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-2020-00049

January 13, 2021

Daniel Mathis, P.E.
Division Administrator
U.S. Department of Transportation
Federal Highway Administration
Suite 501 Evergreen Plaza
711 South Capitol Way
Olympia, Washington 98501-1284

Re: Endangered Species Act Section 7(a)(2) Biological Opinion, and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Response for the I-5 Northbound Marine View Drive to SR 529 Corridor and Interchange Improvements Project, Snohomish County, Washington (Quilceda Creek-Frontal Possession Sound 6th Field HUC 171100110203).

Dear Mr. Mathis:

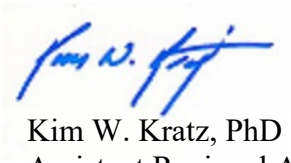
Thank you for your letter of January 3, 2020, requesting initiation of consultation with NOAA's National Marine Fisheries Service (NMFS) pursuant to Section 7 of the Endangered Species Act of 1973 (ESA) (16 U.S.C. 1531 et seq.) for the proposed Federal Highway Administration's (FHWA) design approval for the Washington State Department of Transportation (WSDOT) to construct the I-5/Northbound Marine View Drive to State Route 529 Corridor and Interchange Improvements Project. The project involves constructing a new on-ramp from State Route (SR) 529 to southbound (SB) Interstate 5 (I-5), a new off-ramp from northbound (NB) I-5 to SR 529, and adding a permanent fourth lane, designated for high-occupancy vehicles, on NB I-5 from Marine View Drive in Everett to SR 529 in Marysville, Washington. In this opinion, NMFS concludes that the proposed action is not likely to jeopardize the continued existence of Puget Sound (PS) Chinook (*Oncorhynchus tshawytscha*) or PS steelhead (*O. mykiss*) or result in the destruction or adverse modification of PS Chinook critical habitat. This document also serves to document our concurrence that the proposed action is not likely to adversely affect Georgia Basin (GB) yelloweye (*Sebastes ruberrimus*) rockfish or GB bocaccio (*S. paucispinis*) rockfish. This consultation was conducted in accordance with the 2019 revised regulations that implement Section 7 of the ESA (50 CFR 402, 84 FR 45016).

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

Thank you, also, for your request for consultation pursuant to the essential fish habitat (EFH) provisions in Section 305(b) of the Magnuson-Stevens Fishery Conservation and Management Act (MSA) (16 U.S.C. 1855(b)) for this action. 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 groundfish and Pacific Coast salmon. Therefore, we have included the results of that review in Section 3 of this document.

Please contact DeeDee Jones, deean.jones@noaa.gov, 360-905-2185, if you have any questions concerning this consultation, or if you require additional information.

Sincerely,



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

cc: Angel D. Rivera, FHWA
Susan Buis, USACE
Cameron Kukes, WSDOT
Ruth Park, WSDOT
Cathy George, WSDOT
Katina Kapantais, WSDOT
Tara Stone, WSDOT

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

I-5/NB Marine View Drive to SR 529 Corridor and Interchange Improvements Project, Snohomish County, Washington (171100110203 Snohomish River-Frontal Possession Sound)

NMFS Consultation Number: WCRO-2020-00049

Action Agency: Federal Highway Administration

Affected Species and NMFS' Determinations:

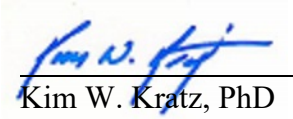
ESA-Listed Species	Status	Is Action Likely to Adversely Affect Species?	Is Action Likely to Jeopardize the Species?	Is Action Likely to Adversely Affect Critical Habitat?	Is Action Likely to Destroy or Adversely Modify Critical Habitat?
Puget Sound ESU[a] Chinook salmon (*Oncorhynchus tshawytscha*)	Threatened	Yes	No	Yes	No
Puget Sound DPS[a] steelhead (*O. mykiss*)	Threatened	Yes	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

[a] ESU = evolutionarily significant unit; DPS = distinct population segment

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
Coastal Pelagic Species	Yes	Yes

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

Issued By:



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

Date: January 13, 2021

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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.), and implementing regulations at 50 CFR 402, as amended.

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 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 within 2 weeks at the NOAA Library Institutional Repository: <https://repository.library.noaa.gov/welcome>. A complete record of this consultation is on file at the NMFS Oregon and Washington Coastal Office.

1.2 Consultation History

Washington State Department of Transportation (WSDOT) and Federal Highway Administration (FHWA) staff met with representatives from NMFS to discuss the project on July 25, 2019. In this meeting, the project description and project effects on listed species and their designated critical habitat, including stormwater effects and in-water work, were discussed. Comments from NMFS were incorporated into the biological assessment (BA). In addition, WSDOT consulted on the proposed mitigation site on September 6, 2018, and received concurrence from NMFS (WCR-2018-10648) on September 21, 2018. On January 3, 2020, WSDOT submitted a BA to NMFS for the I-5/NB Marine View Drive to SR 529 Corridor and Interchange Improvements Project (project) and requested consultations under both ESA and MSA. NMFS received additional project information from WSDOT via email exchanges between March 5, 2020, and April 16, 2020. Upon receiving the additional information, NMFS initiated consultations on April 16, 2020. The basis for NMFS's concurrence with "not likely" determinations are presented in Section 2.12 of this document.

1.3 Proposed Federal Action

"Action" means all activities or programs of any kind authorized, funded, or carried out, in whole or in part, by federal agencies (50 CFR 402.02). 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 FHWA is proposing to approve the WSDOT design to construct a new on-ramp from SR 529 to SB I-5, construct a new off-ramp from NB I-5 to SR 529, and add a permanent fourth lane, designated for high-occupancy vehicles, on NB I-5 from Marine View Drive in Everett to SR 529 in Marysville, Washington (Figure 1). Project elements are described in detail below.

The primary purpose of this project is to improve transportation through the interchange and alleviate the recurring daily congestion and delay at the existing I-5/SR 528 interchange. Proposed improvements to the I-5/SR 529 interchange are expected to increase capacity and safety along the I-5/SR 528 interchange, the SR 528/BNSF at-grade crossing, and the I-5 mainline through the addition of the two missing ramps at the existing I-5/SR 529 half-interchange. Interchange components include a new SB on-ramp that will be approximately 2,400 feet long and between 26 and 34 feet wide; and a new NB off-ramp that will be approximately 1,370 feet long and 24 feet wide.

1.3.1 General Construction Activities

Project construction elements will include staging and site preparation; clearing and grubbing within the project footprint; installation of subgrade ground improvement structures; construction of retaining walls and reinforced slope and fill material; roadway paving; installation of guardrails, barriers, illumination, intelligent transportation system devices, and signs; bridge widening; construction of stormwater conveyance and treatment facilities; and restoration of temporarily impacted areas.

Land-based staging areas will be used for delivery and storage of construction materials and equipment, contractor office and storage trailers, and employee parking. These areas will be fenced and located adjacent to areas where project construction is occurring. Construction staging areas will vary in size and may require grading or excavation to level the site. No unique impacts are anticipated from construction staging. Once construction is complete, all staging areas and remaining exposed soils will be stabilized, landscaped, and restored. Planting and restoration efforts will follow permit conditions, restoration plans, and any temporary construction easement requirements established for the project. The Steamboat Slough Mitigation Site provides mitigation for the proposed improvements to the I-5/SR 529 interchange and was reviewed in a separate consultation with the Services (WSDOT 2018; NMFS consultation WCR-2018-10648).

Site preparation includes installing Temporary Erosion and Sediment Control (TESC) features, mobilizing equipment, and clearing and grubbing. All clearing and grubbing limits will be contained within the WSDOT right-of-way (ROW). Erosion and sediment control Best Management Practices (BMPs) will be implemented to minimize erosion potential and contain eroded soil and sediments before that material enters a receiving water body, consistent with National Pollutant Discharge Elimination System requirements.

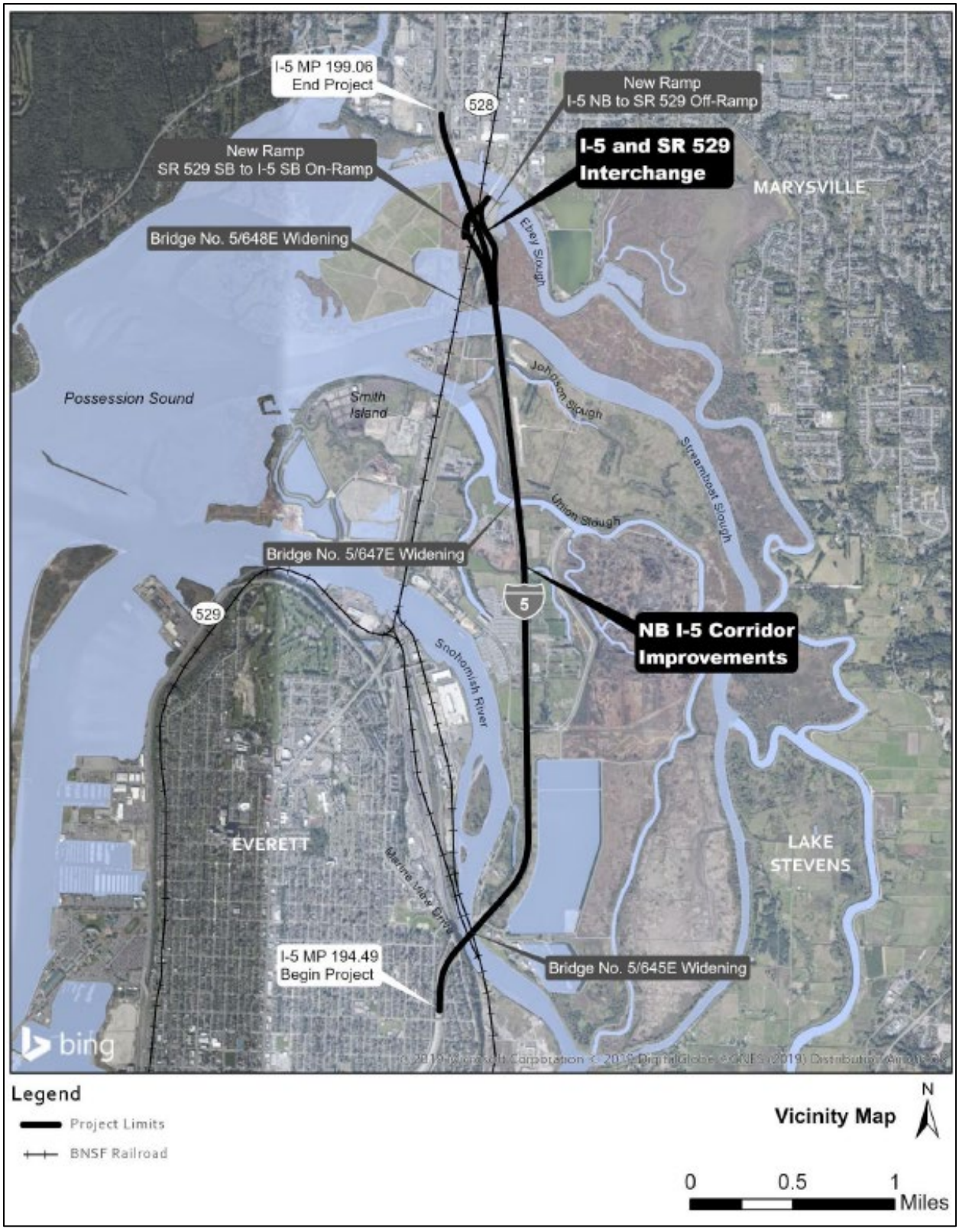

Figure 1. Project Vicinity.

1.3.2 State Route 529 Interchange Improvements

Construction of the NB and SB ramps will require approximately 8,390 cubic yards of soil excavation and approximately 84,000 cubic yards of backfill. Some of the fill areas are within the designated floodplain but not within the designated floodway of the Snohomish River, Steamboat Slough, and Union Slough. The fill will be from approved sources and may include reuse of soils from onsite excavations. The NB off-ramp design includes a concrete box tunnel to convey the shared-use path within the embankment of the new ramp. Both ramps will be built on a 1.25:1 horizontal to vertical (or steeper) reinforced slope embankment.

Due to existing soil conditions, subgrade ground improvements will be required to provide stability for the bridge structures. The ground improvements will occur within a 60-foot radius of the bridge embankments. The type of subgrade ground improvements could include stone columns, jet grouting, driven untreated timber piles, or deep soil mixing. In addition to the ground improvements, the construction of the SB ramp will use driven piles or drilled shafts installed in the ground to support the bridges. Approximately 15 to 40 steel piles or drilled shafts with concrete pile caps will support the bridge columns and abutments. Due to the soil conditions at the site, the piles and shafts will need to be installed to a depth of 200 feet. All pile driving and/or shaft/drilling will occur in upland areas and will not result in in-water noise production.

There are several wetlands in the project area. The construction of the NB and SB ramps will permanently impact 0.8 acre of Wetland D, 1.1 acres of Wetland E, and 395 linear feet of the tidal channel in Wetland D. BMPs will be used to prevent runoff and sedimentation from the site from entering Wetland E during tidal inundation. These BMPs will include temporary sheet piles to separate the work area from the wetland. Sheet piles will be installed along a 5-foot off-set within the tidally influenced Wetland E to keep the construction area watertight and to limit the area of ground disturbance.

The new road surfaces for the NB and SB ramps and bridge widening will be primarily asphalt and concrete and will create 2.59 acres of new pollution-generating impervious surface (PGIS). Stormwater along the new NB I-5 on-ramp will flow through a ditch and a compost amended biofiltration swale (CABS) prior to discharging into the Steamboat Slough Mitigation Site to meet the applicable runoff treatment requirements for the entire project and mitigate for the increased pollution-generating impervious surfaces PGIS.

1.3.3 Culvert Relocation Under Existing SB SR 529

The existing culvert that conveys the tidal channel under SB SR 529 will be filled to construct the new southbound ramp. The existing tidal channel in Wetland D flows through a 24-inch culvert under SB SR 529 that connects the wetland to the tidal channels to the west and south. The culvert will be replaced with a new 24-inch culvert approximately 100 feet south of the current culvert location. According to the Washington Department of Fish and Wildlife (WDFW), the existing culvert is assessed as a fish passage barrier, with passability unknown (WDFW ID 934372; WDFW 2020a). The new culvert will be designed with a tide gate to prevent fish from entering and being trapped in Wetland D between the road embankments of SB SR 529 and the existing SB I-5 off ramp, per guidance from WDFW and the Tulalip Tribes (WSDOT 2019).

Prior to any work related to the culvert replacement, the approximately 200-square-foot work area will be isolated to prevent sediment and turbidity effects downstream in the tidal channels. A cofferdam will be installed around the downstream end of the existing culvert under SB SR 529 at low tide when the tidal channel in Wetland D is dry or nearly dry. Per WSDOT Fish Exclusion Protocols and Standards (WSDOT 2016), a qualified fish biologist will inspect the channel for any fish remaining in residual water after the tide has receded prior to blocking the culvert. Once the work area is isolated by the cofferdam, the area will be dewatered and seepage water will be pumped from a sump on the worksite to a settling facility such as a Baker tank or swale to prevent turbid water from being discharged into the tidal channels.

The work area for the new culvert will be similarly isolated to minimize downstream turbidity following the same protocol described above. The likely construction method will be an open cut to achieve the appropriate grade.

1.3.4 Northbound Interstate 5 Fourth Lane

The project will create a permanent fourth lane on NB I-5, designated for high occupancy vehicles (HOVs) to address recurring NB I-5 mainline congestion. The current paved section on NB I-5 is approximately 56 feet wide and consists of a 10-foot inside shoulder, three 12-foot general purpose (GP) lanes, and an outside 10-foot shoulder. The project will restripe the lanes such that the configuration will consist of a 2-foot inside shoulder, one 11-foot HOV lane, three 11-foot GP lanes, and a 10-foot outside shoulder, which will maintain the existing paved width of 56 feet (Figure 2).

Adding the fourth lane will require reconstructing and/or repaving the existing left shoulder and portions of the right shoulder on NB I-5 between Everett (mile post [MP] 194.49) and Marysville (MP 199.06) to ensure that there is enough pavement thickness to accommodate traffic. No work will occur beyond the existing I-5 road prism. NB I5 will also be resurfaced as part of this project.

Creation of the permanent fourth lane on I-5 will increase the overwater footprint and PGIS of the bridges over the Snohomish River, Union Slough, and Steamboat Slough by 340 square feet, 180 square feet, and 790 square feet, respectively, for a total increase of 1,310 square feet. All three bridges have a curb-to-curb roadway width of 48 feet. Work will involve replacing the existing barriers and a portion of the bridge that overhangs the existing girder per current WSDOT standards.

No in-water work will occur as part of the bridge widening over these water bodies. Containment measures will be installed during construction to capture demolition debris and wastewater. No barge will be used for containment measures on the project.

The new permanent fourth lane will decrease the shoulder widths on the bridge decks, necessitating decreased spacing between storm drainage catch basins on each bridge. The additional catch basins will not change the overall flow patterns but will prevent ponding in the new travel lane. The bridge drains will convey stormwater into new 12-inch-diameter storm sewer pipes mounted below the bridge deck and direct flow to one or both ends of the bridge to existing vegetated filtration swales, CABS, or the Steamboat Slough Mitigation Site. Stormwater runoff from the new NB I-5 on-ramp will flow through a ditch and a CABS prior to discharging to the Steamboat Slough Mitigation Site. These BMPs will prevent most of the direct discharge

of stormwater from additional PGIS into water bodies. Two existing stormwater outfalls that discharge directly into the Steamboat Slough will remain.

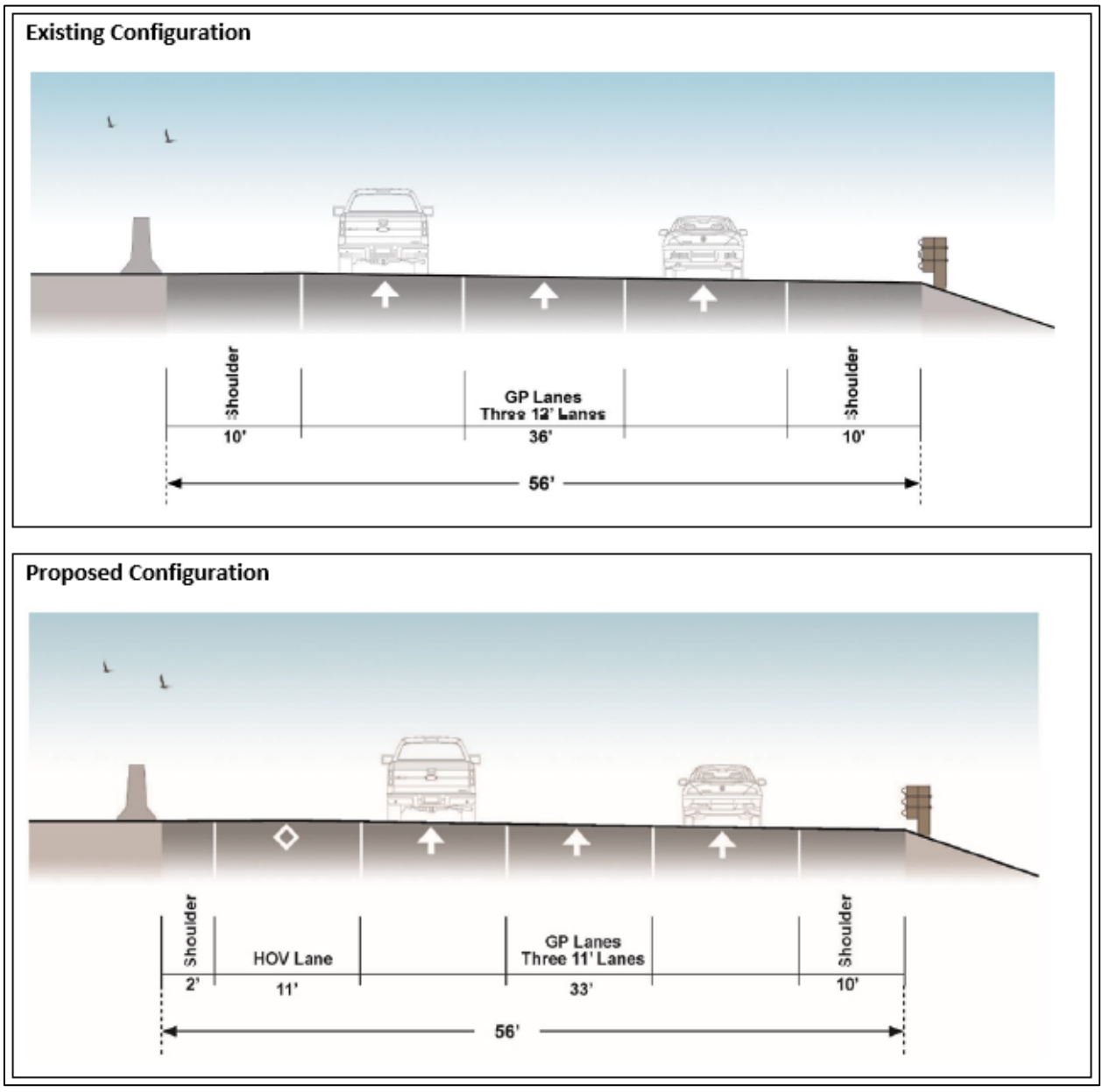

Figure 2. Existing and Proposed NB I-5 Lane Configuration.

1.3.5 Stormwater Management

Much of the stormwater runoff from the NB and SB I-5 and NB SR 529 road surface currently discharges east of I-5 into Ebey Slough, located north of Steamboat Slough and south of SR 528, through a combination of closed storm sewer conveyance and sheet flow dispersion. Runoff from southbound SR 529 and the existing SB I-5 off-ramp to SR 529 flows west of I-5 and disperses into portions of Steamboat Slough. Two existing bioswales within the interchange area that treat runoff from 1.05 acres of PGIS within TDAs 2 and 3 will be removed and replaced with new treatment facilities (Table 1). The existing vegetated filter strip within TDA J that treats 0.110 acre of PGIS will remain (Table 1), but it does not capture flows from within the project limits.

Table 1. Combined Summary of Existing and Proposed Pollution Generating Impervious Surfaces and Stormwater Runoff Treatment Facilities.

Basin	Receiving Water Body	TDA	Existing PGIS in TDA (acres)	Type of Facility	Existing Treatment (acres)	Proposed New PGIS in TDA (acres)	Type of Facility	Proposed Treated PGIS Post Project (acres)
Snohomish River	Snohomish River	A	3.412	NA	NA	0.008	NA	NA
		B	5.035	NA	NA	0	NA	NA
		C	1.504	NA	NA	0	NA	NA
		D	4.887	NA	NA	0	NA	NA
		E	4.901	NA	NA	0	NA	NA
	Union Slough	F	3.395	NA	NA	0	NA	NA
		G	3.166	NA	NA	0	NA	NA
		H	3.100	NA	NA	0.002	NA	NA
		I	0.666	NA	NA	0.002	NA	NA
	Steamboat Slough	J	3.942	VFS	0.110	0	NA	NA
		1	3.028	NA	NA	0.570	CABS	0.570
		2	3.901	BS	0.250	0.758	CABS	2.090
	Ebey Slough	3	6.275	BS	0.800	1.580	CABS	4.240
		4	0	NA	NA	0	NA	NA
Total			**47.212**	–	**1.160**	**2.920**	–	**6.900**

BS = biofiltration swale; CABS = compost amended biofiltration swale; NA = not applicable;
PGIS = pollution generating impervious surface; TDA = threshold discharge area; VFS = vegetated filter strip

New drainage conveyance systems will be added on the proposed I-5 NB and SB interchange ramps, the existing I-5 SB off-ramp, and along the reconstructed portion of SB SR 529. The new conveyance systems will route stormwater runoff from the new PGIS to runoff treatment facilities and retrofit existing PGIS with new treatment facilities. Stormwater runoff from 4.31 acres of existing PGIS and 2.59 acres of new PGIS will be treated with four CABS and one vegetated filter strip (Table 1). Two CABS will be located adjacent to the I-5 NB interchange

ramps (TDA 3) and SR 529 NB roadway (TDA 2) to address water quality effects of roadway widening in areas that will drain to Wetlands E and G, and to treat portions of the existing I-5 PGIS runoff. The third CABS will treat runoff from the I-5 SB on-ramp roadway widening area (TDA 1) draining to Wetland D. The fourth CABS will treat runoff from the widened SB SR 529 and the existing I-5 SB off-ramp, which drains to Wetland D. The existing outfall of TDA 1A on the I-5 bridge over Steamboat Slough will be removed, and stormwater will be routed north and south beneath the bridge. The two existing outfalls in TDA 1B and 1C that discharge directly to Steamboat Slough will remain.

The project is not subject to stormwater flow-control requirements because stormwater runoff discharges to flow-control-exempted water bodies (Snohomish River, Steamboat Slough, and Ebey Slough) or tidally influenced wetlands that are connected to the flow-control-exempt water bodies. The contribution of stormwater to these water bodies is de minimis when compared to the receiving water body flow.

1.3.6 Wetland and Tidal Channel Mitigation

WSDOT proposes to compensate for the permanent loss of Category II estuarine wetlands based on the ratios for concurrent mitigation at the Steamboat Slough Mitigation Site. The Steamboat Slough Mitigation Site rehabilitated 5.62 acres of freshwater wetlands to their historical status as estuarine wetlands and re-established 5.70 acres of fill material to estuarine wetland. The mitigation also created approximately 3,500 linear feet of tidal channels within the estuarine wetlands, which function as high-quality, off-channel fish habitat. WSDOT received concurrence for the Steamboat Slough Mitigation Site from NMFS (WCR-2018-10648) on September 21, 2018, and completed construction of the mitigation site in 2019. Remaining impacts to wetlands will be mitigated at the Snohomish Basin Mitigation Bank.

1.3.7 Project Timing

Construction of the project will begin in January 2021 and will take approximately 24 months to complete. Most project activities are anticipated to occur during daylight hours; however, some night work will also occur at the interchange and along I-5. All in-water work will be conducted by the design-build contractor between July 15 and February 15.

1.3.8 Impact Avoidance and Minimization Measures

BMPs include erosion and sediment control, structural erosion control, sediment retention, and stormwater treatment during project construction and operation. These BMPs will be included in the TESC plan, the Spill Prevention, Control, and Countermeasures (SPCC) plan, the Stormwater Site Plan (SSP), the Hydraulic Project Approval (HPA), and the stormwater report for the project. The proposed project will further avoid and/or minimize effects to natural resources in the action area through the following:

- Clearing, land disturbance, and construction impacts will be confined to the minimum area necessary to complete the project.
- All in-water work (including work in tidally influenced wetlands) will be conducted during the agency-approved in-water work window for estuarine areas. The general in-

water work window for the marine/estuarine areas in the action area is July 1 through February 15.

- Temporary lights for night work will be directed away from waters with listed fish species to the greatest extent possible, with the intent to prevent light from shining on surface waters. Post-construction, standard WSDOT specifications call for street lighting to be hooded or shielded to focus light mainly on the roadway and reduce unnecessary spillover.
- Barges will not be used for bridge barrier replacement work. All over-water work will be conducted from the existing bridges.
- Temporary wetland impact areas will be revegetated with appropriate native species. These areas will be monitored for 3 years to determine if the desired vegetation type has been re-established and to adaptively manage the vegetation growth if/as needed to meet permit requirements.
- A Stormwater Pollution Prevention Plan will be developed, implemented, and maintained to minimize erosion of sediments due to rainfall runoff at construction sites and to reduce, eliminate, and prevent the pollution of stormwater.
- A TESC Plan with measures to address erosion control during and after construction (including directing runoff away from unstabilized ground, slowing runoff with structures and installing silt fences to catch particulates) will be developed and implemented. These measures will reduce the potential for sedimentation in tidal channels and drainages in the project vicinity.
- Preventive measures, such as watering or covering exposed soils during summer months to minimize the wind transport of soils, will be implemented.
- The construction area will be restored to original grades and drainage patterns to the greatest extent possible immediately following construction. To prevent erosion, ungraded or disturbed areas will be immediately mulched for protection from rainfall and wind. Areas will be revegetated as soon as possible after grading is completed.
- Exposed soils will be stabilized with a vegetative cover or other erosion-control treatment immediately following grading construction.
- A SPCC plan will be developed, implemented, and maintained to manage toxic materials associated with construction activities (e.g., equipment leakage, disposal of oily wastes, cleanup of any spills, and storage of petroleum products/chemicals in contained areas away from streams and wetlands).
- Temporarily disturbed areas will be restored to pre-construction conditions.
- Equipment will be checked daily for leaks and will be maintained to prevent lubricants and any other deleterious materials from entering wetlands or below the mean higher high water lines of estuarine waters. All equipment will be free of any external petroleum products, hydraulic fluid, and coolants.
- All equipment will be fueled and maintained in staging areas more than 200 feet from the nearest wetland, ditches, flowing or standing water, unless approved by a WSDOT Biologist. All project construction will be within WSDOT right-of-way and Wetland D between SR 529 and I-5, and along the western edge of Wetland E. Construction activities will avoid impacting Steamboat Slough, Ebey Slough, and Union Slough and downstream effects in tidal channels using BMPs and work area isolation as described above.

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, and 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 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 non-discretionary reasonable and prudent measures (RPMs) and terms and conditions to minimize such impacts.

The FHWA determined the proposed action is not likely to adversely affect PS GB yelloweye rockfish or PS GB bocaccio. Our concurrence is documented in the "Not Likely to Adversely Affect" Determinations section (Section 2.12).

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 relies on the 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 (species) use(s) the term primary constituent element (PCE) or essential features. The 2016 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 2019 regulations define effects of the action using the term "consequences" (50 CFR 402.02). As explained in the preamble to the regulations (84 FR 44977), that definition 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 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.

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' "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 function of the essential PBFs that help to 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. The largest hydrologic responses are expected to occur in basins with significant snow accumulation, where warming decreases snow pack, increases winter flows, and advances the timing of spring melt (Mote et al. 2014; Mote et al. 2016). Rain-dominated watersheds and those with significant contributions from groundwater may be less sensitive to predicted changes in climate (Tague et al. 2013; Mote et al. 2014).

During the last century, regional air temperatures in the Pacific Northwest increased by 1°F to 1.4°F as an annual average, and up to 2°F in some seasons (based on average linear increase per decade) (Kunkel et al. 2013; Abatzoglou et al. 2014). Warming is likely to continue during the next century as average temperatures are projected to increase another 3°F to 10°F, with the largest increases predicted to occur in the summer (Mote et al. 2014). Decreases in summer precipitation of as much as 30 percent by the end of the century are consistently predicted across

climate models (Mote et al. 2014). Precipitation is more likely to occur during October through March, less likely to occur during summer months, and more winter precipitation will be rain than snow (ISAB 2007; Mote et al. 2013; Mote et al. 2014). Earlier snowmelt will cause lower stream flows in late spring, summer, and fall; and water temperatures will be warmer (ISAB 2007; Mote et al. 2014). Models consistently predict increases in the frequency of severe winter precipitation events (i.e., 20-year and 50-year events) in the western United States (Dominguez et al. 2012). The largest increases in winter flood frequency and magnitude are predicted in mixed rain-snow watersheds (Mote et al. 2014).

Overall, about one-third of the current cold-water salmonid habitat in the Pacific Northwest is likely to exceed key water temperature thresholds by the end of this century (Mantua et al. 2009). Higher temperatures will reduce the quality of available salmonid habitat for most freshwater life stages (ISAB 2007). Reduced flows will make it more difficult for migrating fish to pass physical and thermal obstructions, limiting their access to available habitat (Mantua et al. 2010; Isaak et al. 2012). Temperature increases shift timing of key life cycle events for salmonids and species forming the base of their aquatic food webs (Winder and Schindler 2004; Crozier et al. 2011; Tillmann and Siemann 2011). Higher stream temperatures will also cause decreases in dissolved oxygen and may also cause earlier onset of stratification and reduced mixing between layers in lakes and reservoirs, which can also result in reduced oxygen (Myers et al. 1998; Winder and Schindler 2004; Raymondi et al. 2013). Higher temperatures are likely to cause several species to become more susceptible to parasites, disease, and higher predation rates (Crozier et al. 2008; Raymondi et al. 2013; Wainwright and Weitkamp 2013).

As more basins become rain-dominated and prone to more severe winter storms, higher winter stream flows may increase the risk that winter or spring floods in sensitive watersheds will damage spawning redds and wash away incubating eggs (Goode et al. 2013). Earlier peak stream flows will also alter migration timing for salmon smolts and may flush some young salmon and steelhead from rivers to estuaries before they are physically mature, increasing stress and reducing smolt survival (McMahon and Hartman 1989; Lawson et al. 2004).

In addition to changes in freshwater conditions, predicted changes for coastal waters in the Pacific Northwest as a result of climate change include increasing surface water temperature, increasing but highly variable acidity, and increasing storm frequency and magnitude (Mote et al. 2014). Elevated ocean temperatures already documented for the Pacific Northwest are highly likely to continue during the next century, with sea surface temperature projected to increase by 1.8°F to 6.7°F by the end of the century (IPCC 2014). Habitat loss, shifts in species' ranges and abundances, and altered marine food webs could have substantial consequences to anadromous, coastal, and marine species in the Pacific Northwest (Tillmann and Siemann 2011; Reeder et al. 2013). Moreover, as atmospheric carbon emissions increase, increasing levels of carbon are absorbed by the oceans, changing the pH of the water. Acidification also impacts sensitive estuary habitats, where organic matter and nutrient inputs further reduce pH and produce conditions more corrosive than those in offshore waters (Feely et al. 2012; Sunda and Cai 2012).

Global sea levels are expected to continue rising throughout this century, reaching likely predicted increases of 10 to 32 inches by 2081 through 2100 (IPCC 2014). These changes will likely result in increased erosion and more frequent and severe coastal flooding and shifts in the composition of nearshore habitats (Tillmann and Siemann 2011; Reeder et al. 2013). Estuarine-

dependent salmonids such as chum and Chinook salmon are predicted to be impacted by significant reductions in rearing habitat in some Pacific Northwest coastal areas (Glick et al. 2007).

Historically, warm periods in the coastal Pacific Ocean have coincided with relatively low abundances of salmon and steelhead, while cooler ocean periods have coincided with relatively high abundances, and therefore these species are predicted to fare poorly in warming ocean conditions (Scheuerell and Williams 2005; Zabel et al. 2006). This is supported by the recent observation that anomalously warm sea surface temperatures off the coast of Washington from 2013 to 2016 resulted in poor coho and Chinook salmon body condition for juveniles caught in those waters (NWFSC 2015). Changes to estuarine and coastal conditions, as well as the timing of seasonal shifts in these habitats, have the potential to impact a wide range of listed aquatic species (Tillmann and Siemann 2011; Reeder et al. 2013).

The adaptive ability of these threatened and endangered species is depressed due to reductions in population size, habitat quantity and diversity, and loss of behavioral and genetic variation. Without these natural sources of resilience, systematic changes in local and regional climatic conditions due to anthropogenic global climate change will likely reduce long-term viability and sustainability of populations in many of these ESUs (NWFSC 2015). New stressors generated by climate change, or existing stressors with effects that have been amplified by climate change, may also have synergistic impacts on species and ecosystems (Doney et al. 2012). These conditions will possibly intensify the climate change stressors inhibiting recovery of ESA-listed species in the future.

2.2.1 Status of the Species

Table 2 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. These documents are available on the NMFS West Coast Region website: <http://www.westcoast.fisheries.noaa.gov/>.

The Skykomish Chinook salmon spawn throughout the main stem and in some tributaries of the Skykomish and Snohomish Rivers. The Snoqualmie population spawns in the Snoqualmie River and its tributaries, including the Told and Raging Rivers and Tokul Creek. Over the last two 5-year geometric mean counts of spawners (2005 through 2009 and 2010 through 2014), the Skykomish Chinook population suffered a 29 percent decrease, while the Snoqualmie spawner population exhibited a 32 percent decrease (NWFSC 2015).

Steelhead spawning typically occurs in moderate-to-high stream gradient reaches (Hard et al. 2007). The wild (natural-origin) Snohomish/Skykomish and Snoqualmie populations spawn between early March to mid-June (R2 Resource Consultants 2008). Over the last two 5-year geometric mean counts of spawners (2005 through 2009 and 2010 through 2014), the Snohomish/Skykomish steelhead population decreased from 3,084 to 930 total spawners, and the Snoqualmie steelhead population decreased from 1,240 to 680 total spawners (NWFSC 2015). No raw total spawner counts were available for either population in the 2010 through 2014 geometric mean (NWFSC 2015).

Table 2. 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	This ESU comprises 22 populations distributed over five 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 River watershed. Escapement levels for all populations remain well below the technical review team (TRT) planning ranges 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	This DPS comprises 32 populations distributed over three geographic areas. Across the DPS, the trends in abundance showed an initial increase, followed by a long decline beginning in 2005. Steelhead productivity has been temporally variable for most populations since the mid-1980s, with some populations showing modest improvements since 2011. Several populations are still showing dismal productivity, especially among populations in the Central and South Puget Sound. Hatchery fish of both summer and winter runs have posed considerable risk to diversity in natural steelhead in the Puget Sound DPS.	• 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

2.2.2 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 value 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 is serving another important role.

A summary of the status of critical habitat, considered in this opinion, is provided in Table 3, below.

2.3 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). Increased stormwater discharge and temporary elevated sediment and turbidity from ground-disturbing activities in wetlands is expected to have the farthest-reaching effects in the aquatic environment (Figure 3). Effects from elevated sediment and turbidity could extend 300 feet from construction activities.

The distance at which dissolved metals will exceed biological thresholds is expected to be 238 feet from stormwater outfalls. However, pollutants will continue to disperse beyond that distance into Steamboat Slough and Puget Sound. Although the project includes measures to treat stormwater at TDAs where treatment is currently not occurring, no method of treatment other than full infiltration will remove all contaminants. Stormwater discharges will be a chronic source of episodic pollutants that will result in a slight increase of pollutant loading into Steamboat Slough and Puget Sound for the life of the roadway.

Table 3. Critical Habitat, Designation Date, Federal Register Citation, and Status Summary for Critical Habitat Considered in This Opinion**.**

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 miles of streams, 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 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 9285	Critical habitat encompasses 18 subbasins in Washington containing 66 occupied watersheds. Most HUC5 basins with PBFs for salmon are in fair-to-poor or fair-to-good condition (NOAA Fisheries 2005). However, most of these watersheds have some or high potential for improvement. We rated conservation value of HUC5 watersheds within the range of this DPS as high for 41 watersheds, medium for 16 watersheds, and low for 9 watersheds.

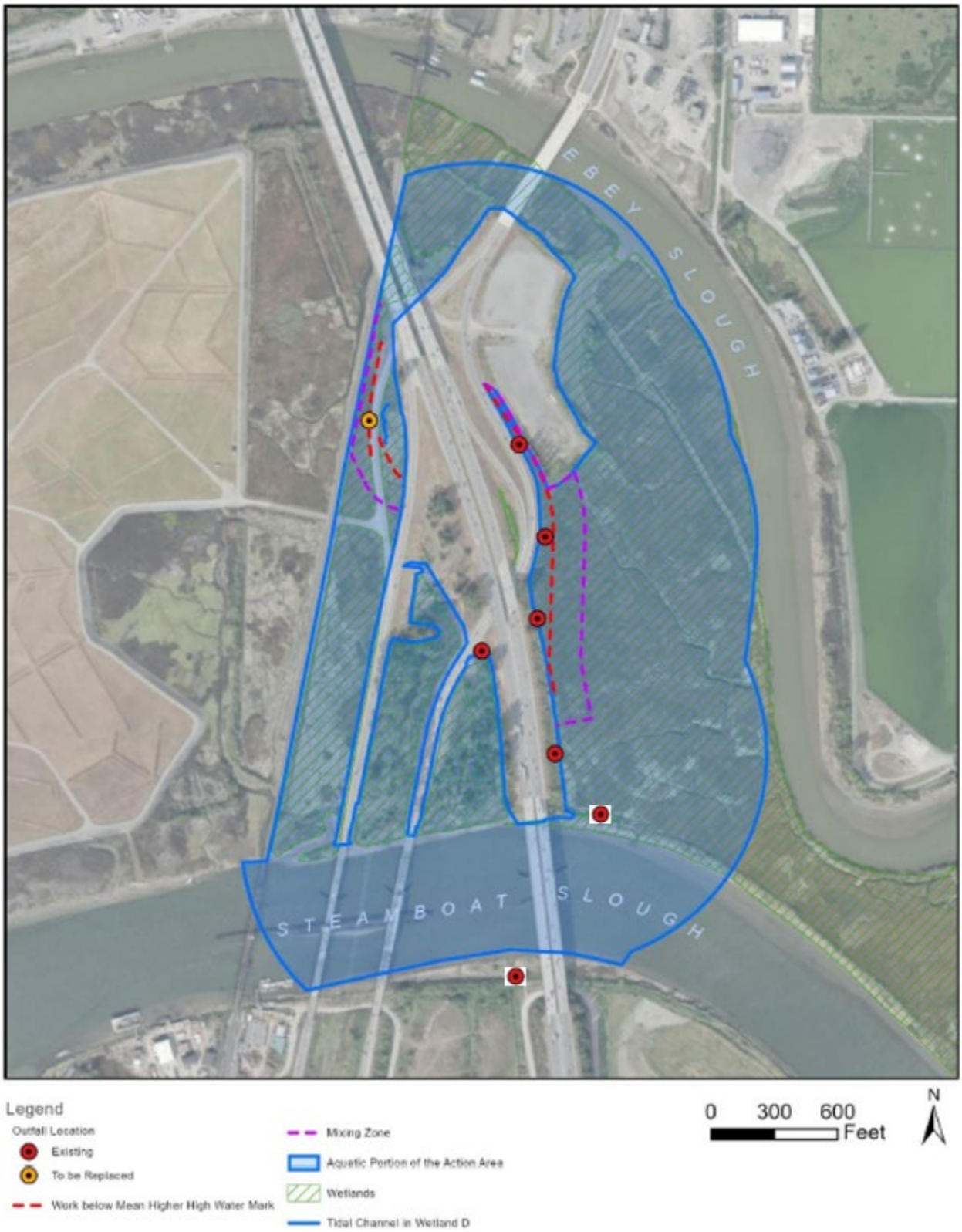

Figure 3. Aquatic Extent of the Action Area.

2.4 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 that 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 project site is located in the tidally influenced portion of the lower Snohomish River. The Snohomish River basin drains an area of approximately 1,780 square miles (Everett and Pentec 2001). The river basin contains about 2,718 miles in stream length, making it the second largest basin draining into Puget Sound. The Snohomish River flows into the Snohomish River Estuary near the City of Snohomish and finally enters the Puget Sound near Everett (Snohomish County 2017). The estuary is approximately 9 miles long and 3 to 4.5 miles broad at its widest point, encompassing six major islands within its 19.5 square miles (Figure 4). The Snohomish River Estuary includes the Snohomish River main stem, three distributary sloughs (Ebey, Steamboat, and Union), and the marshes between Possession Sound and the divergence of Ebey Slough from the main stem.

Since the mid-1800s, the Snohomish River Basin has undergone significant changes (Haas and Collins 2001). As western Washington's second largest river basin, the Snohomish River has been subject to diking, channeling, draining, and removal of thousands of acres of prime estuary habitat to create farmland, roads, and homes. These ongoing practices have left hundreds of acres of the Snohomish River Basin prone to water quality problems and without complex habitat for fish and wildlife (ESA 2017). Many drainage areas within the Snohomish River Basin are urbanized, especially in the lower part of the basin near the cities of Marysville and Everett. Developments, including roads and railroads, bisect streams and drainages; and there are many roadway crossings of streams in the basin.

Transit over the Snohomish River Estuary was completed between 1925 and 1927 to link Everett and Marysville and complete the last section of the Pacific Highway in Washington (Caldick 2012). The I-5 route between Everett and Marysville was completed in 1969 and 1970. SR 529 was created in 1971, and a spur route to serve as a connector between SR 529 and I-5 NB was developed in 1991. Continuing growth in population and employment in Snohomish County has resulted in increased traffic congestion between Everett and Marysville. This is a heavily used section of I-5, with average annual daily traffic ranging from 130,000 to 149,000 trips (WSDOT 2020).

Figure 4. Map of the Snohomish River Estuary (Snohomish County April 15, 2004).

Before anthropogenic changes, the Snohomish River Estuary contained approximately 9,761 acres of tidal marsh between Priest Point and the head of Ebey Slough (excluding mudflats). Approximately one-sixth of this historical marsh area remains. The greatest losses of marsh area have occurred in the forested riverine/tidal zone where timber harvest and diking (for agricultural development) eliminated blind tidal channels. Additionally, diking has changed the channel edge environment of the main stem Snohomish River and the primary distributary sloughs (Everett and Pentac 2001).

Within the action area, the City of Everett and WSDOT have completed restoration projects to help restore the Snohomish River Estuary and mitigate for habitat functions lost after completing the Port of Everett's Marine Terminal Improvement project and in anticipation of this project. The Steamboat Slough Mitigation Site was completed in 2019 and re-established approximately 11 acres of estuarine wetland, providing a functional lift from the previous condition of upland and freshwater wetlands formed over fill. The project created new tidal channels through the marsh, providing approximately 1.93 acres of restored fish habitat. The rest of the estuary is below the tidal elevation less frequently, but is anticipated to develop dendritic channels over time, giving marine species' occasional access to the site.

The Union Slough habitat was restored in 2001 and expanded in 2005 (Port of Everett 2020). The project converted 24 acres of diked agricultural lands to tidal estuarine marsh and mudflats (Port of Everett 2020). In 2019, WSDOT restored approximately 12.5 acres of estuarine habitat along Steamboat Slough for the Steamboat Slough Mitigation Project. The project excavated fill to lower the topography to the original elevation and breached a dike in two locations to allow tidal water from Steamboat Slough into the area.

The Snohomish River Estuary is composed of a large estuarine wetland complex that includes palustrine emergent, scrub-shrub, and forested vegetation communities (ESA 2017). There are nine wetlands located along the project corridor: five wetlands at the I-5/SR 529 interchange and two wetlands along I-5 where the fourth NB travel lane will be created. Wetlands present along the project corridor include one Category I wetland, six Category II wetlands (including two created within the Steamboat Slough Mitigation site), and two Category III wetlands.

Two tidally influenced wetlands (Wetlands D and E) potentially may be affected by project activities. Wetland D is a disturbed estuarine wetland that is isolated from surrounding wetlands by SR 529 and the BNSF Railway. Wetland E is located east of I-5 between Ebey and Steamboat Sloughs. Both wetlands have dense, thin-stemmed vegetation and standing water that help remove sediment and toxicants generated from adjacent highways (WSDOT 2019). Wetlands D and E also provide flow attenuation based on storage capacity and their relative position in the landscape. Both wetlands consist of estuarine emergent plant communities that are dominated by salt-tolerant species including narrow-leaf cattail (*Typha angustifolia*), hard-stem club-rush (*Schoenoplectus acutus*), Lyngbye's sedge (*Carex lyngbyei*), and woody saltwort (*Salicornia depressa*) (WSDOT 2019).

Habitat functions associated with both wetlands include production and export of organic matter, habitat for aquatic invertebrates and birds, native plant richness, and fish habitat. These wetlands provide foraging habitat for a variety of wildlife, including waterfowl, birds, and small mammals. Great blue heron (*Ardea herodias*), red-winged blackbird (*Agelaius phoeniceus*), and

marsh wren (*Cistothorus palustris*) were observed in both wetlands, and river otters (*Lontra canadensis*) were observed in Wetland E (WSDOT 2019). Both wetlands provide juvenile salmonid rearing and migration habitat through tidal channels present in the wetlands.

Most of the non-wetland areas in the project corridor are sparsely vegetated with roadside vegetation communities, except for a small forested patch between I-5 and NB SR 529. This forested area consists of deciduous second-growth forest and is primarily dominated by red alder (*Alnus rubra*) with an understory of salmonberry (*Rubus spectabilis*), twinberry (*Lonicera involucrata*), and trailing blackberry (*R. ursinus*). This area may support a limited number of native and nonnative wildlife species that are adapted to highway noise and human disturbance. No suitable habitats of any listed terrestrial species were identified during field investigations (WSDOT 2019).

The Snohomish River and sloughs in the project vicinity support summer/fall Chinook, chum, pink (even- and odd-year), and coho salmon; summer and winter steelhead; bull trout; and sea-run cutthroat trout (WDFW 2020b). There is no eelgrass in the action area; however, Possession Sound has a mix of native (*Zostera marina*) and Japanese eelgrass (*Z. japonica*) (WDNR 2020). Ebey Slough has a continuous patch of eelgrass along the south shoreline (Marine Cadastre 2020). The Snohomish River main stem channel and sloughs all have a patchy to continuous fringe of salt marsh and low marsh (Ecology 2020a). There is a large, patchy low marsh bed at the Steamboat Slough outlet into Possession Sound (Ecology 2020a).

Historically, land use in the area has been mostly agriculture and forest, but it is rapidly becoming more urban. In the 1980s, Snohomish County was the fastest-growing county in the state. Population increased by 38 percent in this decade, and much of the growth took place in municipalities in the Snohomish River drainage. Increased urbanization likely is having a direct impact on water quality through alteration of stream banks, riparian vegetation, and near stream forest. The growing urbanization also translates to increased pollutant loading from wastewater treatment plants, with potential adverse effects on water quality.

A Total Maximum Daily Load (TMDL) was prepared in 1999 for low dissolved oxygen levels in the Snohomish River Estuary, which includes the Snohomish River, the lower part of the Skykomish River, Port of Gardner, and the adjacent portion of Possession Sound (Butkus et al. 1999). Four wastewater treatment plants discharge treated wastewater within the TMDL study area. Nonpoint sources of pollution were also considered, but only as loads from tributaries entering the Snohomish River or sloughs (Butkus et al. 1999). Since the TMDL was established, the area has been listed as Category 4A in Washington State's Clean Water Act Section 303(d) list of impaired water bodies (Ecology 2020b). Possession Sound and Ebey Slough are listed as Category 5 on the 303(d) list for bacteria (Ecology 2020b).

There are two Snohomish River basin Chinook salmon populations that use the action area, the Skykomish and the Snoqualmie populations. The Snohomish/Skykomish River winter-run and Snoqualmie River winter-run steelhead populations use the action area for migration and rearing.

Benthic invertebrates are small aquatic insects that live in or around the streambed and are used as an indicator of the biological health of an ecosystem. Scientists quantify the composition and diversity of benthic invertebrate populations in a stream to compare the biologic integrity of

different streams. While the benthic index of biotic integrity (B-IBI) score has not been measured for Union, Steamboat, or Ebey Sloughs, the Snohomish River has a good to excellent overall score (Puget Sound Stream Benthos 2020).

In the Snohomish River Basin, effects of climate change include saltwater intrusion into freshwater zones because of rising sea levels, longer and more intense winter flooding, and earlier spring runoffs because of warmer temperatures. Terry Williams, Commissioner of Fisheries and Natural Resources for the Tulalip Tribes, stated that in the Snohomish River Delta, 500-year floods are happening more frequently, along with early spring flooding and early drought (Seattle Times 2015). In response to these issues, governments, tribes, and nonprofits are working to restore and increase the storage capacity of floodplains and revive tidal wetland habitats. The tribes are working with farmers on a range of projects, including turning cattle manure into biogas, improving drainage on some farm land, and converting other acreage into fish habitat (Seattle Times 2015).

Scientists from NOAA Fisheries, the Tulalip Tribes, and Snohomish County have been studying the Snohomish River system for more than 10 years to help inform the design of restoration actions that will be most effective. The baseline data will help detect changes in fish populations, evaluate effectiveness, and apply the knowledge to other restoration actions in the region (NWFSC 2017). The largest restoration project so far in the Snohomish River Basin has been at the Qwuloolt Estuary. About 1,500 linear feet of levee in the Snohomish River Estuary was removed, which reopened 350 acres of historical wetlands to threatened salmon and other species (NWFSC 2017). The estuary is on track to have restored over 1,000 acres of the Salmon Recovery Plan's 10-year goal of 1,237 acres of tidally influenced habitat (NWIFC 2016). Even with these much-needed gains through restoration, recent trends demonstrate that net loss and degradation of key habitats continues (NWIFC 2016).

2.5 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. 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 50 CFR 402.17(a) and (b).

The FHWA proposes to approve the WSDOT design to improve access and alleviate congestion at the I-5/SR 529 interchange. The effects of construction, the widened roadway, and new on- and off-ramps between I-5 and SR 529 include elevated sediment levels, increased stormwater runoff, increased overwater coverage, loss of wetland function and riparian vegetation, possible entrainment of juvenile salmonids, and reduced prey species.

2.5.1 Effects to the Species

Project Timing and Presence in the Action Area

The in-water work window for this project is July 1 through February 15. Studies of ocean-type juvenile Chinook salmon in the Pacific Northwest indicate that they use estuarine and nearshore habitats early in their out-migration and rearing periods (Simenstad et al. 1982; Healey 1991). Juvenile Chinook salmon outmigration through the estuary begins from March through April and peaks in late May through early June (Everett and Pentec 2001). Although most juvenile salmon will have likely left the estuary by the start of in-water work (including work in tidally influenced wetlands), some juvenile salmonid use of estuarine rearing areas has been documented year-round (Rowse and Fresh 2003). Adult Chinook salmon return to the Snohomish River system as early as May to begin their upstream migration, which could extend into October (Everett and Pentec 2001) during the period of in-water work.

Most juvenile steelhead spend 2 to 3 years in freshwater before outmigrating as smolts and thus are less dependent on the estuarine environment for growth, refuge, and osmoregulatory transition (Everett and Pentec 2001). Outmigration of smolts typically occurs from April to June, and, unlike Chinook salmon, steelhead spend little time in estuarine and nearshore areas and move quickly to the offshore environment (NMFS 2018). Adult winter steelhead return from November through April and may be present during in-water work.

Water Quality—Construction Activities

Ground-disturbing activities in wetlands and the tidal channel adjacent to Steamboat Slough can cause short-term and localized increases in turbidity and total suspended solids (TSS). The effects of suspended sediment on fish increase in severity with sediment concentration and exposure time and can progressively include behavioral avoidance and/or disorientation, physiological stress (e.g., coughing), gill abrasion, and death. Newcombe and Jensen (1996) analyzed numerous reports on documented fish responses to suspended sediment in streams and estuaries, and identified a scale of ill effects based on sediment concentration and duration of exposure, or dose. Exposure to concentrations of suspended sediments expected during the proposed sheet-pile installation could elicit sublethal effects such as a short-term reduction in feeding rate or success, or minor physiological stress such as coughing or increased respiration. Studies show that salmonids have an ability to detect and distinguish turbidity and other water quality gradients (Simenstad 1988; Quinn 2005), and that larger juvenile salmonids are more tolerant to suspended sediment than smaller juveniles (Servizi and Martens 1991; Newcombe and Jensen 1996).

Sediment and turbidity will be minimized to the extent possible during construction; however, it is likely that sediment will be disturbed in the action area. In-water construction activities that could result in the temporary resuspension of sediments include the installation and removal of sheet piles for cofferdam construction and the installation of retaining walls. When disturbed in wetland areas, sediment may be somewhat controlled by BMPs; however, release into the action area is likely, given the tidal fluctuations that saturate the wetlands daily. Temporary turbidity

impacts would be minimal and short term. Appropriate BMPs, including TESC measures, will be implemented to minimize temporary increases in sediment loading.

The proposed action involves construction activities and equipment staging near Steamboat Slough and over the Snohomish River, Union Slough, and Steamboat Slough that will increase the potential for accidental releases of fuel, oil, and other contaminants. All work in or near water bodies in the action area will comply with the terms of federal, state, and local permits, minimizing the potential for sediment or pollutants to be carried from work sites to water bodies by stormwater. In addition, all work will be conducted in compliance with the TESC plan and SPCC plan for the project, and BMPs will be implemented to prevent construction-related sediment or pollutants from entering surface waters. For instance, the BMPs require that all equipment be free of leaks and that refueling, maintenance, and staging occur at least 200 feet from a stream. Additionally, the BMPs require that any hazardous material spills be cleaned up immediately. Given the minimization measures and the BMPs proposed, NMFS expects the likelihood of an accidental spill of contaminants reaching a waterway to be unlikely, and, therefore, discountable.

Water Quality—Stormwater Runoff

Rainwater falling on paved surfaces can accumulate heat, creating a localized increase in water temperature associated with runoff; however, water quality treatment associated with the proposed project is expected to promote runoff infiltration during precipitation events. Water quality monitoring at the Snohomish River, Steamboat Slough, and Ebey Slough showed temperature excursions exceeding the Ecology criterion in 2008; however, the listing was reviewed by Ecology Coastal and Estuarine Assessment Unit staff, who concluded that there are insufficient human influences in the area to produce significant temperature increases (Ecology 2020b). Therefore, the temperature exceedances at the location were deemed to be a result of natural conditions (Ecology 2020b).

Highways collect a variety of pollutants from vehicular traffic and are disproportionate contributors to overall pollutant loads in water bodies (Wheeler et al. 2005). Pollutants are mobilized by runoff water and are transported to nearby water bodies. Traffic residue contains several metals including iron, zinc, lead, cadmium, nickel, copper, and chromium (Wheeler et al. 2005), as well as many other unregulated chemicals. These include several toxic chemicals that have been linked to deformities, injury and/or death of salmonids and other fish, such as: pharmaceuticals, polycyclic aromatic hydrocarbons (PAHs), fire retardants, and residues from vehicle tires, brake pads and emissions (Trudeau 2017; Young et al. 2018). The metals come from disintegrating tires, brake pads, and other vehicle parts and accumulate in roadside dust and soil (Wheeler et al. 2005).

Dissolved copper and dissolved zinc are the constituents of greatest concern because they are prevalent in stormwater, they are biologically active at low concentrations, and they have adverse effects on salmonids (Sprague 1968; Sandahl et al. 2007). Also, while enhanced stormwater BMPs are effective at removing contaminants such as PAHs from stormwater runoff, BMPs are less effective at removing dissolved metals. Increased copper and zinc loading presents two pathways for possible adverse effects in the aquatic environment: (1) direct

exposure to water column pollutant concentrations in excess of biological effects thresholds, and (2) indirect adverse effects resulting from the accumulation of pollutants in the environment over time, altered food web productivity, and possible dietary exposure.

Sublethal concentrations of dissolved copper have been shown to impair olfactory function in salmon in freshwater (Tierney et al. 2010). Baldwin et al. (2003) found that 30- to 60-minute exposures to a dissolved copper concentration of 2.3 micrograms per liter (µg/L) over background level caused olfactory inhibition in coho salmon juveniles. Sandahl et al. (2007) found that a 3-hour exposure to a dissolved copper concentration of 2.0 µg/L caused olfactory inhibition in coho salmon juveniles. That copper-induced loss of smell leads to a reduction in predator avoidance (McIntyre et al. 2008). Further, fish have shown avoidance of sublethal levels of dissolved copper in freshwater (Giattina et al. 1982).

The toxicity of zinc is widely variable, dependent upon concurrent levels of calcium, magnesium, and sodium in the water column (De Schamphelaere and Janssen 2004). A review of zinc toxicity studies reveals effects including reduced growth, avoidance, reproduction impairment, increased respiration, decreased swimming ability, increased jaw and bronchial abnormalities, hyperactivity, hyperglycemia, and reduced survival in freshwater fish (Eisler 1993). Juvenile fish are more sensitive to elevated zinc concentrations than adults (EPA 1987). Sprague (1968) documented avoidance in juvenile rainbow trout exposed to dissolved zinc concentrations of 5.6 µg/L over background levels.

Because the discharge will include a complex load of organic and inorganic contaminants into water bodies that are already affected by contaminants, the incremental addition of even small amounts of these pollutants are a source of potential adverse effects to salmon and steelhead, even when the new source load cannot be distinguished from ambient levels (Hecht et al. 2007; Laetz et al. 2009; Macneale et al. 2010; Sandahl et al. 2007; Spromberg and Meador 2006). Some contaminants also accumulate in both the prey of and tissues of salmon and steelhead where, depending on the level of exposure, they cause a variety of lethal and sublethal effects, including disrupted behavior, reduced olfactory function, immune suppression, reduced growth, disrupted smoltification, hormone disruption, disrupted reproduction, cellular damage, and physical and developmental abnormalities (Fresh et al. 2005; Hecht et al. 2007). Even at very low levels, chronic exposures to those contaminants can have a wide range of adverse effects on the species considered in this opinion (Carls et al. 2008; Comeleo et al. 1996; Feist et al. 2011; Hecht et al. 2007; Sandahl et al. 2007; Spromberg and Meador 2006). Furthermore, multiple facts influence the effects of contaminants on individual fish. These factors include life history stage at time of exposure, and the particular species exposed, geographic distribution of the species, the duration of exposure, and land use patterns where the projects occur, which influences the composition of chemicals to which the individual fish are exposed (Feist et al. 2011; Johnson et al. 2013; Scholz et al. 2011; Spromberg and Scholz 2011; Stehr et al. 2009). Repeated and chronic exposures, even of very low levels, are still likely to injure or kill individual fish, by themselves and through synergistic interactions with other contaminants already present in the water (Baldwin et al. 2009; Feist et al. 2011; Hicken et al. 2011; Spromberg and Meador 2006; Spromberg and Scholz 2011).

There are 14 TDAs in and around the action area that discharge into the Snohomish River, Union Slough, Steamboat Slough, Ebey Slough, and tidally influenced wetlands. Currently, untreated

stormwater discharges to Steamboat Slough and the tidally influenced wetlands. WSDOT will maintain the existing drainage pattern and natural dispersion process in the action area through existing vegetated ditches and tidally influenced wetlands. The proposed project will result in the addition of approximately 2.92 acres of new PGIS to the project area and will treat 100 percent of the new PGIS within the I-5/SR529 interchange, as well as 4.7 acres of existing PGIS to improve project area runoff quality prior to discharging into estuarine wetlands. Because of the increase in the new impervious surface area, the HI-RUN model was used to evaluate the potential effects of stormwater on listed species.

The HI-RUN model evaluates existing and proposed pollutant loading values from each TDA (end-of-pipe loading and subroutine analysis) and existing and proposed pollutant concentrations at specific outfall discharge locations after mixing within the associated receiving water (receiving water dilution subroutine analysis). The end-of-pipe loading analysis was conducted using the proposed stormwater runoff characteristics for TDAs 1 through 4. Other TDAs (TDAs A through J) were not analyzed in HI-RUN because no stormwater treatment is proposed in those TDAs. The vast majority of new PGIS (99.6 percent; 2.91 of 2.92 acres) is in TDAs 1 through 3. All TDAs exceeded the P(exceed) value for the dissolved zinc threshold, indicating that there is more than a 55 percent chance that the proposed pollutant loading would exceed the current baseline condition. Table 4 shows end-of-pipe pollutant loading calculation results, which indicate that the median pollutant loads of total copper, dissolved copper, dissolved zinc, and total suspended solids will be slightly higher than the baseline conditions for TDA 1. For TDAs 2 and 3, most of the median pollutant loads will be reduced, except for dissolved copper. There are no changes on pollutant loadings calculated for TDA 4.

Table 4. HI-RUN Results for Threshold Discharge Areas 1 through 4.

	TDA 1		TDA 2		TDA 3		TDA 4	
Parameter	Median Existing Load (lbs/year)	Median Proposed Load (lbs/year)	Median Existing Load (lbs/year)	Median Proposed Load (lbs/year)	Median Existing Load (lbs/year)	Median Proposed Load (lbs/year)	Median Existing Load (lbs/year)	Median Proposed Load (lbs/year)
Total copper	0.35	0.37	0.429	0.34	0.651	0.47	0.001	0.001
Dissolved copper	0.081	0.091	0.102	0.11	0.162	0.16	0	0
Total zinc	2.13	2.2	2.6	2	3.93	2.8	0.007	0.007
Dissolved zinc	0.604	0.66	0.752	0.71	1.17	1	0.002	0.002
Total suspended solids	1,367	1,409	1,662	1,235	2,542	1,644	4.51	4.51

TDA = threshold discharge area; lbs/year = pounds per year

The HI-RUN receiving water dilution subroutine analysis could not be used to estimate mixing zones for the TDA outfalls, because the HI-RUN model was not designed for outputs to tidally influenced waters. An alternative model recommended for mixing zone analysis in lake or estuarine water bodies, CORMIX, was not used due to the complexity of the discharge network and receiving waters as well as limited baseline data available to populate the model. Instead, WSDOT (2020) made estimates of mixing zones for two scenarios present: (1) outfalls that will

discharge stormwater into tidally influenced wetlands, and (2) outfalls that will discharge stormwater directly into surface waters (Steamboat Slough, Union Slough, and the Snohomish River).

For outfalls discharging into tidally influenced wetlands, salmonid exposure to pollutants will vary depending on tidal cycles. Tidal elevations in the Snohomish River Estuary range from about 9.8 feet (neap tide) to 13 feet (spring tide) (Yang and Khangaonkar 2008). Given this range in tidal elevations, it is possible that salmonids present in estuarine wetlands during some storms or high-tide events may be exposed to stormwater pollutants. Strong tidal mixing may dilute stormwater pollutants within relatively short distances (<100 feet), but exposure of listed fish to harmful levels is possible. Some storm events during low tide would discharge stormwater to wetlands, and the stormwater would disperse through wetland tidal channels. The outfalls range from 600 to 800 feet from the edge of the nearest slough surface water, so it is likely that stormwater pollutants would dilute to background by the time tidal waters return to the sloughs (WSDOT 2020).

For outfalls that discharge stormwater directly into Steamboat Slough, WSDOT (2020) compared Steamboat Slough to another site at which a CORMIX analysis was used to estimate a dilution zone. Comparing dilution zone, pollutant concentrations, and water velocity, the analysis conservatively estimated a total dilution zone distance of 238 feet at each outfall to Steamboat Slough. Within the dilution zones, salmonids may be exposed to higher concentrations of suspended solids, dissolved copper, and dissolved zinc.

Stormwater BMPs are designed to reduce the area where acute and chronic toxicity levels are exceeded, but they do not reduce overall pollution loading in Puget Sound. Although the project includes measures to treat stormwater at TDAs where treatment is currently not occurring, it will result in a slight net increase in the amount of pollution loading in the receiving waterbodies and Puget Sound. Stormwater runoff from the existing and new PGIS will continue for the life of the roadway.

While discharge from the project cannot be specifically associated with adverse effects of specific individuals from the species considered in this opinion, these contaminants have been shown to injure or kill individual fish either by themselves or through additive, interactive, and synergistic interactions with other contaminants (Baldwin et al. 2009; Hicken et al. 2011; Laetz et al. 2009; Spromberg and Meador 2006; Spromberg and Scholz 2011). Thus, the contribution of these contaminants from the project, while small, will be an additive contribution to the already degraded aquatic habitat of these species. The effects of this action on the ESA-listed species considered in this opinion therefore include the presumption of additional exposure to contaminants present in the discharge of stormwater, and potential synergistic effects as these contaminants interact with other compounds already present in the receiving water bodies.

Overwater Coverage

The area of overwater coverage of the widened bridges will be approximately 745 square feet over the Snohomish River (330 square feet), Union Slough (115 square feet), and Steamboat Slough (300 square feet). Overwater structures can cause delays in migration for PS Chinook

salmon and steelhead from disorientation, fish school dispersal (resulting in loss of refugia), and altered migration routes around the structures (Simenstad et al. 1999). A study on the effects of overwater shading on migrating juvenile salmon showed that bridges delay some migrating smolts (Bloch et al. 2009). These delays were typically short in duration since the smolts would migrate towards the shoreline prior to continuing their migration to Possession Sound. However, many predatory species prefer habitat under bridges, and the delay in salmonid migration may increase risk of predators (Bloch et al. 2009).

The presence of overwater structures may also reduce the production of benthic and epibenthic macroinvertebrates due to reduced light transmission and decreased primary production through shading. A WSDOT (2009) study on light transmission under the SR 520 Bridge found that low, wide bridge decks create deep shade in the area underneath the bridge decks, with little to no vegetation growing beneath them; whereas higher, thinner bridge decks can let in a significant amount of light beneath the deck; and vegetation cover (including trees and dense shrubs) can be quite high in those areas. Overall, the study determined that bridge heights over 24 feet have relatively minor impacts on vegetation in terms of total cover; and higher bridges can support a diverse range of vegetation (WSDOT 2009). The heights of the bridges over the Snohomish River, Union Slough, Steamboat Slough, and Ebey Slough are 50 feet, 18 feet, 50 feet, and 30 feet, respectively.

While the bridges continue the presence of a light/dark interface that may disorient migrating fish and increase the risk of predation, the increase in overwater cover is unlikely to increase the risk of predation or disrupt migration. Other impacts, such as loss in primary production and forage material due to shading effects, are minimal due to the bridge elevation.

Habitat Alteration

Approximately 1.93 acres of wetland vegetation will be permanently cleared and construction of the ramps will require the placement of fill within Wetlands D and E, permanently eliminating 0.8 acre of Wetland D and 1.1 acres of Wetland E. Emergent vegetation and macroinvertebrates affected by dewatering a portion of the tidal channel are expected to recolonize in the temporarily affected areas relatively quickly. Benthic invertebrates generally recolonize disturbed areas within a few months to 1 year (Merz and Chan 2005).

Permanent loss of estuarine habitat could affect feeding and shelter for juvenile salmonids because estuarine habitat generally provides refuge from predators and supports juvenile salmonid prey species. The project could also remove potential dispersal areas of rockfish larvae by permanently filling estuarine wetlands, although the presence of larvae in the affected areas is extremely low and not likely detectable.

Loss of Riparian Vegetation

Indirect effects associated with the removal of riparian vegetation can result in increased water temperatures (Mitchell 1999; Opperman and Merenlender 2004) and decreased water quality (Lowrance et al. 1985; Welsch 1991), attributable to a loss of shade and cover over the active

channel. Vegetation removal will be limited to roadside areas; no tree removal is anticipated to occur because most work would be within the existing paved area. Approximately 1.93 acres of wetland vegetation and 0.56 acre of scrub-shrub vegetation will be temporarily cleared for the SR 529 interchange work. However, the loss of vegetation as a result of the proposed action is expected to be temporary because all disturbed areas will be restored and replanted with native riparian vegetation to minimize impacts from project construction. Vegetation planting and monitoring will abide by federal, state, and local permits; and NMFS believes that the absence of mature vegetation for a small portion of the reach is unlikely to significantly impact rearing and migrating salmonids.

Project Site Dewatering

The project construction will require dewatering an area of approximately 200 square feet of a tidally inundated channel at low tide. NMFS anticipates temporary changes to instream flow upstream, within, and downstream of the project site during the ramp construction and the relocation of the existing culvert.

Stream flow diversion and dewatering could harm individual rearing salmonids by concentrating or stranding them in residual wetted areas, or entrapping them within the interstices of channel substrate where they may not be seen by fish relocation personnel. Juvenile salmonids that avoid capture in the project work area will likely die due to desiccation, thermal stress, or crushing. However, fish relocation efforts are expected to be effective at removing fish from the area. Therefore, NMFS expects that the number of juvenile Chinook salmon and steelhead that may be missed and have the potential to be left within the dewatered area will be very low.

Dewatering operations may also affect aquatic food sources that Chinook salmon and steelhead use for forage. Benthic aquatic macroinvertebrates, an important food source for salmonids, may be killed or their abundance reduced when the river channel is dewatered (Cushman 1985). However, effects to aquatic macroinvertebrates resulting from channel-flow diversions and dewatering will be temporary because construction activities will be short term (12 months). Rapid recolonization (2 weeks to 2 months) of disturbed areas by macroinvertebrates is expected following the removal of all cofferdams (Merz and Chan 2005). In addition, the effect of macroinvertebrate loss on juvenile salmonids is likely to be negligible because food from the sloughs and other side channels will be available. Therefore, Chinook salmon and steelhead are not anticipated to be exposed to a reduction in food sources from the temporary reduction in aquatic macroinvertebrates as a result of dewatering activities.

Fish Handling and Exclusion

The isolation and dewatering of approximately 200 square feet of tidal channel bed may require fish handling to ensure all juvenile salmonids are excluded from the work area. Such displacement can lead to higher energy expenditures by salmonids as they seek equilibrium and seek to replace existing feeding opportunities. The mechanical processes of using nets to move fish contributes to stress, although short-term contact is less likely to cause injury or death. Handling stresses fish, increasing plasma levels of cortisol and glucose (Hemre and Krogdahl

1996; Frisch and Anderson 2000). Due to the soft substrate in the excluded area, all fish should be able to be removed using hand nets and seines. Because contractors will wait until a low in the tidal cycle to isolate the area for dewatering, no adults are anticipated to be in the small side channel.

Relevance of Local Effects on Fish to Population Viability

Salmonids from the PS Chinook ESU and PS steelhead DPS analyzed in this Opinion use the action area for rearing and migration. Considering the small area to be isolated in the action area, the number of listed species encountering effects of the action is likely to be very low. The effects on the growth and survival of a small number of individual salmon is unlikely to affect abundance, productivity, or distribution of the component populations of the ESA-listed salmonids in the action area. Even considering cumulative effects anticipated in the action area, when they are combined with the effects of the action and added to the environmental baseline, the aggregate of impacts to the species will affect too few fish to influence population viability characteristics of the affected species.

2.5.2 Effects on Critical Habitat

The NMFS designated critical habitat for the Puget Sound Chinook salmon on September 2, 2005 (70 FR 52630) and for Puget Sound steelhead on February 24, 2016 (81 FR 9252). Only one of the six PBFs of salmonid critical habitat (PBF #4) is in the action area:

> … 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, aquatic vegetation, large rocks and boulders, side channels; and (iii) juvenile and adult forage, including aquatic invertebrates and fishes, supporting growth and maturation.

Water Quality

Good water quality is a component of estuarine habitats. Although construction activities will increase suspended sediments during project activities, the effects will be short term and will return to pre-project levels as soon as construction activities cease. If the estuarine habitat is affected by increased suspended sediment from construction activity, degraded water quality conditions will result in a minor reduction in estuarine rearing and migration habitat. The majority of ground-disturbing activities will be contained behind sheet-pile cofferdams, and impacts to water quality will be minimized with BMPs.

Stormwater discharged directly to surface waters in Steamboat Slough at two outfalls will be diluted within 238 feet of each outfall. Based on water quality review in the Puget Sound region it is assumed that water quality in the estuarine environment will be systemically though only incrementally impaired due to pollutant imported from the proposed action. The degree to which estuarine habitat will be impaired is unknown, as the greater habitat area, volume of water, salinity, and flushing to the estuarine environment may attenuate some of the assumed effects.

Natural Cover

There will be no affect to natural cover. Vegetation temporarily removed for construction is currently within wetlands and along the roadside. Riparian vegetation will not be removed from along the shoreline where it provides natural cover.

Forage

There will be a decreased quality of forage opportunity due to disturbance during construction and tidal channel dewatering. Approximately 200 square feet of channel will be dewatered and disturbed during construction. The effects will be short term and will return to pre-project levels as soon as construction activities cease.

Harding et al. (2018) demonstrated how Pacific herring (a forage fish and keystone species) exposed to urban stormwater runoff suffer cardiac injury and reduced growth so it is reasonable to assume that in estuarine forage species that are a PBF of salmonids will be impaired by the contribution of stormwater from the proposed action.

Relevance to the Watershed of Local Effects on Critical Habitat in the Action Area

The Snohomish River contains designated critical habitat for two populations of PS Chinook salmon. Present habitat conditions in the action area are degraded due to numerous management activities in the contributing drainage basin, including hydropower development, loss of mature riparian forests, increased sediment inputs, removal of large wood, intense urbanization, agriculture, alteration of floodplain and stream morphology (i.e., channel modifications and diking), riparian vegetation disturbance, wetland draining and conversion, dredging, armoring of shorelines, marina and port development, road and railroad construction and maintenance, logging, and mining.

The proposed action is expected to have adverse effects on the water quality and forage of the estuarine rearing PBFs of critical habitat in the action area. But when these effects are added to the environmental baseline and cumulative effects, none of these adverse effects is large enough in the action area to be significant at the scale of the river reach or watershed because they are of limited duration and the PBFs will return to the baseline condition upon completion of the construction work.

2.6 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 versus cumulative effects. Therefore, all relevant future climate-related environmental conditions in the action area are described in the environmental baseline (Section 2.4).

NMFS does not expect any new non-federal activities within the action area because the action area has no potential area for development (residential, commercial, or industrial). However, on the watershed scale, future upland development activities lacking a federal nexus will continue and are expected to lead to increased impervious surface, surface water runoff, and non-point pollution 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.

2.7 Integration and Synthesis

The Integration and Synthesis section is the final step in our assessment of the risk posed to species and critical habitat as a result of implementing the proposed action. In this section, we add the effects of the action (Section 2.5) to the environmental baseline (Section 2.4) and the cumulative effects (Section 2.6), 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.

Abundance across the PS Chinook salmon ESU generally decreased between 2010 and 2014, with only 6 small populations of 22 total populations showing a positive change in natural-origin spawner abundances. Similarly, the PS steelhead DPS decreased between 2010 and 2014, with all but a few populations declining at a rate of 3 to 10 percent annually. The current status of the affected species is related to their degraded critical habitat and poor baseline condition. In general, baseline habitat conditions in the Puget Sound region have been degraded, chiefly by human development. Much of the shoreline in the action area has been restored through various mitigation and restoration projects but is still impacted by transportation development.

Climate change is likely to exacerbate several of the ongoing habitat issues, such as increased summer temperatures and decreased summer flows in the freshwater environment and ocean acidification and sea level rise in the marine environment. Much of the estuarine and freshwater wetland habitat that historically existed in the project vicinity has been degraded by agriculture, development, and transportation infrastructure. It is estimated that the area of historical tidal marsh in the Snohomish River Estuary has been reduced by approximately 83 percent. Although there have been several restoration projects in the area that improved estuarine wetland and shoreline habitat, the extent of habitat modifications in the area significantly impairs several aspects of critical habitat and puts its function for listed salmonids at risk.

In summary, the status of the species and its habitat are both poor. The baseline conditions of habitat have been degraded, mostly by human development. In addition to these degraded conditions, the cumulative effects driven by development pressures from population growth and climate change will likely continue to adversely affect critical habitat and the species that depend on critical habitat functions. These cumulative effects will likely be related to agricultural and residential development above the ordinary high water level of surface water bodies where neither the U.S. Army Corps of Engineers or the FHWA has regulatory oversight, and thus they will not have a federal nexus. These habitat alterations may take place within critical habitat or influence critical habitat by listed species.

The number of salmonids that are likely to be injured or killed due to the loss of forage or degraded water quality resulting from the proposed action are too few to cause a measurable effect on the long-term abundance or productivity of any affected populations or to appreciably reduce the likelihood of survival and recovery of PS Chinook salmon and PS steelhead. A small number of juvenile PS Chinook salmon and PS steelhead that will be excluded and removed during dewatering for the culvert replacement and the reduction of foraging success will be proportional to the size of the isolated area, approximately 200 square feet, as well as the potential exposure to untreated stormwater near stormwater outfalls, approximately 238 feet from each outfall. This is a small fraction of the forage, rearing, and migration habitat that exists in this area of the estuary. The proposed action will have no effect on spatial structure of the population. Therefore, the proposed action will not reduce the productivity or survival of the affected populations of PS Chinook salmon or PS steelhead, even when combined with the environmental baseline and additional pressure from cumulative effects and climate change.

For salmon critical habitat, as summarized above, the proposed project will have limited short-term effects to estuarine critical habitat PBFs in the action area. The proposed action will result in stormwater treatment in areas where none currently exists. The potential adverse effects of direct stormwater input and increased PGIS are expected to be minor and dilute to background conditions within a short distance (238 feet) from the stormwater outfall, but pollutants in stormwater runoff have the potential to be distributed throughout Steamboat Slough and Puget Sound. The potential adverse effects of construction activities are expected to be minor and persist for a short time. The PBFs will recover their function quickly from construction activities such that the quality of PBFs will not be diminished in the long term. The long-term adverse effects from increased PGIS and direct input of stormwater will persist for the duration of the WSDOT infrastructure. While measurable in the action area, on a critical habitat designation scale, their effect will be small.

Even though the baseline is degraded and cumulative effects likely will continue to adversely affect critical habitat, the added adverse effects of the proposed action are too small on a designation level to appreciably reduce the conditions of critical habitat or preclude re-establishing properly functioning conditions. Overall, when added to the baseline and cumulative effects, the effects of the action on critical habitat do not significantly affect the conservation value of critical habitat at the designation scale.

For all the reasons described in the preceding paragraphs of this section, the proposed action will not appreciably reduce the likelihood of both survival and recovery of the species in the wild by

reducing its numbers, reproduction, or distribution, nor will the proposed action reduce the value of designated critical habitat for the conservation of the species.

2.8 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 cumulative effects, it is NMFS' biological opinion that the proposed action is not likely to jeopardize the continued existence of PS Chinook salmon and PS steelhead and/or destroy or adversely modify PS Chinook salmon designated critical habitat.

2.9 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). "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.

2.9.1 Amount or Extent of Take

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

Individual PS Chinook salmon and PS steelhead will be present in and co-occur with the effects of the action. Therefore, incidental take of individuals is reasonably certain to occur. Take will occur in the form of harm, where dewatering, fish exclusion, and direct release of stormwater will injure fish by reducing forage material in the dewatered area, cause injury or mortality, and by reducing survival and growth of exposed juveniles.

Take in the form of harm from these causes cannot be accurately quantified as an actual number of fish. The distribution and abundance of fish within the action area cannot be predicted based on existing habitat conditions, and because of temporal and dynamic variability in population dynamics in the action area, nor can NMFS precisely predict the number of fish that are reasonably certain to respond adversely to habitat modified by the proposed action. When NMFS cannot quantify take in numbers of affected animals, we instead consider shifts to the likely extent of changes in habitat quantity and quality to indicate the extent of take.

The best available indicator for the extent of take is the area where the project will affect juvenile Chinook salmon and steelhead forage and nearshore rearing and migration. We define this take

based on the dewatering footprint that removes forage habitat and the amount of new PGIS that will be created as a result of the proposed project. This indicator is proportional to the amount of take because the number of fish exposed to reduced levels of forage and to pollutant exposure would increase with the area of benthic habitat disturbed by dewatering activity and increased stormwater output from the new PGIS. We define the maximum extent of take as approximately 200 square feet in the dewatered tidal channel area and 2.92 acres of additional PGIS. If the dewatering footprint exceeds 200 square feet, or PGIS exceeds 2.92 acres, reinitiation of consultation will be warranted. These indicators are a valid reinitiation trigger because the FHWA can take remedial action if the dewatering area or stormwater output affect more habitat than proposed.

2.9.2 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.

2.9.3 Reasonable and Prudent Measures

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

The FHWA shall:

1. Ensure completion of a monitoring and reporting program to confirm this Opinion is meeting its objective of limiting the extent of take and minimizing take from permitted activities. Please electronically send these reports to: <projectreports.wcr@noaa.gov>.

2. Minimize incidental take of PS Chinook salmon and PS steelhead associated with project site dewatering.

3. Minimize incidental take of PS Chinook salmon and PS steelhead associated with long-term exposure to stormwater pollutants.

2.9.4 Terms and Conditions

The terms and conditions described below are non-discretionary, and the FHWA or any applicant must comply with them in order to implement the RPMs (50 CFR 402.14). The FHWA 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) The following terms and conditions implement reasonable and prudent measure 1:

   a) Reporting: The FHWA must report to NMFS and projectreports.wcr@noaa.gov all monitoring items within 60 days of project completion, including:

i) Dimensions of the dewatered area
ii) Acreage of new PGIS
iii) Verification that all BMPs and minimization measures were implemented

2) The following term and condition implements reasonable and prudent measure 2. To minimize incidental take of PS Chinook salmon and PS steelhead associated with project site dewatering, the FHWA shall:

   a) Limit the area of dewatering to the 200 square feet described in the biological assessment.

3) The following terms and conditions implement reasonable and prudent measure 3. To minimize incidental take of PS Chinook salmon and PS steelhead associated with long-term exposure to stormwater pollutants, the FHWA shall:

   a) Minimize the amount of stormwater by limiting new PGIS to the 2.92 acres described in the biological assessment.
   b) Ensure the stormwater facilities are built as proposed and as relied-on by NMFS while conducting this consultation.

2.10 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).

NMFS has identified the following measure to further minimize or avoid adverse effects on listed species:

1) Explore opportunities to provide additional stormwater treatment for all PGIS in the project area.

2.11 Reinitiation of Consultation

This concludes formal consultation for I-5/NB Marine View Drive to SR 529 Corridor and Interchange Improvements Project.

As 50 CFR 402.16 states, 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 if: (1) the amount or extent of incidental taking specified in the ITS is exceeded, (2) new information reveals effects of the agency action that may affect listed species or critical habitat in a manner or to an extent not considered in this opinion, (3) 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 (4) a new species is listed or critical habitat designated that may be affected by the action.

2.12 "Not Likely to Adversely Affect" Determinations

The applicable standard to find the 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.

Georgia Basin Rockfish
Bocaccio
Yelloweye

The likelihood of adults of ESA-listed rockfish occurring within the action area is discountable. Adult rockfish typically occupy waters deeper than 120 feet (Love et al. 2002) and are very unlikely to occur with the action area because it contains waters less than 50 feet deep. Puget Sound/Georgia Basin DPS of yelloweye rockfish critical habitat includes deep-water marine habitat, only. Deep-water marine habitat includes waters deeper than 30 meters (98 feet), which is the approximate extent of the photic zone in Puget Sound. No nearshore component was included in the critical habitat listing for Georgia Basin rockfish.

Juvenile yelloweye rockfish are not typically found in shallow intertidal waters (Love et al. 1991). Yelloweye rockfish are most frequently observed in waters deeper than 30 meters (98 feet) near the upper depth range of adults (Yamanaka et al. 2006) and prefer rocky habitats. Because of the depth and substrate preference, it is extremely unlikely that yelloweye rockfish would be present, and thus exposed, to any of the effects of the proposed action.

Juvenile bocaccio settle onto rocky or cobbly substrates in the shallow nearshore at 3 to 6 months of age in areas that support kelp and other aquatic vegetation, and they move to progressively deeper waters as they grow (Love et al. 1991; Love et al. 2002; Palsson et al. 2009). Juvenile bocaccio rockfish also recruit to sandy zones with eelgrass or drift algae (Love et al. 2002). Juvenile bocaccio are unlikely to be affected by construction activities because there is no suitable aquatic vegetation in the action area (WDNR 2020).

Therefore, we conclude that the proposed action will have discountable effects on yelloweye rockfish and bocaccio.

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. The MSA (Section 3) defines EFH as "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity." Adverse effect means any impact that reduces the 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) also requires NMFS to recommend measures that can be taken by the action agency to conserve EFH.

This analysis is based, in part, on the EFH assessment provided by the FHWA and descriptions of EFH for Pacific Coast groundfish (Pacific Fishery Management Council [PFMC] 2005) and Pacific Coast salmon (PFMC 2014) 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 action area overlaps with identified EFH for Pacific Coast salmon, Pacific Coast groundfish, and coastal pelagic species.

3.2 Adverse Effects on Essential Fish Habitat

The proposed actions will negatively impact water quality, via short-term adverse effects associated with construction activities and long-term adverse effects associated with stormwater outfalls. The negative impacts to water quality on habitat will impair normal rearing behavior through decreased forage capacity.

3.3 Essential Fish Habitat Conservation Recommendations

NMFS expects that full implementation of the following EFH conservation recommendations would protect EFH by avoiding or minimizing the adverse effects described in Section 3.2, due to temporary dewatering of a tidal channel area and the increase in stormwater runoff pollutants associated with increased PGIS. The conservation recommendations are a subset of the ESA terms and conditions. NMFS recommends that:

- The FHWA provide a report detailing dewatering dimensions to NMFS within 60 days of project completion.
- Report any violations of WDFW's Hydraulic Project Approval or Ecology's requirements to NMFS.

3.4 Statutory Response Requirement

As required by Section 305(b)(4)(B) of the MSA, WSDOT 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 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 anticipating effects of the action and the measures needed to avoid, minimize, mitigate, or offset such effects (50 CFR 600.920(k)(l)).

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 FHWA 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 the FHWA. Other interested users could include WSDOT, the cities of Everett and Marysville, and other interested individuals. Individual copies of this opinion were provided to the FHWA. The document will be available within 2 weeks at the NOAA Library Institutional Repository: <https://repository.library.noaa.gov/welcome>. The format and naming adheres 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 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.

5. REFERENCES

Abatzoglou, J.T., D.E. Rupp, and P.W. Mote. 2014. Seasonal Climate Variability and Change in the Pacific Northwest of the United States. Journal of Climate 27(5):2125–2142.

Baldwin, D.H., J.F. Sandahl, J.S. Labenia, and N.L. Scholz. 2003. Sublethal Effects of Copper on Coho Salmon: Impacts on Nonoverlapping Receptor Pathways in the Peripheral Olfactory Nervous System. Environmental Toxicology and Chemistry 22(10):2266–2274.

Baldwin, D.H., J.A. Spromberg, T.K. Collier, and N.L. Scholz. 2009. A fish of many scales: extrapolating sublethal pesticide exposures to the productivity of wild salmon populations. Ecological Applications 19(8):2004-2015.

Bloch, P., M. Celedonia, and R. Tabor. 2009. Do Bridges Affect Migrating Juvenile Salmon: Tracking Juvenile Salmon and Predator Fish Movements and Habitat Use Near the SR 520 Bridge in Lake Washington. Adapting to Change: Ecological Considerations for Bridges. Conference Paper from the 2009 ICOET Conference, Duluth, Minnesota.

Butkus, S.R., R.F. Cusimano, and D.E. Wright. 1999. Snohomish River Estuary Total Maximum Daily Load Submittal Report. Washington State Department of Ecology, Water Quality Program, Olympia, Washington. August.

Caldick, J. 2012. Ebey Slough Bridge (1925–2012). HistoryLink.org Essay 10023. Posted March 23, 2012. Accessed January 30, 2020. <https://www.historylink.org/File/10023>.

Carls, M.G., L. Holland, M. Larsen, T.K. Collier, N.L. Scholz, and J. Incardona. 2008. Fish embryos are damaged by dissolved PAHs, not oil particles. Aquatic Toxicology 88(2):121-127.

Comeleo, R.L., J.F. Paul, P.V. August, J. Copeland, C. Baker, S.S. Hale, and R.W. Latimer. 1996. Relationships between watershed stressors and sediment contamination in Chesapeake Bay estuaries. Landscape Ecology 11(5):307-319

Crozier, L.G., A.P. Hendry, P.W. Lawson, T.P. Quinn, N.J. Mantua, J. Battin, R.G. Shaw, and R.B. Huey. 2008. Potential Responses to Climate Change in Organisms with Complex Life Histories: Evolution and Plasticity in Pacific Salmon. Evolutionary Applications 1(2):252–270.

Crozier, L.G., M.D. Scheuerell, and E.W. Zabel. 2011. Using Time Series Analysis to Characterize Evolutionary and Plastic Responses to Environmental Change: A Case Study of a Shift Toward Earlier Migration Date in Sockeye Salmon. The American Naturalist 178 (6):755–773.

Cushman, R.M. 1985. Review of Ecological Effects of Rapidly Varying Flows Downstream from Hydroelectric Facilities. North American Journal of Fisheries Management 5:330–339.

De Schamphelaere, K.A., and C.R. Janssen. 2004. Bioavailability and Chronic Toxicity of Zinc to Juvenile Rainbow Trout (*Oncorhynchus mykiss*): Comparison with Other Fish Species and Development of a Biotic Ligand Model. Environmental Science and Technology 38:6201–6209.

Dominguez, F., E. Rivera, D.P. Lettenmaier, and C.L. Castro. 2012. Changes in Winter Precipitation Extremes for the Western United States under a Warmer Climate as Simulated by Regional Climate Models. Geophysical Research Letters 39(5).

Doney, S.C., M. Ruckelshaus, J.E. Duffy, J.P. Barry, F. Chan, C.A. English, H.M. Galindo, J.M. Grebmeier, A.B. Hollowed, N. Knowlton, J. Polovina, N.N. Rabalais, W.J. Sydeman, and L.D. Talley. 2012. Climate Change Impacts on Marine Ecosystems. Annual Review of Marine Science 4:11–37.

Ecology. 2020a. Washington State Coastal Atlas Map. Washington State Department of Ecology, Accessed January 31, 2020. <https://fortress.wa.gov/ecy/coastalatlas/tools/Map.aspx>.

Ecology. 2020b. Washington State Water Quality Assessment, 303(d)/305(b) List. Washington State Department of Ecology, Accessed January 31, 2020. <https://fortress.wa.gov/ecy/waterqualityatlas/map.aspx>.

Eisler, R. 1993. Zinc Hazards to Fish, Wildlife, and Invertebrates: A Synoptic Review. U.S. Department of the Interior, Fish and Wildlife Service. Biological Report 10.

EPA. 1987. Ambient Water Quality Criteria for Zinc – 1987. U.S. Environmental Protection Agency, Publication 440/5-87-003, Washington, District of Columbia. February.

ESA. 2017. City of Snohomish Shoreline Master Program Shoreline Inventory and Characterization. Prepared for City of Snohomish by Environmental Science Associates, June 2010, updated May 2017.

Everett and Pentac. 2001. Salmon Overlay to the Snohomish Estuary Wetland Integration Plan. Prepared by City of Everett, Planning and Community Development and Pentec Environmental, March 12.

Feely, R.A., T. Klinger, J.A. Newton, and M. Chadsey (*editors*). 2012. Scientific Summary of Ocean Acidification in Washington State Marine Waters. NOAA Office of Oceanic and Atmospheric Research Special Report.

Feist, B.E., E.R. Buhle, P. Arnold, J.W. Davis, and N.L. Scholz. 2011. Landscape ecotoxicology of coho salmon spawner mortality in urban streams. Plos One 6(8):e23424.

Fresh, K.L., E. Casillas, L.L. Johnson, and D.L. Bottom. 2005. Role of the estuary in the recovery of Columbia River Basin salmon and steelhead: An evaluation of the effects of selected factors on salmonid population viability. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-NWFSC-69. 105p.

Frisch, A.J., and T.A. Anderson. The Response of Coral Trout (*Plectropomus leopardus*) to Capture, Handling, and Transport and Shallow Water Stress. Fish Physiology and Biochemistry 23(1):23–24.

Giattina, J.D., R.R. Garton, and D.G. Stevens. 1982. Avoidance of Copper and Nickel by Rainbow Trout as Monitored by a Computer-Based Data Acquisition System. Transactions of the American Fisheries Society 111:491–504.

Glick, P., J. Clough, and B. Nunley. 2007. Sea-Level Rise and Coastal Habitats in the Pacific Northwest: An Analysis for Puget Sound, Southwestern Washington, and Northwestern Oregon. National Wildlife Federation, Seattle, Washington.

Goode, J.R., J.M. Buffington, D. Tonina, D.J. Isaak, R.F. Thurow, S. Wenger, D. Nagel, C. Luce, D. Tetzlaff, and C. Soulsby. 2013. Potential Effects of Climate Change on Streambed Scour and Risks to Salmonid Survival in Snow-Dominated Mountain Basins. Hydrological Processes 27(5):750–765.

Haas, A., and B. Collins. 2001. A Historical Analysis of Habitat Alterations in the Snohomish River Valley, Washington. Since the Mid-19th Century: Implications for Chinook and Coho Salmon. Tulalip Tribes and Snohomish County Public Works. February.

Hard, J.J., J.M. Myers, M.J. Ford, R.G. Cope, G.R. Pess, R.S. Waples, G.A. Winans, B.A. Berejikian, F.W. Waknitz, P.B. Adams, P.A. Bisson, D.E. Campton, and R.R. Reisenbichler. 2007. Status Review of Puget Sound Steelhead (*Oncorhynchus mykiss*). U.S. Department of Commerce, NOAA Technical Memorandum, NMFS-NWFSC-81.

Harding, L.B., M. Tagal, N. Scholz, J.P. Incardona, and J.K. McIntyre. 2018. Cardiac injury and reduced growth in Pacific herring exposed to urban stormwater runoff. Presented at Salish Sea Ecosystem Conference.

Hecht, S.A., D.H. Baldwin, C.A. Mebane, T. Hawkes, S.J. Gross, and N.L. Scholz. 2007. An overview of sensory effects on juvenile salmonids exposed to dissolved copper: Applying a benchmark concentration approach to evaluate sublethal neurobehavioral toxicity. U.S. Department of Commerce, NOAA Fisheries, NOAA Technical Memorandum NMFS-NWFSC-83. 39 p.

Healey, M.C. 1991. Life History of Chinook Salmon (*Oncorhynchus tshawytscha*). C. Groot and L. Margolis, *editors*. Pacific Salmon Life Histories. UBC Press, Vancouver, British Columbia, Canada.

Hemre, G.I., and A. Krogdahl. 1996. Effect of Handling and Fish Size on Secondary Changes in Carbohydrate Metabolism in Atlantic Salmon, *Salmo salar*. L. Aquaculture Nutrition 2(4):249–252.

Hicken, C.E., T.L. Linbo, D.H. Baldwin, M.L. Willis, M.S. Myers, L. Holland, M. Larsen, M.S. Stekoll, S.D. Rice, T.K. Collier, N.L. Scholz, and J.P. Incardona. 2011. Sublethal exposure to crude oil during embryonic development alters cardiac morphology and reduces aerobic capacity in adult fish. Proceedings of the National Academy of Sciences 108(17):7086-7090.

Isaak, D.J., S. Wollrab, D. Horan, and G. Chandler. 2012. Climate Change Effects on Stream and River Temperatures Across the Northwest US from 1980–2009 and Implications for Salmonid Fishes. Climatic Change 113(2):499–524.

IPCC. 2014. Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II, and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (Core Writing Team, R.K. Pachauri and L.A. Meyer [*editors*]). IPCC, Geneva, Switzerland.

ISAB (*editor*). 2007. Climate change impacts on Columbia River Basin fish and wildlife. *In*: Climate Change Report, ISAB 2007-2. Independent Scientific Advisory Board, Northwest Power and Conservation Council. Portland, Oregon.

Johnson, L., B. Anulacion, M. Arkoosh, O.P. Olson, C. Sloan, S.Y. Sol, J. Spromberg, D.J. Teel, G. Yanagida, and G. Ylitalo. 2013. Persistent organic pollutants in juvenile Chinook salmon in the Columbia River Basin: Implications for stock recovery. Transactions of the American Fisheries Society 142:21-40.

Kunkel, K.E., L.E. Stevens, S.E. Stevens, L. Sun, E. Janssen, D. Wuebbles, K.T. Redmond, and J.G. Dobson. 2013. Regional Climate Trends and Scenarios for the U.S. National Climate Assessment: Part 6. Climate of the Northwest U.S. NOAA Technical Report NESDIS 142-6. National Oceanic and Atmospheric Administration, National Environmental Satellite, Data, and Information Service, Washington, District of Columbia.

Laetz, C.A, D.H. Baldwin, T.K. Collier, V. Hebert, J.D. Stark, and N.L. Scholz. 2009. The Synergistic Toxicity of Pesticide Mixtures: Implications of Risk Assessment and the Conservation of Endangered Pacific Salmon. Environmental Health Perspectives 117(3): 348-353.Lawson, P.W., E.A. Logerwell, N.J. Mantua, R.C. Francis, and V.N. Agostini. 2004. Environmental Factors Influencing Freshwater Survival and Smolt Production in Pacific Northwest Coho Salmon (*Oncorhynchus kisutch*). Canadian Journal of Fisheries and Aquatic Sciences 61(3):360–373.

Love, M.S., M. Carr, and L. Haldorson. 1991. The Ecology of Substrate-Associated Juveniles of the Genus Sebastes. Environmental Biology of Fishes 30:225–243.

Love, M.S., M. Yoklavich, and L. Thorstein. 2002. The Rockfishes of the Northeast Pacific. University of California Press.

Lowrance, R., R. Leonard, and J. Sheridan. 1985. Managing Riparian Ecosystems to Control Nonpoint Source Pollution. Journal of Soil and Water Conservation 40:87–91.

Mantua, N., I. Tohver, and A. Hamlet. 2009. Impacts of Climate Change on Key Aspects of Freshwater Salmon Habitat in Washington State. *In*: The Washington Climate Change Impacts Assessment: Evaluating Washington's Future in a Changing Climate, M.M. Elsner, J. Littell, and L. Whitely Binder, *editors*. pp. 217–253. The Climate Impacts Group, University of Washington, Seattle, Washington.

Mantua, N., I. Tohver, and A. Hamlet. 2010. Climate Change Impacts on Streamflow Extremes and Summertime Stream Temperature and Their Possible Consequences for Freshwater Salmon Habitat in Washington State. Climatic Change 102(1):187–223.

Marine Cadastre. 2020. Marine Cadastre National Viewer. NOAA Office for Coastal Management. Accessed January 31, 2020. <https://marinecadastre.gov/nationalviewer/>.

McIntyre, J.K., D.H. Baldwin, J.P. Meador, and N.L. Scholz. 2008. Chemosensory Deprivation in Juvenile Coho Salmon Exposed to Dissolved Copper Under Varying Water Chemistry Conditions. Environmental Science and Technology 42:6774–6775.

McMahon, T.E., and G.F. Hartman. 1989. Influence of Cover Complexity and Current Velocity on Winter Habitat Use by Juvenile Coho Salmon (*Oncorhynchus kisutch*). Canadian Journal of Fisheries and Aquatic Sciences 46:1551–1557.

Macneale, K.H., P.M. Kiffney, and N.L. Scholz. 2010. Pesticides, aquatic food webs, and the conservation of Pacific Salmon. Front Ecol Environ 8(9): 475-482.

Merz, J.E., and L.K.O. Chan. 2005. Effects of a Gravel Augmentation on Macroinvertebrate Assemblages in a Regulated California River. River Research and Applications 21(1):61–74.

Mitchell, S. 1999. A Simple Model for Estimating Mean Monthly Stream Temperatures After Riparian Canopy Removal. Environmental Management 24:77–83.

Mote, P.W., J.T. Abatzoglou, and K.E. Kunkel. 2013. Climate: Variability and Change in the Past and the Future. *In*: Climate Change in the Northwest: Implications for Our Landscapes, Waters, and Communities, M.M. Dalton, P.W. Mote, and A.K. Snover, *editors*.
pp. 41–58. Island Press, Washington, District of Columbia.

Mote, P., A.K. Snover, S. Capalbo, S.D. Eigenbrode, P. Glick, J. Littell, R. Raymondi, and S. Reeder. 2014. Ch. 21: Northwest. Climate Change Impacts in the United States: The Third National Climate Assessment. J.M. Melillo, Terese (T.C.) Richmond, and G.W. Yohe, *editors*. US Global Change Research Program 487–513.

Mote, P.W., D.E. Rupp, S. Li, D.J. Sharp, F. Otto, P.F. Uhe, M. Xiao, D.P. Lettenmaier, H. Cullen, and M.R. Allen. 2016. Perspectives on the Cause of Exceptionally Low 2015 Snowpack in the Western United States. Geophysical Research Letters, 43, doi:10.1002/2016GLO69665.

Myers, J.M., R.G. Kope, G.J. Bryant, D. Teel, L.J Lierheimer, T.C. Wainwright, W.S. Grant, F.W. Waknitz, K. Neely, S.T. Lindley, and R.S. Waples. 1998. Status Review of Chinook Salmon from Washington, Idaho, Oregon, and California. U.S. Department of Commerce, NOAA Technical Memorandum. NMFS-NWFSC-35.

Newcombe, C.P., and J.O.T. Jensen. 1996. Channel Suspended Sediment and Fisheries: Synthesis for Quantitative Assessment of Risk and Impact. North American Journal of Fisheries Management 16(4):693–727.

NMFS. 2005. Final Assessment of NOAA Fisheries' Critical Habitat Analytical Review Teams for 12 Evolutionarily Significant Units of West Coast Salmon and Steelhead. NOAA Protected Resources Division, Portland, Oregon.

NMFS. 2006. Puget Sound Salmon Recovery Plan, Volume I. Plan adopted by the National Marine Fisheries Service, July 19, 2007.

NMFS. 2018. Endangered Species Act Section 7 Formal Consultation and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Consultation for U.S. Army Corps of Engineers' Proposed 25-Year Maintenance Dredging Program for Eight Federally-Authorized Navigation Channels in Western Washington State.

NMFS. 2019. ESA Recovery Plan for the Puget Sound Steelhead Distinct Population Segment (*Oncorhynchus mykiss*). National Marine Fisheries Service, Seattle, Washington.

NWFSC. 2015. Status Review Update for Pacific Salmon and Steelhead Listed Under the Endangered Species Act: Pacific Northwest. Northwest Fisheries Science Center, December 21.

NWFSC. 2017. Bulldozers Welcome the Tides Back to Prime Salmon Habitat in Snohomish River Estuary. Accessed October 4, 2017. <https://www.nwfsc.noaa.gov/news/features/bulldozers_tides/index.cfm>.

NWIFC. 2016. State of Our Watersheds. A report by Treaty Tribes in Western Washington.

Opperman, J., and A.M. Merenlender. 2004. The Effectiveness of Riparian Restoration for Improving Instream Fish Habitat in Four Hardwood-Dominated California Streams. North American Journal of Fisheries Management 24(3):822–834.

Palsson, W.A., T. Tsou, G.G. Bargmann, R.M. Buckley, J.E. West, M.L. Mills, Y.W. Cheng, and R.E. Pacunski. 2009. The Biology and Assessment of Rockfishes in Puget Sound. Washington Department of Fish and Wildlife.

PFMC. 2005. Amendment 18 (bycatch mitigation program), Amendment 19 (essential fish habitat) to the Pacific Coast Groundfish Fishery Management Plan for the California, Oregon, and Washington Groundfish Fishery. Pacific Fishery Management Council, Portland, Oregon. November.

PFMC. 2014. Appendix A to the Pacific Coast Salmon Fishery Management Plan, as modified by Amendment 18. Identification and Description of Essential Fish Habitat, Adverse Impacts, and Recommended Conservation Measures for Salmon.

Port of Everett. 2020. Union Slough Mitigation Bank & Trail. Port of Everett. Accessed January 30, 2020. <http://www.portofeverett.com/recreation/waterfront-trails/union-slough-mitigation-bank-trail>.

Puget Sound Stream Benthos. 2020. Puget Sound Stream Benthos, Benthic Index of Biotic Integrity: Snohomish River. Accessed January 31, 2020. <https://www.pugetsoundstreambenthos.org/Biotic-Integrity-Scores.aspx?Stream-Area=Snohomish%20River>.

Quinn, T.P. 2005. The Behavior and Ecology of Pacific Salmon and Trout. UW Press.

R2 Resource Consultants. 2008. Snohomish Basin Steelhead Trout (*Oncorhynchus mykiss*) "State of the Knowledge" Technical Memorandum. Prepared for Snohomish Basin Recovery Technical Team, Snohomish County. January 10.

Raymondi, R.R., J.E. Cuhaciyan, P. Glick, S.M. Capalbo, L.L. Houston, S.L. Shafer, and O. Grah. 2013. Water Resources: Implications of Changes in Temperature and Precipitation. *In*: Climate Change in the Northwest: Implications for Our Landscapes, Waters, and Communities, M.M. Dalton, P.W. Mote, and A.K. Snover, *editors*. pp. 41–58. Island Press, Washington, District of Columbia.

Reeder, W.S., P.R. Ruggiero, S.L. Shafer, A.K. Snover, L.L Houston, P. Glick, J.A. Newton, and S.M. Capalbo. 2013. Coasts: Complex Changes Affecting the Northwest's Diverse Shorelines. *In*: Climate Change in the Northwest: Implications for Our Landscapes, Waters, and Communities, M.M. Dalton, P.W. Mote, and A.K. Snover, *editors*. pp. 41–58. Island Press, Washington, District of Columbia.

Rowse, M. and K. Fresh. 2003. Juvenile Salmonid Utilization of the Snohomish River estuary, Puget Sound. *In*: Proceedings of the 2003 Georgia Basin/Puget Sound Research Conference, T.W. Droscher and D.A. Fraser, *editors*.

Sandahl, J.F., D.H. Baldwin, J.J. Jenkins, and N.L. Scholz. 2007. A Sensory System at the Interface Between Urban Stormwater Runoff and Salmon Survival. Environmental Science and Technology 41(8):2998–3004.

Scheuerell, M.D., and J.G. Williams. 2005. Forecasting Climate-Induced Changes in the Survival of Snake River Spring/Summer Chinook Salmon (*Oncorhynchus tshawytscha*). Fisheries Oceanography 14:448–457.

Scholz, N.L., M.S. Myers, S.G. McCarthy, J.S. Labenia, J.K. McIntyre, G.M. Ylitalo, L.D. Rhodes, C.A. Laetz, C.M. Stehr, B.L. French, B. McMillan, D. Wilson, L. Reed, K.D. Lynch, S. Damm, J.W. Davis, and T.K. Collier. 2011. Recurrent die-offs of adult coho salmon returning to spawn in Puget Sound lowland urban streams. Plos One 6(12):e28013.

Seattle Times. 2015. U.S. Recognizes 2 W. Washington Climate-Change Projects. Accessed on January 31, 2020. <https://www.seattletimes.com/seattle-news/environment/us-recognizes-2-w-washington-climate-change-projects/>.

Servizi, J.A., and D.W. Martens. 1991. Effect of Temperature, Season, and Fish Size on Acute Lethality of Suspended Sediments to Coho Salmon (*Oncorhynchus kisutch*). Canadian Journal of Fisheries and Aquatic Sciences 48(3):493–497.

Shared Strategy for Puget Sound. 2007. Puget Sound Chinook Salmon Recovery Plan: Monitoring and Adaptive Management Plan, Volume II. Shared Strategy for Puget Sound, October 31.

Simenstad, C.A., K.L. Fresh, and E.O. Salo 1982. The Role of Puget Sound and Washington Coastal Estuaries in the Life History of Pacific Salmon: An Unappreciated Function. V.S. Kennedy, *editor*. Estuarine Comparisons. Academic Press, New York, New York.

Simenstad, C.A. 1988. Summary and Conclusions from Workshop and Working Group Discussions. Pages 144–152 *in*: Proceedings, Workshop on the Effects of Dredging on Anadromous Pacific Coast Fishes, Seattle, Washington, September 8–9, 1988. C.A. Simenstad, *editor*. Washington Sea Grant Program, University of Washington, Seattle, Washington.

Simenstad, C.A., B.J. Nightengale, R.M. Thom, and D.K. Shreffer. 1999. Impacts of Ferry Terminals on Juvenile Salmon Migrating Along Puget Sound Shorelines, Phase I: Synthesis of State of Knowledge. Final Res. Rept., Res. Proj. T9903, Task A2, Washington State Department of Transportation, Washington State Trans. Center (TRAC), Seattle, Washington.

Snohomish County. 2004. Estuary Map. Snohomish County, Washington, produced April 15, 2004. Accessed January 31, 2020. <https://snohomishcountywa.gov/DocumentCenter/View/9803/Esturary-Map?bidId=>.

Snohomish County. 2017. Snohomish Watershed Salmon Recovery Planning. Accessed on October 17, 2017. <https://snohomishcountywa.gov/1127/Snohomish-Watershed-Salmon-Recovery-Plan>.

Sprague, J.B. 1968. Avoidance Reactions of Rainbow Trout to Zinc Sulphate Solutions. Water Research 2:367–372.

Spromberg, J.A., and J.P. Meador. 2006. Relating chronic toxicity responses to population-level effects: A comparison of population-level parameters for three salmon species as a function of low-level toxicity. Ecological Modeling 199:240-252.

Spromberg, J.A., and N.L. Scholz. 2011. Estimating future decline of wild coho salmon populations resulting from early spawner die-offs in urbanizing watersheds of the Pacific Northwest, USA. Integrated Environmental Assessment and Management 7(4):648-656.

Stehr, C.M., T.L. Linbo, D.H. Baldwin, N.L. Scholz, and J.P. Incardona. 2009. Evaluating the effects of forestry herbicides on fish development using rapid phenotypic screens. North American Journal of Fisheries Management 29(4):975-984.

Sunda, W.G., and W.J. Cai. 2012. Eutrophication Induced CO2-Acidification of Subsurface Coastal Waters: Interactive Effects of Temperature, Salinity, and Atmospheric CO2. Environmental Science & Technology 46(19):10651–10659.

Tague, C. L., J.S. Choate, and G. Grant. 2013. Parameterizing Sub-Surface Drainage with Geology to Improve Modeling Streamflow Responses to Climate in Data Limited Environments. Hydrology and Earth System Sciences 17(1):341–354.

Tierney, K.B., D.H. Baldwin, T.J. Hara, P.S. Ross, N.L. Scholz, and C.J. Kennedy. 2010. Olfactory Toxicity in Fishes, Aquatic Toxicology 96:2–26.

Tillmann, P., and D. Siemann. 2011. Climate Change Effects and Adaptation Approaches in Marine and Coastal Ecosystems of the North Pacific Landscape Conservation Cooperative Region. National Wildlife Federation.

Trudeau, M.P. 2017. State of the knowledge: Long-term, cumulative impacts of urban wastewater and stormwater on freshwater systems. Final Report Submitted to the Canadian Water Network. January 30, 2017.

Wainwright, T.C., and L.A. Weitkamp. 2013. Effects of Climate Change on Oregon Coast Coho Salmon: Habitat and Life-Cycle Interactions. Northwest Science 87(3):219–242.

WDFW. 2020a. Washington State Fish Passage Barrier Mapping. Accessed January 31, 2020. <https://geodataservices.wdfw.wa.gov/hp/fishpassage/index.html>.

WDFW. 2020b. PHS on the Web. Washington Department of Fish and Wildlife, Accessed January 31, 2020. <http://apps.wdfw.wa.gov/phsontheweb/>.

WDNR. 2020. Puget Sound Seagrass Monitoring, Submerged Vegetation Monitoring Program. Washington Department of Natural Resources. Accessed January 31, 2020. <https://wadnr.maps.arcgis.com/apps/webappviewer/index.html?id=83b8389234454abc8725827b49272a31>.

Welsch, D.J. 1991. Riparian Forest Buffers: Functions and Design for Protection and Enhancement of Water Resources. USDA Forest Service, NA-PR-07-91. Radnor, Pennsylvania.

Wheeler, A.P., P.L. Angermeier, and A.E. Rosenberger. 2005. Impacts of New Highways and Subsequent Landscape Urbanization on Stream Habitat and Biota. Reviews in Fisheries Science 13(3):141–164.

Winder, M., and D.E. Schindler. 2004. Climate Change Uncouples Trophic Interactions in an Aquatic Ecosystem. Ecology 85:2100–2106.

WSDOT. 2009. Final Wetland Vegetation Response to Shade Special Study Technical Memorandum. Prepared for Washington State Department of Transportation, Federal Highway Administration, and Sound Transit. August.

WSDOT. 2016. WSDOT Fish Exclusion Protocols and Standards. Washington State Department of Transportation. September.

WSDOT. 2018. Biological Assessment for SR 529 Steamboat Slough Mitigation Site. WSDOT Project No. A00549B/XL5468, USACE Reference No. NWS-2018-697-DOT.

WSDOT. 2019. Biological Assessment: I-5/NB Marine View Drive to SR 529 Corridor and Interchange Improvements Project. Prepared for Washington State Department of Transportation, Northwest Region. December 9.

WSDOT. 2020. Traffic Geoportal. Washington State Department of Transportation. Accessed March 31, 2020. <https://www.wsdot.wa.gov/data/tools/geoportal/?config=traffic>.

Yamanaka, K.L., L.C. Lacko, R. Withler, C. Grandin, J.K. Lochead, J.C. Martin, and S.S. Wallace. 2006. A Review of Yelloweye Rockfish *Sebastes ruberrimus* Along the Pacific Coast of Canada: Biology, Distribution, and Abundance Trends. Department of Fisheries and Oceans, Ottawa, Ontario, Canada.

Yang, Z., and T. Khangaonkar. 2008. Modeling of Salt Intrusion, Intertidal Mixing, and Circulation in a Braided Estuary. Journal of Coastal Research, Special Issue No. 52. Surface Water Modeling, pp. 171–180.

Young, A., Kochenkov, V., McIntyre, J.K., Stark, J.D., and Coffin, A.B. 2018. Urban stormwater runoff negatively impacts lateral line development in larval zebrafish and salmon embryos. Scientific Reports 8: 2830.

Zabel, R.W., M.D. Scheuerell, M.M. McClure, and J.G. Williams. 2006. The Interplay Between Climate Variability and Density Dependence in the Population Viability of Chinook Salmon. Conservation Biology 20(1):190–200.