically active zone.

Creosote-treated piles leach PAHs into the surrounding sediments, as well as directly into the water (Evans et al. 2009, Parametrix 2011; Smith 2008, Werme et al. 2010). Therefore, the sediments that would be mobilized during pile removal very likely contain PAHs from the creosote-treated piles. PAHs may also be released from the timber piles should they break during their removal. As described above, the amount of sediment that would be mobilized by construction activities would be small, and any PAHs that may be mobilized would likely dissipate within a few hours, through evaporation at the surface, dilution in the water column (Smith 2008, Werme et al. 2010), or by settling out of the water with the sediments. Therefore, in-water contaminant concentrations would be very low and short-lived. However, the purpose of the project is to remove existing pollutants from the sediments. While the action may result in some resuspension of pollutants during project implementation, the long-term risk of future exposure would be reduced.

Propeller Wash

Project-related propeller wash is likely to adversely affect juvenile PS Chinook salmon. Spinning boat propellers kill fish and small aquatic organisms (Killgore et al. 2011; VIMS 2011). Spinning propellers also generate fast-moving turbulent water that is known as propeller wash. Exposure to propeller wash can displace and disorient small fish. It can also mobilize sediments and dislodge aquatic organisms, particularly in shallow water and/or at high power settings. This is called propeller scour.

Project-related vessel operations would cause propeller wash within the action area. Adult fishes may be present in the action area during the project activities. However, should they be present, they would avoid the project-related noise and activity. Further, they would be able to swim against most propeller wash they may be exposed to without any meaningful effect on their fitness or normal behaviors. Conversely, the juvenile Chinook salmon (juvenile steelhead are not expected during the work window) that would be present within the area are likely to be relatively close to the surface and too small to effectively swim against the propeller wash. Individuals that are struck or very nearly missed by the propeller would be injured or killed by the exposure. Farther away, propeller wash may displace and disorient fish. Depending on the direction and strength of the thrust plume, displacement could increase energetic costs, reduce feeding success, and may increase the vulnerability to predators for individuals that tumble stunned and/or disoriented in the wash.

The number of juvenile PS Chinook salmon that would be affected by propeller wash attributable to this action is unquantifiable with any degree of certainty. As stated above, the best available information indicated that very few juvenile Chinook salmon would be in this reach before February when the project would be within two weeks of annual conclusion. Further, the relatively small size of the affected area would limit the exposure risk to a small subset of those migrating in early February. Therefore, the number of juvenile PS chinook salmon that would be affected by propeller wash would be extremely low, and too small to cause detectable population-level effects. Juvenile PS steelhead do not begin outmigration until March and would not be present during boat operations.

Project-related propeller scour may also diminish the density and diversity of the benthic community at the project sites. However, most the substrate vulnerable to propeller scour would be within the dredging footprint, the impacts of which are described below under altered benthic habitat. Within LDW, the total propeller scour area would likely comprise a tiny portion of the benthic substrate within the action area, and the disturbed benthic organisms would likely recover very quickly after the project is complete. Therefore, the effects of propeller scour on benthic resources would be too small to cause any detectable effects on the fitness and normal behaviors of PS Chinook salmon and PS steelhead in the action area.

Reduced Prey Abundance

Juvenile salmon and steelhead diets in the action area are tied to epibenthic prey organisms occurring in shallow water areas. In-water work for this remedial action would temporarily disturb existing epibenthic organisms and habitat in the work area. The substrate along the shore is highly modified in some areas and exhibits an abundance of armoring, resulting in less area of production of epibenthic communities on bottom substrates in these shallow water locations. Other areas have more natural or restored conditions. Although disturbances to benthic habitat would occur during project activities, it is expected – due to existing compromised habitat for prey species because of the presence of chemical contamination and the context of the work area within an already disturbed landscape – impacts to juvenile Chinook salmon and steelhead via disturbance of the epibenthic prey community would be minimal and short term in the immediate area of dredging and material placement. The benthic community in disturbed areas is expected to recover within 1 to 2 years (and up to 3 years for complex diversity) with species from nearby areas moving into the disturbed area to recolonize, though this recovery would happen in stages because work would occur over multiple years (i.e., areas disturbed in year one would be approaching full recovery as the project concludes in year three). Dredging could also cause a limited increase in exposure of benthic infauna to resuspended contaminants or residuals in areas close by the dredge areas.

The areas disturbed by material placement that are not dredged (i.e., placement of ENR, amended cover, and RMC material in the dredge perimeter) would recover faster than dredged areas because some benthic invertebrates are expected to survive material placement. RMC material would be placed in these dredge perimeter areas to address residual contamination. The length of recovery is estimated to be weeks rather than 1 to 2 years expected for dredged areas and may be shorter depending on the depth of placement material. Benthic species in these areas could experience very minor increase in contaminant concentration in the short term. Moreover, the overall purpose of conducting the removal of sediment contamination in the action area is to reduce exposure to existing contaminants and provide long-term benefits to prey species, as well as juvenile Chinook salmon and steelhead, by significantly improving overall benthic habitat conditions. The lower risk to juvenile salmonids from contaminant exposures means that more salmonids should return as adults. Per the ROD requirements (EPA 2014), habitat areas that are dredged would be backfilled to existing grades, and additional areas would have placement of ENR materials on top of existing bed sediments. Adult Chinook salmon typically do not feed during migration, so their food source is limited to the offshore marine area (outside of the action area) and would not be impacted through the proposed action. Adult steelhead are iteroparous, and would continue to consume prey as returning adults, but as larger fish, they are likely to seek out much larger prey than the benthic assemblies would provide. Therefore, any effect on adults would be tied to degradation to the food web (i.e., degraded benthic assemblies result in reduced prey items for adult steelhead). However, the overall purpose of proposed project is to the remove contaminated sediments, which would improve the conditions for the benthic assemblies and subsequently potentially improving the quantity and quality of PS steelhead food resources. Considering adult fish’s mobility and the relative short-term nature of the effect, prey availability is also unlikely to be significant to adult steelhead.

Exposure to contaminated forage is likely to adversely affect juvenile PS Chinook salmon and PS steelhead. As described under degraded water quality, the planned dredging would mobilize about 3,891 cy of contaminated sediment. Those residual sediments would settle onto the top layer of the substrate within about 150 feet of the dredged area, where contaminants would remain biologically available for years.

The contamination levels of the LDW is high as it is a heavily industrialized area. Romberg (2005) discusses the spread of contaminated sediments that were mobilized by the removal of creosote-treated piles from the Seattle Ferry Terminal, including digging into the sediment with a clamshell bucket to remove broken piles. Soon after the work, high PAH levels were detected 250 to 800 feet away, across the surface of a clean sand cap that had been installed less than a year earlier. Contaminant concentrations remained above pre-contamination levels 10 years later. Lead and mercury values also increased on the cap, but the concentrations of both metals decreased to background levels after 3 years.

Over the 159 days of dredging (over three work windows), most of the mobilized sediment, and therefore the highest concentrations of contaminants, would likely settle back to the river bed in or close to the area where the dredging would be done. However, currents and vessel propeller wash may act to spread contaminated sediments as far away as 300 feet from the dredging (Washington Department of Ecology (WDOE) turbidity point of compliance for this project). Within that area, contaminants such as PAHs and dioxin would be biologically available for years, at steadily decreasing levels as they become covered by incoming river sediments. While present, some of those contaminants are likely to be taken up by some of the invertebrate prey organisms within the affected area. However, the project has residual management elements. The purpose of residuals management is to provide a clean post-remedial action surface condition with concentrations that are all below surface RALs. Residual contamination can remain within the dredge prism and be resuspended to settle out close to the dredge areas in adjacent sediments. Placing RMC is an effective and standard approach to manage generated residuals. Where sufficiently thin and low-concentration residuals are present, short- and long-term mixing of the clean RMC material into underlying residuals would support attainment of the cleanup criteria. The placement of a clean cover layer accelerates the natural recovery process in the biologically active zone.

Juvenile Chinook salmon and steelhead are expected to pass through the action area each year. During their transit through the action area, at least some of those juveniles are likely to feed on the invertebrate resources within the action area, some of which may be contaminated by dredge-mobilized sediments. The annual number of juvenile PS Chinook salmon and steelhead that may be exposed to contaminated forage attributable to this action is unquantifiable with any degree of certainty, as is the amount of contaminated prey that any individual fish may consume, or the intensity of any effects that an exposed individual may experience.

The project area is approximately 132 acres, the proposed dredging and contingency activity is limited to 15.22 acres (and work within these acres would be spread across three work windows). The RAAs with dredging elements would experience the most impact with lessening impacts when moving away from the dredging activity. All 15.22 acres are expected to be impacted, but on a gradient. Work would occur across multiple work windows, so riverbed that is disturbed during the first work window would be recovered or approaching recovery by the completion of the project. Work in subsequent years would be expected to recover three years from that season’s completion. During this time benthic prey is less available and may be of lower quality to juveniles, incrementally diminishing the growth and fitness of four separate cohorts of individual juvenile outmigrants from the ESA listed salmonid species that pass through the action area. Given the relatively small area from within available prey sources in the river system, and the high level of mobility that juvenile migrants have when they reach the marine environment, it is unlikely that many individual fish would experience contaminated forage, reduce forage or increased competition to a degree that impairs their growth, fitness, or survival. Even if several fish from each cohort of each population had diminished foraging success, we anticipate that this would be a transitory condition as they migrate to more suitable forage locations. The level of reduced growth, fitness, or survival would be impossible to detect numerically, and the reduced abundance in juvenile cohorts would probably be insufficient to be discerned as an influence on productivity of the populations.

Altered Benthic Habitat

The LDW is a migratory corridor for juvenile and adult Chinook salmon and steelhead as well as a rearing area for juvenile Chinook and steelhead. Nearshore habitat in the action area used by these species would be affected in the short term due to dredging/excavation, material placement, and in-water structure modification activities that would disturb and/or cover existing surface sediments. A habitat evaluation was conducted to determine the impacts to habitat from implementing the remedial activities within each RAA. The impact of remedial activities to all habitat types, including the ROD-defined “habitat area” (EPA 2014) was evaluated.

The habitat evaluation was completed using semi-quantitative methods and the HEA-based Puget Sound Nearshore Calculator (PSNC) to determine potential impacts to habitat from implementing remedial activities. The PSNC was used to evaluate impacts associated with piling removal and installation, bulkhead reinforcement, and debris pile removals. The semi-quantitative approach was used to evaluate impacts associated with dredging and material placement activities. The habitat evaluation compares existing habitat conditions to post-remediation conditions to determine potential impacts and benefits to habitat of implementing the proposed action.

Existing habitat conditions were developed from data and information collected as part of the Phase I and Phase II PDI (Anchor QEA and Windward 2022), including bathymetry, substrate, bank vegetation, shoreline condition, and overwater and in-water structures (including loss of 240 ft^2 for bulkhead reinforcement and 2,160 ft^2 for outfall bank protection). Aerial imagery was also used to confirm data collected as part of the PDI. The resulting mapped habitat polygons were assigned an elevation-based habitat category relative to MLLW. Post-remediation habitat conditions were then assigned based on engineering design details for each RAA, plus its 40-foot RMC perimeter. For the semi-quantitative evaluation, spatial analysis tools were used to reassign habitat categories in each RAA (plus RMC) based on changes to elevation and substrate type that would occur because of remedial activities. Design details extracted for the PSNC include length and diameter of pilings, length and elevation of shoreline armoring removal and replacement, area and elevation of debris removal and area of riparian disturbance.

Impact avoidance, minimization, and conservation measures would be implemented during construction to avoid unnecessary impacts and minimize the negative effects of the proposed action. Specifically, dredge areas in shallow subtidal and intertidal areas would be backfilled to grade using suitable habitat material consisting of sand and gravel to avoid converting habitat from shallow to deep water. Also, in dredged areas, RMC material would be placed after dredging within the dredge footprint (in areas not backfilled) and dredge perimeter to address residuals above the RALs.

The semi-qualitive habitat evaluation of sediment chemical remediation activities, including dredging and capping shows that no changes in habitat type (e.g., from intertidal to shallow subtidal) are expected in 98 percent of the remediation areas. Changes in habitat elevation and/or degradation status are expected to occur in a total of 0.33 acre in RAAs 22, 29, 32, and 33/34/35. A change from Degraded Upper Intertidal to Degraded Lower Intertidal in RAA 22 is related to removal of two debris pilings. Because these areas are adjacent to a bulkhead wall, they are still considered degraded habitat after debris removal. However, the benefit related to the debris pile removal is quantified by the PSNC, as described below.

- Removal of scattered riprap and debris in RAA29 from dredging in this area would result in a habitat change from Degraded Upper Intertidal to Upper Intertidal.
- Removal of scattered riprap and debris in RAAs 32 and 33/34/35 from dredging would result in habitat change from Degraded Upper Intertidal to Upper Intertidal and Degraded Lower Intertidal to Lower Intertidal.
- In the engineered cap area of RAA 27, the existing substrate consists of riprap and debris within the cap area. Because the surface substrate in this area would be riprap armor, there is no change in the substrate type post remediation.
- In the engineered cap area in RAA 14/15/16, riprap armor would also be placed in a deep subtidal area that is expected to quickly fill in with native material and cover the riprap. As such, no permanent change in substrate is expected in this area.

The semi-quantitative habitat evaluation results indicate that there would be project-related habitat benefits from incidental debris/riprap removal in addition to the expected benthic habitat, sediment quality, and water quality improvements from sediment chemical remediation.

The results of the PSNC portion of the habitat evaluation are reported in discounted-service-acre-year (DSAYs), where a DSAY represents the value of all the ecosystem service provided by 1 acre of habitat over 1 year. A negative DSAY indicates a habitat impact; a positive DSAY indicates a habitat benefit. The habitat evaluation compared baseline habitat conditions to a post-remediation habitat conditions for activities including pile installation and removal, creosote removal, bulkhead reinforcement, debris removal, and riparian disturbance and replanting. The activities are reported as habitat impacts and benefits. This project is expected to result in positive DSAYs and improve nearshore habitat conditions. The implementation of this project would result in improved riverbed chemical attributes while largely maintaining its physical characteristics of the near shore environment. Therefore, the changes to benthic habitat, in the short term, would maintain species' productivity levels, and be beneficial in the long term by removing stressors from the habitat.

2.5. Cumulative Effects

"Cumulative effects" are those effects of future State or private activities, not involving Federal activities, that are reasonably certain to occur within the action area of the Federal action subject to consultation [50 CFR 402.02 and 402.17(a)]. Future Federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to section 7 of the ESA.

Some continuing non-Federal activities are reasonably certain to contribute to climate effects within the action area. However, it is difficult if not impossible to distinguish between the action area's future environmental conditions caused by global climate change that are properly part of the environmental baseline *vs.* cumulative effects. Therefore, all relevant future climate-related environmental conditions in the action area are described earlier in the discussion of environmental baseline (Section 2.3). Because the LDW is expected to remain highly industrialized and utilized for several decades, we expect climate change conditions to become more pronounced over that time, which we anticipate may disrupt important habitat features and ecosystem functions that are critical for salmonid survival and recovery.

NMFS does not expect any new non-Federal activities within the action area because the area is already highly developed with industrial activities and work within the water would fall under federal authorities such as the Clean Water Act. However, at the watershed scale, future upland development activities lacking a federal nexus will continue and are expected to lead to increased impervious surface, surface runoff, and non-point discharges. NMFS expects these activities to continue in perpetuity. These activities will degrade water quality and exert a negative influence on ESA-listed species. Any future federal actions will be subject to section 7(a)(2) consultation under ESA.

2.6. Integration and Synthesis

The Integration and Synthesis section is the final step in assessing the risk that the proposed action poses to species and critical habitat. In this section, we add the effects of the action (Section 2.4) to the environmental baseline (Section 2.3) and the cumulative effects (Section 2.5), taking into account the status of the species and critical habitat (Section 2.2), to formulate the agency's biological opinion as to whether the proposed action is likely to: (1) reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing its numbers, reproduction, or distribution; or (2) appreciably diminish the value of designated or proposed critical habitat as a whole for the conservation of the species.

The two species considered in this opinion are listed as threatened with extinction because of declines in abundance, poor productivity, and reduced spatial structure and diminished diversity. Systemic anthropogenic detriments in fresh and marine habitats are limiting the productivity for PS Chinook salmon and PS steelhead.

The environmental baseline in the action area is a mix of commercial fishing and vessel infrastructure as well as commercial development landward of the highest astronomical tide, or HAT, that degrade habitat conditions for listed species in their nearshore marine life stage. Within the action area there are sources of noise and shade (vessels), water quality impairments (nonpoint sources), and artificial light (marinas and fishing piers). To this context of species status and baseline conditions, we add the temporary effects of the proposed action, together with the cumulative effects (which are anticipated to be future nonpoint sources of water quality impairment associated with development and stressors associated with climate change), in order to determine the effect of the project on the likelihood of species' survival and recovery. We also evaluate if the project's habitat effects will appreciably diminish the value of designated critical habitat for the conservation of the species. Such alterations may include, but are not limited to, those that alter the physical or biological features essential to the conservation of a species or that preclude or significantly delay development of such features.

2.6.1 ESA Critical Habitat

The temporary effect on features of designated critical habitat for PS Chinook salmon and PS steelhead would be water quality and benthic disturbance. We expect diminishment of water quality based on turbidity and associated resuspended contaminants, as they would remain high several hours after dredging ceases. Turbidity and resuspended contaminants would diminish water quality for up to 264 days total, but spread over three consecutive work windows, and would affect approximately 28.1 aces. Furthermore, to address resuspension of contaminants the project has residual management elements. The purpose of residuals management is to provide a clean post-remedial action surface condition with concentrations that are all below surface RALs. Residual contamination can remain within the dredge prism and be resuspended to settle out close to the dredge areas in adjacent sediments. Placing RMC is an effective and standard approach to manage generated residuals. Where sufficiently thin and low-concentration residuals are present, short- and long-term mixing of the clean RMC material into underlying residuals would support attainment of the cleanup criteria. The placement of a clean cover layer accelerates the natural recovery process in the biologically active zone. Because the annual duration is brief, primarily occurs when adult fish rather than juveniles are present, occurs when water temperatures are cold, has residual management elements, and baseline water quality levels are re-established shortly after the disturbance, the impaired water quality PBF does on not diminish conservation values of the action area.

The effects on benthic communities is also temporary, but much more persistent. Recovery time for the affected area is expected to not last longer than three years, with noticeable areas of recovery starting on the outer edges of the dredged area, starting weeks to months after dredging is completed. Furthermore, this recovery would happen in stages because work would occur over multiple years (i.e., areas disturbed in year one would be approaching full recovery as the project concludes in year three). Despite the duration of this effect, the forage PBF diminishment is not sufficient to diminish conservation values of the action area because only a maximum of three cohorts of juvenile PS Chinook salmon would experience this decline, and the reduced forage base is most notable in the first year, ameliorating as benthic communities re-establish.

The beneficial effects of removing known contaminants would improve water quality and substrate condition of the habitat. These effects would be incremental but permanent improvements to habitat within the action area.

When added to the baseline, and considered together with the anticipated negative cumulative impact of numerous non-federal effects, the temporary effects of the proposed action are not likely to impair long term conservation values of critical habitat designated for PS Chinook salmon and PS steelhead, particularly because sources of prey are not considered limiting for listed species within the lower river. We have determined that the temporary impairments would not reduce conservation values of the critical habitat to serve the recovery goals for the listed species.

The remedial nature of the proposed project is reasonably certain to offset the long-term loss of habitat function from the dredging, material placement, pile replacement/removal, and bulkhead reinforcement resulting in a net zero loss of habitat function. The temporary impacts that disrupt benthic environments would diminish juvenile fish rearing habitats and food sources in the action area; however, when scaled up to the designation scale, the effects are not expected to impact the ESU or DPS because it is likely that a very small number of fishes would be impacted. Reduced diversity or density of epibenthic mesofauna also reduces prey resources for juvenile salmonids – but again would be offset by the habitat improvements associated with the proposed project. We expect the overall conservation value, despite adverse effects, will be retained.

2.6.2 ESA Listed Species

Because the work windows are timed when juvenile salmon migration is largely avoided we expect that juvenile PS Chinook salmon would only minimally be exposed to turbidity in the work window. These fish are likely to have a behavioral response to this exposure, and any injury (e.g., gill abrasion) is unlikely to impair fitness of the adult fish for spawning.

The most chronic of the temporary effects – reduced benthic prey for up to 1 to 2 years (and three to regain complex diversity) – should not affect fitness or survival of enough fish to discernibly reduce abundance of any cohort of any population within those 3 years.

Accordingly, NMFS expects only a very small reduction in numbers of PS Chinook salmon and PS steelhead, if any, as a consequence of their exposure to the temporary effects. These effects, even when considered with cumulative effects, are insufficient to alter the productivity, spatial structure, or genetic diversity of any of the species. Therefore, when considered with the environmental baseline in the action area and cumulative effects, the action, as proposed, does not increase risk to the affected populations to a level that would appreciably reduce the likelihood for survival and recovery of the PS Chinook salmon ESU or PS steelhead DPS.

2.7. Conclusion

After reviewing and analyzing the current status of the listed species and critical habitat, the environmental baseline within the action area, the effects of the proposed action, the effects of other activities caused by the proposed action, and the cumulative effects, it is NMFS' biological opinion that the proposed action is not likely to jeopardize the continued existence of PS Chinook salmon or PS steelhead or destroy or adversely modify their designated critical habitat.

2.8. Incidental Take Statement

Section 9 of the ESA and Federal regulations pursuant to section 4(d) of the ESA prohibit the take of endangered and threatened species, respectively, without a special exemption. "Take" is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. "Harm" is further defined by regulation to include significant habitat modification or degradation that actually kills or injures fish or wildlife by significantly impairing essential behavioral patterns, including breeding, spawning, rearing, migrating, feeding, or sheltering (50 CFR 222.102). "Harass" is further defined by interim guidance as to "create the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavioral patterns which include, but are not limited to, breeding, feeding, or sheltering." "Incidental take" is defined by regulation as takings that result from, but are not the purpose of, carrying out an otherwise lawful activity conducted by the Federal agency or applicant (50 CFR 402.02). Section 7(b)(4) and section 7(o)(2) provide that taking that is incidental to an otherwise lawful agency action is not considered to be prohibited taking under the ESA if that action is performed in compliance with the terms and conditions of this ITS.

2.8.1 Amount or Extent of Take

In the biological opinion, NMFS determined that incidental take is reasonably certain to occur as follows:

Harm of PS Chinook salmon and adult PS steelhead from exposure to:

- suspended sediments/contaminants;
- reduced prey availability;
- altered benthic habitat;
- noise from pile driving and pile removal; and
- propeller wash.

Harm of juvenile PS steelhead from exposure to:

- suspended sediments/contaminants;
- reduced prey availability; and
- altered benthic habitat.

The distribution and abundance of the fish that occur within an action area are affected by habitat quality, competition, predation, and the interaction of processes that influence genetic, population, and environmental characteristics. These biotic and environmental processes interact in ways that may be random or directional, and may operate across far broader temporal and spatial scales than are affected by the proposed action. Thus, the distribution and abundance of fish within the action area cannot be attributed entirely to habitat conditions, nor can the NMFS precisely predict the number of fishes that are reasonably certain to be injured or killed if their habitat is modified or degraded by the proposed action.

Therefore, the NMFS cannot predict with meaningful accuracy the number of juvenile PS Chinook salmon or PS steelhead that are reasonably certain to be injured or killed annually by the exposure to the stressors identified above. Additionally, the NMFS knows of no device or practicable technique that would yield reliable counts of individuals that may experience these impacts. In such circumstances, the NMFS uses a causal link established between the activity and the likely extent and duration of changes in habitat conditions as surrogates to describe the extent of take as a numerical level of habitat disturbance. The most appropriate surrogates for take are action related parameters that are directly related to the magnitude of the expected take.

In summary, the extent of PS Chinook salmon and PS steelhead take for this action is defined as:

- The extent of take in the form of harm from water quality reductions associated with suspended sediments during dredging and placement of material, including exposure to contaminated sediments during dredging, is a total of 159 days of dredging to occur over three consecutive work windows. Additional time dredging would likely expose more fish to this degraded habitat condition.

- The extent of take in the form of harm from reduce benthic prey is of 28.1 acres of benthic habitat modified by dredging. Dredging in a larger area would reduce prey across a larger footprint, displacing a larger number of fishes to other areas for sufficient forage.
- The extent of take in the form of harm from reduced bank conditions is 2,160 ft^2 material where would be placed for outfall bank protection. A larger area of rock material would reduce prey base and refugia conditions for a greater number of juvenile salmonids.
- The extent of take in the form of harassment from pile driving noise is the number of piles and size of piles to be installed. Here the maximum installation by vibratory driving of 12 steel pipe piles no larger than 36 inches in diameter and removal of exiting piles; Driving more piles or larger piles increases the duration or intensity of harassing noise conditions.
- The extent of take in the form of harm from degraded bank habitat caused by installing sheet piles is the 160 linear feet of installed sheet piles. A larger amount of sheet pile will further reduce habitat values that would otherwise support rearing and migrating juvenile salmonids.

2.8.2 Effect of the Take

In the biological opinion, NMFS determined that the amount or extent of anticipated take, coupled with other effects of the proposed action, is not likely to result in jeopardy to the species or destruction or adverse modification of critical habitat.

2.8.3 Reasonable and Prudent Measures

"Reasonable and prudent measures" are measures that are necessary or appropriate to minimize the impact of the amount or extent of incidental take (50 CFR 402.02).

The EPA shall require their contractor to:

1) Ensure the implementation of monitoring and reporting to confirm that the take exemption for the proposed action is not exceeded.

2) Minimize incidental take of PS Chinook salmon and PS steelhead from exposure to propeller wash.

2.8.4 Terms and Conditions

In order to be exempt from the prohibitions of section 9 of the ESA, the Federal action agency must comply (or must ensure that any applicant complies) with the following terms and conditions. The EPA or any applicant has a continuing duty to monitor the impacts of incidental take and must report the progress of the action and its impact on the species as specified in this ITS (50 CFR 402.14). If the entity to whom a term and condition is directed does not comply with the following terms and conditions, protective coverage for the proposed action would likely lapse.

1. To implement RPM number 1, Implement a monitoring and reporting system to confirm that the take exemption for the proposed action is not exceeded, the EPA shall develop

and implement a plan to collect and report details about the take of listed fish. That plan shall:

  a. Require the contractor to maintain and submit logs to verify:
     i. The dates and description(s) of the remedial activities;
     ii. The dates and GPS location(s) of the activities;
     iii. Turbidity monitoring and measures taken to maintain the turbidity plume within 150 feet of remedial activities; and
     iv. The daily and cumulative sediment removal and material placement totals
  b. Require the contractor to establish procedures for the submission of the activity logs and other materials to the EPA, and
  c. Require the EPA to submit an electronic annual construction update and post-construction report to NMFS within 8 months of project completion in each work window. Send the report to: projectreports.wcr@noaa.gov. Be sure to include Attn: WCRO-2023-01903 in the subject line.

2. To implement RPM Number 2, Minimize incidental take of PS. Chinook salmon and PS steelhead from exposure to project-related propeller wash, the EPA shall require the contractors to limit project-related vessel operations to within the October 1 and February 15 work window. If work must exceed that window, NMFS must be notified in advance in order to determine if re-initiation is required.

2.9. Conservation Recommendations

Section 7(a)(1) of the ESA directs Federal agencies to use their authorities to further the purposes of the ESA by carrying out conservation programs for the benefit of the threatened and endangered species. Specifically, "conservation recommendations" are suggestions regarding discretionary measures to minimize or avoid adverse effects of a proposed action on listed species or critical habitat or regarding the development of information (50 CFR 402.02).

1) The EPA should require their contracted vessels to use the lowest safe speeds and power settings when maneuvering in shallow waters close to the shore line to minimize propeller wash and mobilization of sediments.

2) Increase habitat complexity near the bulkhead by planting native vegetation such as willows and cottonwoods and adding habitat features such as large woody debris.

2.10. "Not Likely to Adversely Affect" Determinations

This assessment was prepared pursuant to section 7(a)(2) of the ESA, implementing regulations at 50 CFR 402 and agency guidance for preparation of letters of concurrence.

As described in Section 2 and below, the EPA's BA had concluded that the proposed action would not likely to adversely affect SR killer whale (*Orcinus orca*), Puget Sound/Georgia Basin yelloweye rockfish (*Sebastes ruberrimus*), Puget Sound/Georgia Basin bocaccio (*Sebastes paucispinis*), and sunflower sea star (*Pycnopodia helianthoides*). Project effects outside of the yellow boundary in Figure 5 is limited to prey availability for SR killer whales (i.e., PS Chinook salmon initial survival contributing to future prey availability). There will be no other significant physical or chemical effects in the marine environment; therefore, the NMFS has concluded that Puget Sound/Georgia Basin yelloweye rockfish, Puget Sound/Georgia Basin bocaccio, and sunflower sea star or their critical habitat would not be affected by the action There will be no further discussion on these species. The NMFS has concluded that the proposed action would be not likely to adversely affect SR killer whales and their designated critical habitat. Detailed information about the biology, habitat, and conservation status and trends of SR killer whales can be found in the listing regulations and critical habitat designations published in the Federal Register, as well as in the recovery plans and other sources at: https://www.fisheries.noaa.gov/species-directory/threatened-endangered/fish/, and are incorporated here by reference.

The applicable standard to find that a proposed action is not likely to adversely affect listed species or critical habitat is that all of the effects of the action are expected to be discountable, insignificant, or completely beneficial. Beneficial effects are contemporaneous positive effects without any adverse effects to the species or critical habitat. Insignificant effects relate to the size of the impact and should never reach the scale where take occurs. Discountable effects are those extremely unlikely to occur. The effects analysis in this section relies heavily on the descriptions of the proposed action and project site conditions discussed in Sections 1.3 and 2.4, and on the effects analysis presented in Section 2.5.

Effects on Critical Habitat

This assessment considers the intensity of expected effects in terms of the change that would cause in affected PBFs from their baseline conditions, and the severity of each effect, considered in terms of the time required to recover from the effect. Ephemeral effects are those that are likely to last for hours or days, short-term effects would likely last for weeks, and long-term effects are likely to last for months, years or decades.

Designated critical habitat for SR killer whales includes marine waters of the Puget Sound that are at least 20 feet deep. The expected effects on SR killer whale critical habitat from completion of the proposed action, including full application of the conservation measures and BMPs, would be limited to the impacts on the PBFs as described below:

Water quality to support growth and development
The proposed dredging would cause no detectable effects on marine water quality. These effects are discountable.

Prey species of sufficient quantity, quality, and availability to support individual growth reproduction and development, as well as overall population growth
The proposed action would cause long-term unmeasurable effects on prey availability and quality. Action-related impacts would annually injure extremely low numbers of individual juvenile Chinook salmon (primary prey), including exposing some individuals to contaminated prey. However, their numbers and levels of contamination would be too small to cause detectable effects on prey availability, or to create any detectable trophic link between the sediment contaminants and SR killer whales. Therefore, it would cause no detectable reduction in prey

availability and quality. Furthermore, the purpose of the proposed project is to removed contaminants from the LWD; therefore, after the initial disturbance stabilizes the quantity and quality of prey fish entering marine waters would be improved. We consider these effects at a low enough level that the effects are insignificant.

Passage conditions to allow for migrating, resting, and foraging
No actions occurring in marine waters where SR killer whales occur will impair passage conditions.

Therefore, the proposed action's effects on this feature is discountable.

For the reasons expressed immediately above, all effects on SR killer whale critical habitat are discountable or insignificant and the NMFS concurs with the EPA's determination that the proposed action is not likely to adversely affect ESA-listed SR killer whale designated critical habitat.

Effects on Listed Species

SR killer whales are limited to marine water habitats, and would not be directly exposed to any project-related effects. However, there is a small chance that they are exposed to indirect effects through the trophic web. As described in Section 2.2 the PS Chinook salmon population that would be affected by the proposed action is extremely small. As described in Section 2.5, the proposed action would annually affect too few individuals to cause detectable population-level affects. Furthermore, the likelihood that any individual juvenile Chinook salmon survives its ocean phase to become prey of SR killer whale is very low (Gamble et al. 2018). Therefore, any project-related reduction in Chinook salmon availability for SR killer whales would be undetectable. Similarly, although some juvenile Chinook salmon would be exposed to contaminated prey at the project site, their individual levels of contamination as well as the total numbers of annually exposed individuals would be too low to cause any detectable trophic link between the sediment contaminants and SR killer whales.

Moreover, the overall purpose of proposed project is to the remove contaminated sediments, reducing the risk of juvenile chinook exposure to contamination and subsequently potentially improving the quantity and quality of a SR killer whale food resource.

Because the short-term effects are not appreciable at the scale of an individual whale, we consider the effects insignificant. The long-term effect is also difficult to measure but is intended to reduce the potential exposure to contaminants and would considered beneficial. Accordingly, the action is not likely to adversely affect SR killer whales.

2.11. Reinitiation of Consultation

This concludes section 7 consultation for Upper Reach of the Lower Duwamish Waterway Superfund Site Remedial Action.

Under 50 CFR 402.16(a): "Reinitiation of consultation is required and shall be requested by the Federal agency or by the Service where discretionary Federal agency involvement or control over the action has been retained or is authorized by law and: (1) If the amount or extent of taking specified in the incidental take statement is exceeded; (2) If new information reveals effects of the agency action that may affect listed species or critical habitat in a manner or to an extent not previously considered; (3) If the identified action is subsequently modified in a manner that causes an effect to the listed species or critical habitat that was not considered in the biological opinion or written concurrence; or (4) If a new species is listed or critical habitat designated that may be affected by the identified action."

3. MAGNUSON–STEVENS FISHERY CONSERVATION AND MANAGEMENT ACT ESSENTIAL FISH HABITAT RESPONSE

Section 305(b) of the MSA directs Federal agencies to consult with NMFS on all actions or proposed actions that may adversely affect EFH. Under the MSA, this consultation is intended to promote the conservation of EFH as necessary to support sustainable fisheries and the managed species' contribution to a healthy ecosystem. For the purposes of the MSA, EFH means "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity", and includes the physical, biological, and chemical properties that are used by fish (50 CFR 600.10). Adverse effect means any impact that reduces quality or quantity of EFH, and may include direct or indirect physical, chemical, or biological alteration of the waters or substrate and loss of (or injury to) benthic organisms, prey species and their habitat, and other ecosystem components, if such modifications reduce the quality or quantity of EFH. Adverse effects on EFH may result from actions occurring within EFH or outside of it and may include site-specific or EFH-wide impacts, including individual, cumulative, or synergistic consequences of actions (50 CFR 600.810). Section 305(b) of the MSA also requires NMFS to recommend measures that can be taken by the action agency to conserve EFH. Such recommendations may include measures to avoid, minimize, mitigate, or otherwise offset the adverse effects of the action on EFH [CFR 600.905(b)].

This analysis is based, in part, on the EFH assessment provided by the EPA and descriptions of EFH for Pacific Coast groundfish (Pacific Fishery Management Council (PFMC 2023) and Pacific Coast salmon (PFMC 2022) contained in the fishery management plans developed by the PFMC and approved by the Secretary of Commerce.

3.1. Essential Fish Habitat Affected by the Project

The entire action area fully overlaps with identified EFH for Pacific Coast Salmon and Pacific Coast Groundfish. The project location is within the Green-Duwamish estuary, where aquatic conditions consist of marine waters from Elliot Bay transitioning with freshwater from the Duwamish River. Groundfish EFH extends to where the salinity drops below 0.5 parts per thousand during the period of average annual low flow within the Green River. The WDFW and Wildlife Priority Habitats and Species map indicate usage of the LDW by priority species with the vicinity of the project location, including Chinook (*Oncorhynchus tshawytscha*), sockey (*O. nerka*), and chum (*O. keta*) salmon, steelhead (*O. mykiss*) and residential coastal cutthroat (*O. clarki*), as well as bull trout (*Salvelinus malma*) (WDFW 2018).

3.2. Adverse Effects on Essential Fish Habitat

The ESA portion of this document (Sections 1 and 2) describes the proposed action and its adverse effects on ESA-listed species and critical habitat, and is relevant to the effects on EFH. Based on the analysis of effects presented in Section 2.5 the proposed action would cause long-term minor adverse effects on EFH for Pacific Coast Salmon and Pacific Coast Groundfish as summarized below:

1) Water Quality: – The proposed action would cause long-term minor adverse effects on water quality. The action would cause no meaningful changes in water temperature, and no changes in salinity, but dredging, material placement and pile installation/removal would increase suspended solids and may slightly reduce DO, it may also resuspend contaminants. Detectable effects would be limited to the area within about 300 feet of dredging and vessel operations and would persist over 264 days spread over three consecutive work windows. However, the overall purpose of the proposed project is to remove and/or isolate sediment contamination in the action area and would provide long-term benefits to prey species, as we as to salmonid species.
2) Water quantity, depth, and velocity: – The proposed action would cause a long-term minor increase in the water depth within the project footprint. No change in water quantity or velocity are expected.
3) Riparian-stream-marine energy exchanges: – No changes are expected.
4) Channel gradient and stability: – No changes are expected.
5) Prey availability: – The proposed action would cause long term minor adverse effects on prey availability. In-water excavation and installation of sand and gravel would slightly reduce prey availability for 1 to 2 years (and 3 years for complex diversity) following disturbances by removing and/or covering benthic communities. Again, the overall purpose of conducting the removal of sediment contamination in the action area is to reduce exposure to existing contaminants and provide long-term benefits to prey species.
6) Cover and habitat complexity: – The proposed action would cause long-term minor adverse effects on this attribute. Dredging would reduce benthic communities for 1 to 2 years (and 3 years for complex diversity) following the end of disturbance.
7) Water quantity: – No changes are expected.
8) Space: – No changes are expected.
9) Habitat connectivity from headwaters to the ocean: – No changes are expected.
10) Groundwater-stream interactions: – No changes are expected.
11) Connectivity with terrestrial ecosystems: – The proposed action would remove some shoreline vegetation. In most cases this would be invasive species and any cut vegetation would be replaced with native species.

3.3. Essential Fish Habitat Conservation Recommendations

NMFS determined that the following conservation recommendations are necessary to avoid, minimize, mitigate, or otherwise offset the impact of the proposed action on EFH.

1) Compliance of water quality standards by conducting water quality monitoring during remediation activities. At the point of compliance, turbidity shall not exceed 5 NTUs more than background turbidity when the background turbidity is 50 NTUs or less, or these shall

not be more than a 10 percent increase in turbidity when the background turbidity is more than 50 NTUs.

2) Dredging should be carried out in a manner that minimizes spillage of excess sediments from the bucket. This includes, but is not limited to:
   - Using effective materials or filter fabric on the barge to avoid contaminated sediments and water from being deposited back into the river.
   - Avoiding the practice of washing contaminated material off the barge and back into the water. This can be accomplished by the use of filter fabric.
   - Using Filter fabric or some other device to minimize spillage of material into the water during the unloading of the barge to the upland facility.
3) Contractor should have the most current, accurate Global Positioning System dredge positioning to control the horizontal and vertical extend of the dredge. A horizontal and vertical control plan would be prepared, submitted to the contractor, and adhered to by the dredge contractor to ensure dredging does not occur outside the limits of the dredge prism.
4) Ensure that an emergency cleanup plan is in the place in the event a vehicle has an incident where contaminated material is spilled. This plan would be on-board the vehicle at all times.
   - The use of the lowest safe speeds and power settings when maneuvering vessels in shallow waters close to the shoreline.

Fully implementing these EFH conservation recommendations would protect, by avoiding or minimizing the adverse effects described in Section 3.2, above, for Pacific Coast salmon and Pacific Coast groundfish.

3.4. Statutory Response Requirement

As required by section 305(b)(4)(B) of the MSA, EPA must provide a detailed response in writing to NMFS within 30 days after receiving an EFH Conservation Recommendation. Such a response must be provided at least 10 days prior to final approval of the action if the response is inconsistent with any of NMFS' EFH Conservation Recommendations unless NMFS and the Federal agency have agreed to use alternative time frames for the Federal agency response. The response must include a description of the measures proposed by the agency for avoiding, minimizing, mitigating, or otherwise offsetting the impact of the activity on EFH. In the case of a response that is inconsistent with the Conservation Recommendations, the Federal agency must explain its reasons for not following the recommendations, including the scientific justification for any disagreements with NMFS over the anticipated effects of the action and the measures needed to avoid, minimize, mitigate, or offset such effects [50 CFR 600.920(k)(1)].

In response to increased oversight of overall EFH program effectiveness by the Office of Management and Budget, NMFS established a quarterly reporting requirement to determine how many conservation recommendations are provided as part of each EFH consultation and how many are adopted by the action agency. Therefore, we ask that in your statutory reply to the EFH portion of this consultation, you clearly identify the number of conservation recommendations accepted.

3.5. Supplemental Consultation

The EPA must reinitiate EFH consultation with NMFS if the proposed action is substantially revised in a way that may adversely affect EFH, or if new information becomes available that affects the basis for NMFS' EFH Conservation Recommendations [50 CFR 600.920(l)].

4. DATA QUALITY ACT DOCUMENTATION AND PRE-DISSEMINATION REVIEW

The Data Quality Act (DQA) specifies three components contributing to the quality of a document. They are utility, integrity, and objectivity. This section of the opinion addresses these DQA components, documents compliance with the DQA, and certifies that this opinion has undergone pre-dissemination review.

4.1 Utility

Utility principally refers to ensuring that the information contained in this consultation is helpful, serviceable, and beneficial to the intended users. The intended users of this opinion are EPA. Other interested users could include Lower Duwamish Waterway Group, and Washington State Department of Ecology. Individual copies of this opinion were provided to the EPA. The document will be available at the NOAA Library Institutional Repository [https://repository.library.noaa.gov/welcome]. The format and naming adhere to conventional standards for style.

4.2 Integrity

This consultation was completed on a computer system managed by NMFS in accordance with relevant information technology security policies and standards set out in Appendix III, 'Security of Automated Information Resources,' Office of Management and Budget Circular A-130; the Computer Security Act; and the Government Information Security Reform Act.

4.3 Objectivity

Information Product Category: Natural Resource Plan

Standards: This consultation and supporting documents are clear, concise, complete, and unbiased; and were developed using commonly accepted scientific research methods. They adhere to published standards including the NMFS ESA Consultation Handbook, ESA regulations, 50 CFR 402.01 et seq., and the MSA implementing regulations regarding EFH, 50 CFR part 600.

Best Available Information: This consultation and supporting documents use the best available information, as referenced in the References section. The analyses in this opinion and EFH consultation contain more background on information sources and quality.

Referencing: All supporting materials, information, data and analyses are properly referenced, consistent with standard scientific referencing style.

Review Process: This consultation was drafted by NMFS staff with training in ESA and MSA implementation, and reviewed in accordance with West Coast Region ESA quality control and assurance processes.

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