FINAL ENVIRONMENTAL IMPACT STATEMENT
and SECTION 4(f) and 6(f) EVALUATIONS
SR 520 BRIDGE REPLACEMENT AND HOV PROGRAM

MAY 2011

SR 520, I-5 to Medina: Bridge Replacement and HOV Project

Attachment 18
Biological Opinions

U.S. Department of Transportation
Federal Highway Administration

Washington State
Department of Transportation

USFWS Biological Opinion

United States Department of the Interior

FISH AND WILDLIFE SERVICE

Washington Fish and Wildlife Office
510 Desmond Dr. SE, Suite 102
Lacey, Washington 98503

APR 15 2011

In Reply Refer To:
13410-2011-F-0063

Daniel M. Mathis
Division Administrator
Federal Highway Administration
Evergreen Plaza Building
711 Capitol Way South, Suite 501
Olympia, Washington 98501-1284

ATTN: Randy Everett

Dear Mr. Mathis:

This document transmits the U.S. Fish and Wildlife Service's Biological Opinion (Opinion) based on our review of the proposed State Route 520, Interstate-5 to Medina Bridge Replacement and HOV Project, and its effects on the bull trout (*Salvelinus confluentus*) and designated bull trout critical habitat, in accordance with section 7 of the Endangered Species Act of 1973, as amended (16 U.S.C. 1531 *et seq.*).

Your request for initiation of formal consultation, dated November 23, 2010, was received in our office on November 24, 2010. The Federal Highway Administration (FHWA) provided information in support of "may affect, likely to adversely affect" determinations for the bull trout and bull trout critical habitat. On February 11, 2011, we received from the Washington State Department of Transportation and FHWA written responses to our requests for additional information relevant to the effect determinations for the bull trout and bull trout critical habitat.

The enclosed Opinion addresses the proposed action's adverse effects on the bull trout and bull trout critical habitat, and includes mandatory terms and conditions intended to minimize certain adverse effects. The FHWA has determined that the proposed project will have "no effect" on several listed species and critical habitat known to occur in Grays Harbor, King, Pierce, and Thurston Counties, Washington. There is no requirement for the U.S. Fish and Wildlife Service to concur on "no effect" determinations and, therefore, your determinations that the project will have no effect on these species and critical habitat rest with the action agency.

TAKE PRIDE IN AMERICA

If you have any questions regarding the Opinion or your responsibilities under the Endangered Species Act, please contact Ryan McReynolds at (360) 753-6047 or Emily Teachout at (360) 753-9583 of this office.

Sincerely,

Ken S. Berg, Manager
Washington Fish and Wildlife Office

cc:
FHWA, Seattle, WA (R. Everett)
WSDOT, Seattle, WA (A. Hanson)
WSDOT, Seattle, WA (M. Meade)
WSDOT, Olympia, WA (P. Wagner)

Endangered Species Act - Section 7 Consultation

BIOLOGICAL OPINION

U.S. Fish and Wildlife Service Reference: 13410-2011-F-0063

State Route 520, Interstate-5 to Medina Bridge Replacement and HOV Project

Grays Harbor, King, Pierce, Snohomish, Thurston, and Whatcom Counties, Washington

Agency:

Federal Highway Administration
Olympia, Washington

Consultation Conducted By:

U.S. Fish and Wildlife Service
Washington Fish and Wildlife Office
Lacey, Washington

Ken S. Berg, Manager
Washington Fish and Wildlife Office

7-15-11
Date

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LIST OF ACRONYMS AND ABBREVIATIONS

Act	Endangered Species Act of 1973, as amended (16 U.S.C. l531 *et seq.*)
AKART	All Known, Available and Reasonable Technologies
BA	Biological Assessment
BMP	Best Management Practices
Cd	cadmium
Cr	chromium
CSO	combined sewer system overflows
CSS	combined sewer system
CTC	Concrete Technology Corporation
Cu	Copper
DO	dissolved oxygen
EPA	U.S. Environmental Protection Agency
FHWA	Federal Highway Administration
FMO	Foraging, Migration and Overwintering
HOV	High-Occupancy Vehicle
I-5	Interstate 5
MHHW	mean higher high-water
Ni	Nickel
NPDES	National Pollutant Discharge Elimination System
NTU	Nephelometric Turbidity Units
OHWM	Ordinary High Water Mark
Opinion	Biological Opinion
PAH	polycyclic aromatic hydrocarbons

Pb	lead
PCB	polychlorinated biphenyls
PCE	Primary Constituent Elements
PEL	Probable Effect Levels
PGIS	pollution-generating impervious surface
RPM	Reasonable and Prudent Measures
SEL	sound exposure level
Service	U.S. Fish and Wildlife Service
SEV	Severity of Effect
SL	sound level
SPL	sound pressure level
SQG	sediment quality guidelines
SR	State Route
TDA	threshold discharge areas
TEL	Threshold Effect Levels
TL	transmission loss
TMDL	Total Maximum Daily Load
TSS	Total suspended solids
TTS	Temporary Threshold Shift
USACE	U.S. Army Corps of Engineers
WDOE	Washington State Department of Ecology
WSDOT	Washington State Department of Transportation
Zn	Zinc

CONSULTATION HISTORY

The Washington State Department of Transportation (WSDOT) and the Federal Highway Administration (FHWA) propose safety and mobility improvements along approximately five miles of State Route (SR) 520, between the Interstate-5 (I-5)/SR 520 interchange in Seattle, Washington, and the SR 520/92nd Avenue NE interchange in Yarrow Point, Washington.

The proposed action would address existing structural deficiencies along one of metro-Seattle's, and the region's, most important commuter, transit, and freight corridors. The proposed action will also establish a six thru-lane configuration (four west- and east-bound general purpose lanes; two west- and east-bound HOV/transit lanes), and thereby increase traffic capacity, improve levels of service, and reduce current and projected traffic congestion and travel times. The proposed action also includes environmental enhancements in the form of improved multi-modal access, taller bridges and approaches, treatment for highway stormwater runoff, and a suite of mitigation proposals specifically aimed at addressing limiting factors for native fish production in the Lake Washington watershed.

In addition to the corridor improvements along SR 520, the proposed action includes compensatory mitigation conducted elsewhere within the Lake Washington watershed and additional activities at existing port and industrial facilities located across six counties in western Washington (Grays Harbor, King, Pierce, Snohomish, Thurston, and Whatcom Counties). The proposed action includes production, storage, and outfitting of floating bridge pontoons and anchors at existing port and industrial facilities in Olympia, Tacoma, Seattle, Everett, and Bellingham.

The proposed project is funded in part by the FHWA, and will require a Clean Water Act section 404 permit from the U.S. Army Corps of Engineers (USACE). Federal funding and issuance of a section 404 permit establish a nexus requiring consultation under section 7(a)(2) of the Endangered Species Act of 1973, as amended (16 U.S.C. l53I *et seq.*) (Act). The FHWA is the lead federal agency for this action.

The U.S. Fish and Wildlife Service (Service) based this Biological Opinion (Opinion) on the following sources of information: 1) the Biological Assessment (BA), dated November 2010 and received November 24, 2010, 2) exchanges of information dated February 11, February 23, and February 25, 2011, 3) a field review of the project site(s), and 4) various scientific literature and personal communications cited herein. A complete record of this consultation is on file at the Washington Fish and Wildlife Office in Lacey, Washington.

The following timeline summarizes the history of this consultation:

Spring 2000 through Fall 2010 – The Service provides technical assistance through early involvement during the National Environmental Policy Act, Signatory Agency Committee, and Safe Accountable Flexible Efficient Transportation Equity Act environmental review processes.

March 2008 through October 2010 – The WSDOT and the Service engage in regular, twice-monthly meetings and conference calls to discuss design issues, conservation measures, information needs in support of consultation, and other related matters in advance of the initiation of consultation.

June 2010 through September 2010 – The Service participates in a series of Natural Resource Technical Working Group meetings and workshops held with the WSDOT, Muckleshoot Indian Tribe, Washington State Department of Fish and Wildlife (WDFW), National Marine Fisheries Service (NMFS), USACE, City of Seattle, and other interested parties and permit authorities in order to identify, evaluate, and prioritize mitigation elements and proposals that would offset potential temporary and permanent impacts to aquatic resources.

November 24, 2010 – The FHWA submits a BA providing information in support of "may affect, likely to adversely affect" determinations for the bull trout *(Salvelinus confluentus)* and designated bull trout critical habitat. The Service initiates consultation with receipt of the BA on November 24, 2010.

January 12, 2011 – The Service transmits a letter concurring with the FHWA's effect determinations for the bull trout and designated bull trout critical habitat, and requesting additional information relevant to the potential effects of the proposed action.

February 11, 2011 – The FHWA transmits a letter providing responses to the Service's requests for additional information.

February 17, 2011 – The Service meets with the FHWA and WSDOT to discuss draft terms and conditions.

February 23, 2011 – The FHWA provides written responses addressing draft terms and conditions.

February 25, 2011 – The FHWA provides bubble curtain design specifications and identifies one change to the proposed mitigation component.

March 21, 2011 – The Service shares a copy of the draft Opinion with the FHWA for their review.

February 4, 6, and 7, 2011 – The Service negotiates final changes to the Opinion with the FHWA, including details related to in-water work windows, impact pile driving without an attenuation device, and hydroacoustic monitoring.

BIOLOGICAL OPINION

DESCRIPTION OF THE PROPOSED ACTION

The WSDOT and the FHWA propose safety and mobility improvements along approximately five miles of SR 520, between the I-5/SR 520 interchange in Seattle, Washington, and the SR 520/92nd Avenue NE interchange in Yarrow Point, Washington.

The proposed action would improve mobility and address existing structural deficiencies along one of the most important commuter, transit, and freight corridors in the region. In addition to the corridor improvements, the proposed action also includes activities elsewhere within the Lake Washington watershed (compensatory mitigation) and at existing port and industrial facilities located across six counties in western Washington (Grays Harbor, King, Pierce, Snohomish, Thurston, and Whatcom Counties).

The WSDOT and the FHWA propose the following as elements of the SR 520, I-5 to Medina Bridge Replacement and HOV Project:

- Traffic safety and mobility improvements at the I-5/SR 520 interchange, including a new reversible high-occupancy vehicle (HOV) ramp, a lid over SR 520, and enhanced pedestrian facilities;

- Replacement of the existing, structurally deficient (seismically-vulnerable) SR 520 bridges and ramps over Portage Bay;

- Traffic safety and mobility improvements at the SR 520/Montlake Boulevard interchange, including a large, new lid providing enhanced transit and bicycle/pedestrian facilities, a new bascule bridge built in-parallel to the existing bascule bridge over the Montlake Cut, and related surface street improvements;

- Replacement of the existing, structurally deficient (seismically-vulnerable) west and east approaches to the SR 520 floating bridge across Lake Washington;

- Production, storage, and outfitting of floating bridge pontoons and anchors at existing port and industrial facilities in Grays Harbor, Olympia, Tacoma, Seattle, Everett, and Bellingham;

- Replacement of the existing, structurally deficient SR 520 floating bridge;

- Construction of new bridge maintenance facilities (building, dock, and moorage) below and adjacent to the east approach;

- Reconfiguration of the Evergreen Point Road transit facility, lane restriping, and other improvements between Evergreen Point Road and 92nd Avenue NE so as to provide a seamless HOV and transit network; and,

- Compensatory mitigation for unavoidable impacts to wetlands, buffers, aquatic resources, and parks (multiple sites throughout the Lake Washington watershed).

The proposed action is part of the WSDOT's larger program of transit, safety, and mobility improvements along SR 520, between the I-5/SR 520 interchange in Seattle, and the SR 520/SR 202 interchange in Redmond (WSDOT 2010a, p. 1-1). The program includes two additional projects that the FHWA has determined have independent utility. Corridor improvements extending between Evergreen Point Road and the SR 520/SR 202 interchange were the subject of an independent section 7 consultation completed during 2009 (SR 520, Medina to SR 202 Eastside Transit and HOV Project; FWS Ref. No. 13410-2008-I-0601). Construction and operation of a pontoon casting basin located in Grays Harbor, production, moorage/storage, outfitting, and delivery of finished pontoons to Lake Washington, and emergency repair of the existing floating bridge span in the event of catastrophic failure were the subject of an independent section 7 consultation completed during 2010 (SR 520, Pontoon Construction Project; FWS Ref. No. 13410-2010-F-0497).

The legal description for the proposed corridor improvements is Section 24, Township 25 North, Range 5 East, and Sections 20, 21, and 22, Township 25 North, Range 4 East. The action includes compensatory mitigation activities proposed at multiple sites throughout the Lake Washington watershed, and activities conducted at existing port and industrial facilities in Grays Harbor, Olympia, Tacoma, Seattle, Everett, and Bellingham. Legal descriptions for these additional activities, and the names assigned to these locations by the WSDOT for the purpose of permitting, are identified below (Table 1).

Figure 1 depicts the on-corridor project limits. Figure 2 depicts port locations and shipping routes.

Table 1. Off-corridor legal locations.

Mitigation Activities		
Site Name	County	Legal Location
Washington Department of Natural Resources Parcel No. 0723059105	King	Section 7, Township 23 North, Range 4 East
Cedar River (Multiple Parcel Numbers)	King	Section 23, Township 23 North, Range 5 East
Seward Park Parcel No. 2324049007	King	Sections 14, 23, and 24, Township 24 North, Range 4 East
Magnuson Park Parcel No. 0225049061	King	Sections 1 and 2, Township 24 North, Range 4 East
Taylor Creek (Multiple Parcel Numbers)	King	Section 1, Township 23 North, Range 4 East
Bear Creek (Multiple Parcel Numbers)	King	Sections 11 and 12, Township 25 North, Range 5 East
Union Bay Natural Area Parcel No. 1625049001	King	Sections 15 and 16, Township 25 North, Range 4 East
WSDOT-Owned Peninsula Parcel No. 212504UNKN	King	Section 21, Township 25 North, Range 4 East
Washington Park Arboretum Parcel No. 2125049044	King	Sections 21 and 28, Township 25 North, Range 4 East
Washington Park Arboretum West (Bryant Building) Parcel No. 1142004555	King	Section 17, Township 25 North, Range 4 East
Activities at Existing Port and Industrial Facilities		
Site Name	County	Legal Location
Port of Grays Harbor (Terminals T1-T4)	Grays Harbor	Section 10, Township 17 North, Range 10 West
Port of Olympia	Thurston	Sections 39 and 42, Township 18 North, Range 2 West
Port of Tacoma	Pierce	Sections 22, 25-28, and 33-36, Township 21 North, Range 3 East; and, Sections 1, 2, 37, and 38, Township 20 North, Range 3 East
Port of Seattle	King	Section 31, Township 25 North, Range 4 East; Sections 6, 7, and 18, Township 24 North, Range 4 East; and, Sections 12 and 13, Township 24 North, Range 3 East
Port of Everett	Snohomish	Sections 7, 8, 18, 19, and 30, Township 29 North, Range 5 East
Port of Bellingham	Whatcom	Sections 25, 26, 36, and 43 Township 38 North, Range 2 East; and, Section 30, Township 38 North, Range 3 East

Figure 1. On-corridor project limits (WSDOT 2010a, p. 2-3).

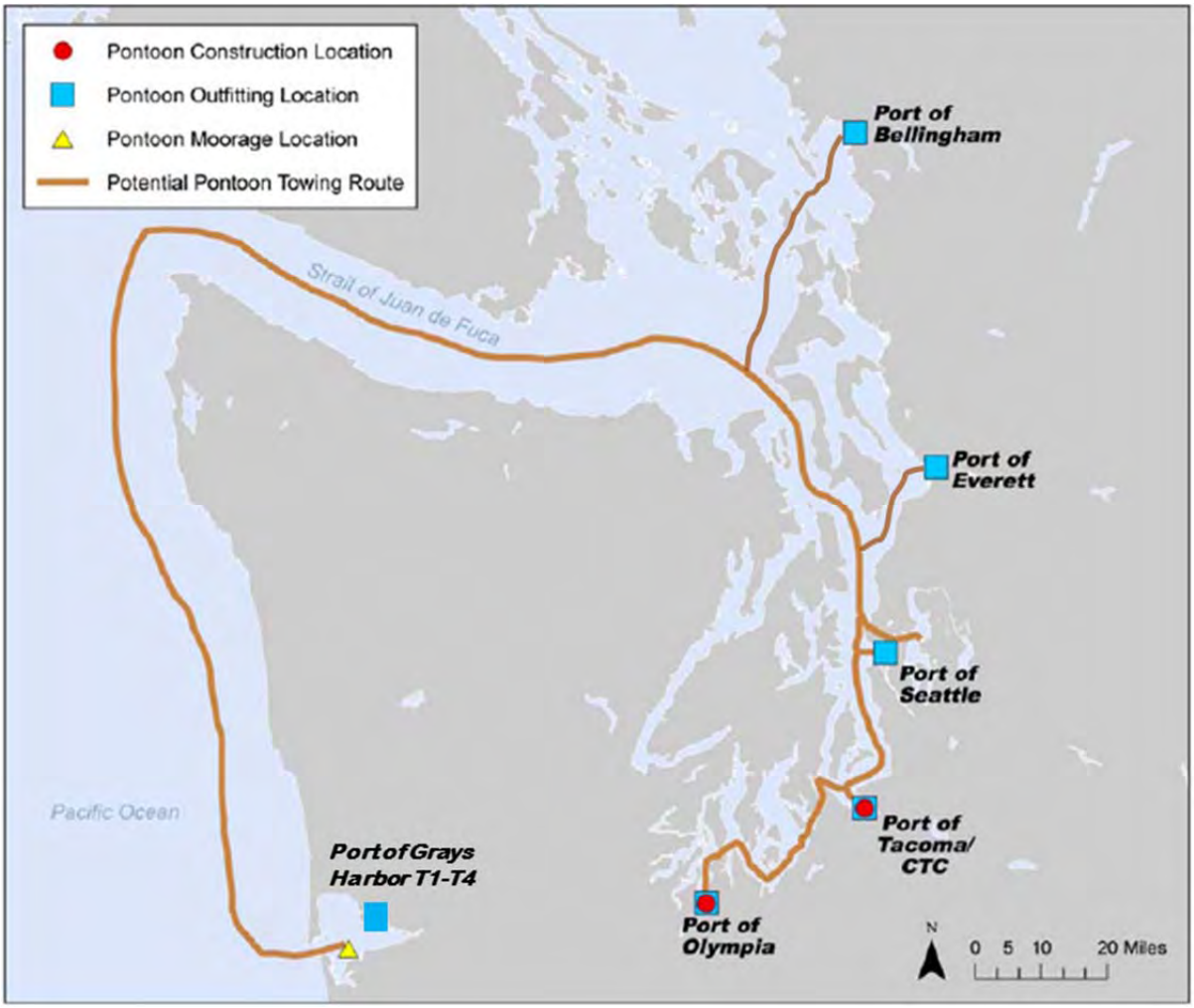


Figure 2. Port locations and shipping routes (WSDOT 2010a, p. 2-59).

The sub-sections that follow discuss the project elements and items of work in greater detail. A complete description is contained in the BA submitted by the WSDOT and the FHWA (WSDOT 2010a). Those descriptions are incorporated here by reference, except where they have been revised or amended as agreed to during the course of consultation and documented in correspondence between the FHWA and the Service.

SR 520 Corridor Improvements

The proposed action will establish a six thru-lane configuration, two general purpose lanes and one HOV/transit lane in each direction, between the I-5/SR 520 interchange in Seattle, and the SR 520/84th Avenue NE interchange in Yarrow Point. The action will improve transit, HOV, and multi-modal access, improve levels of service, and reduce current and projected traffic congestion and travel times.

I-5/SR 520 Interchange

Through this portion of the corridor the proposed traffic safety and mobility improvements include a new reversible HOV ramp, a wide lid with public green-space (10th Avenue East and Delmar Avenue East), enhanced bicycle and pedestrian facilities, and stormwater conveyance and treatment systems (WSDOT 2010a, pp. 2-5, 2-6, 2-62 thru 2-64).

Portage Bay and Montlake

Through this portion of the corridor the proposed traffic safety and mobility improvements include:

- A new, wider and higher bridge over Portage Bay, constructed on drilled shafts and mudline footings with approximately 53 in-water concrete columns, and providing six thru-lanes plus a westbound managed shoulder (WSDOT 2010a, pp. 2-5, 2-6, 2-64 thru 2-70);

- A large, new lid constructed above SR 520 at the Montlake Boulevard interchange, providing enhanced transit and bicycle/pedestrian facilities, public green-space, and surface street connections (WSDOT 2010a, pp. 2-7 thru 2-9, 2-74 thru 2-78);

- A new bascule bridge built in-parallel to the existing bascule bridge over the Montlake Cut (WSDOT 2010a, pp. 2-7 thru 2-9, 2-74 thru 2-78); and,

- Stormwater conveyance and treatment systems, including two, large, constructed stormwater treatment wetlands providing enhanced treatment for highway runoff (WSDOT 2010a, pp. 2-64 and 2-75).

Floating Span and Approaches

Through this portion of the corridor the proposed traffic safety and mobility improvements include:

- New, wider and higher bridges and approaches over Union Bay (extending from south of the Montlake Cut, to east of Foster Island) and Lake Washington, constructed on drilled shafts and mudline footings (east approach only) with approximately 236 in-water concrete columns, and providing six thru-lanes plus bicycle/pedestrian facilities (WSDOT 2010a, pp. 2-11, 2-15, 2-80 thru 2-85, 2-98 thru 2-101);

- A new, wider and higher, six-lane floating bridge with bicycle/pedestrian facilities, spanning the deepest portions of Lake Washington, aligned to the north of the existing floating bridge, and composed of approximately 77 hollow, concrete pontoons, 58 floating bridge pontoon anchors, and a steel and concrete superstructure (WSDOT 2010a, pp. 2-11 thru 2-15, 2-91 thru 2-94); and,

- Stormwater conveyance and treatment systems, including the same constructed stormwater treatment wetland serving the Montlake vicinity (referred to as MOHAI or WS-PR), a small bioswale beneath and adjacent to the east approach, and an innovative stormwater treatment method for the floating bridge developed in cooperation with the Washington State Department of Ecology (WDOE) (WSDOT 2010b) (WSDOT 2010a, pp. 2-80, 2-81, 2-109 thru 2-112).

Eastside Transition and Other Improvements

Additional improvements include:

- Reconfiguration of the Evergreen Point Road transit facility, and lane restriping between Evergreen Point Road and 92nd Avenue NE, to provide a seamless HOV and transit network (WSDOT 2010a, pp. 2-15 thru 2-17); and,

- New bridge maintenance facilities, including an approximately 12,000 ft^2 building, dock (with approximately five in-water concrete columns), and two-boat moorage, constructed below and adjacent to the east approach (WSDOT 2010a, pp. 2-15, 2-101, 2-102).

Stormwater Design

The project area includes approximately 71 acres of existing pollution-generating impervious surface (PGIS), associated with the I-5 and SR 520 thru-lanes, bridges, approaches, ramps, interchanges, and intersecting surface streets. At completion of the proposed project, the project area will include approximately 84 acres of "effective" PGIS, which excludes non-pollution-generating portions of the lids and roadways beneath lids. Most of the net-new PGIS will be located within three threshold discharge areas, and will drain and discharge after treatment at three distinct locations (WS-D, WS-PR or MOHAI, and WS-BR4 along the floating bridge span). A portion of the stormwater runoff originating from within the project limits will continue to enter the City of Seattle's combined sewer system (WSDOT 2010a, pp. 2-18, 2-104 thru 2-109).

The project's proposed stormwater treatment design would provide basic or enhanced treatment for runoff originating from approximately 69 acres of PGIS. This represents a stormwater treatment retrofit of more than 500 percent of the net-new PGIS by area. Where practicable, given siting and other considerations, the project will provide enhanced treatment for improved solids and metals control (approximately 35 acres), in the form of constructed stormwater treatment wetlands. The stormwater treatment design also includes an innovative, enhanced treatment method for runoff originating from the floating bridge. This method, which includes at a minimum, a maintenance program of monthly high-efficiency sweeping and twice-annual catch basin cleaning, was developed in cooperation with the WDOE through a study and evaluation of "All Known, Available and Reasonable Technologies" for treatment (AKART) (WSDOT 2010b). All stormwater runoff originating from within the project limits discharges to flow control exempt waterbodies (Lake Union, Portage Bay, the Montlake Cut, Union Bay, Lake Washington, and Fairweather Bay). Therefore, the proposed stormwater design does not include detention or infiltration facilities. Stormwater entering the City of Seattle's combined sewer

system is routed to the West Point Wastewater Treatment Plant, which ultimately discharges treated wastewater to the Puget Sound (WSDOT 2010a, pp. 2-108 thru 2-114).

The conditionally-approved AKART treatment method for stormwater runoff originating from the floating bridge is subject to a site-specific program of monitoring and reporting. This monitoring will confirm achievement of AKART predictions and allow for adaptive management of the site-specific maintenance program (Fitzpatrick, pers. comm. 2010).

Conservation Measures – Design

In addition to improved transit, HOV, and multi-modal access, and treatment for highway stormwater runoff, the proposed action includes other environmental enhancements. These include taller bridges and approaches with fewer in-water columns, and a lighting design intended to reduce potential effects to aquatic resources. The action also includes a suite of mitigation proposals specifically aimed at addressing limiting factors for native fish production in the Lake Washington watershed; that element is described in a sub-section that follows (*Mitigation Components*).

The proposed action includes a corridor alignment selected to reduce, where possible, impacts to sensitive resources, including wetlands, buffers, and parks. The corridor improvements utilize increased bridge span lengths, to reduce the total number of in-water columns and their footprint. To the extent practicable, the proposed bridges and approaches are elevated to reduce shading on adjacent wetlands and waters, and to facilitate stormwater conveyance and treatment.

The proposed lighting design will reduce the amount of artificial light cast onto adjacent waters. This improvement upon the existing conditions will be most evident along the west approach and floating bridge, where the total number of roadway light fixtures will be reduced by more than 50 percent (WSDOT 2010a, p. 2-115).

Where the corridor improvements extend over, or are directly adjacent to waters, roadway lighting will be limited to conflict points such as merges (on-ramps, off-ramps), auxiliary lanes, and weaving sections. Similar to the current roadway lighting configuration, the project will place continuous lighting along the SR 520 corridor, from I-5 to Foster Island, and on bridges crossing the Montlake Cut. However, except for the interim west approach connection (i.e., a temporary condition during construction), no roadway lighting is proposed for the fixed portions of the bridge east of Foster Island (including the floating span). Recessed lighting will illuminate the proposed bicycle and pedestrian path along these structures, but will be shielded to reduce incident light on the adjacent waters. Along the proposed maintenance dock below and adjacent to the east approach, the lighting design includes on-demand overhead lighting, and only low-intensity path lighting would remain on at all times (WSDOT 2010a, pp. 2-18, 2-14 thru 2-117).

To the extent practicable, the proposed lighting design will limit incident light levels on adjacent waters to approximately 2.0 foot-candles at all locations. However, along the west approach, preliminary designs suggest it should be possible to limit incident light to considerably lower levels (0.2 foot-candles or less) (WSDOT 2010a, p. 6-152).

Construction Methods, Schedule, and Quantities

The FHWA expects that final design and construction of the proposed project will commence under a series of individual contracts. Construction would be phased, beginning with replacement of the most vulnerable structures (floating bridge and approaches, Portage Bay bridge), before completing the other corridor improvements (Montlake interchange, I-5/SR 520 interchange, etc.). Construction is scheduled to commence during 2012 and will require more than six years to complete (WSDOT 2010a, pp. ES -1, 2-63).

The subsections that follow provide additional details specific to the construction elements, beginning with those activities conducted at existing port and industrial facilities in Olympia, Tacoma, Seattle, Everett, and Bellingham (i.e., production, storage, and outfitting of floating bridge pontoons and anchors). A complete description is contained in the BA submitted by the WSDOT and the FHWA (WSDOT 2010a).

Pontoon Construction

The proposed corridor improvements include replacement of the existing, structurally deficient SR 520 floating bridge. The new floating bridge will require approximately 77 hollow, concrete, cross, longitudinal, and supplemental stability pontoons. Some of these pontoons are being constructed at the Grays Harbor casting basin as part of the SR 520 Pontoon Construction Project (FWS Ref. No. 13410-2010-F-0497), but additional pontoons will be needed, and these are proposed for construction at the Ports of Olympia and Tacoma (WSDOT 2010a, pp. 2-51 thru 2-57).

At the existing Port of Olympia facility, pontoon construction will be a largely land-based operation, with the exception of the launching of the finished pontoons. Submersible barges will be used to launch pontoons from deep water locations in the south Puget Sound.

At the existing Port of Tacoma facilities, the Concrete Technology Corporation (CTC) casting basin and adjacent sites, most of these operations will be land-based. However, the CTC casting basin opens directly to tidally-influenced portions of the Blair Waterway (Commencement Bay), and the FHWA acknowledges a risk of fish entrainment during gate openings and float-out of finished pontoons.

Pontoon construction at the Port of Tacoma facilities will require approximately ten CTC casting basin gate openings, scheduled for between August 2012 and June 2014. The project will thoroughly clean the finished pontoons and casting basin prior to opening the gate to prevent introducing deleterious materials to the adjacent waters. After float-out of the finished pontoons, and in conjunction with subsequent dewatering of the closed casting basin (using screened pumps), the project will capture and release any entrained fish to adjacent waters. The project will implement the WSDOT's *Fish Exclusion Protocols and Standards* (WSDOT 2009) to minimize the risk of physical injury and lessen sources of stress during fish capture and handling operations.

Anchor Construction

The new SR 520 floating bridge will require approximately 58 large, fluke or gravity anchors. The FHWA expects that many of these anchors will be fabricated at the existing Port of Olympia and/or Port of Tacoma facilities (WSDOT 2010a, pp. 2-38 thru 2-41, 2-51, 2-52).

Fabrication of bridge pontoon anchors is an entirely land-based operation. For the sake of providing added flexibility, this Opinion assumes that the project may fabricate anchors at any of the same port and industrial facilities the project intends to use for pontoon outfitting (discussed below). These facilities are located in Grays Harbor, Olympia, Tacoma, Seattle, Everett, and Bellingham.

Pontoon Outfitting

Once constructed, finished floating bridge pontoons must be outfitted with their modular, over-water components (or superstructure). This outfitting includes steelwork, and the forming and pouring of concrete, conducted on top of the finished pontoons while berthed at existing port and industrial facilities (WSDOT 2010a, pp. 2-60, 2-61).

In addition to outfitting performed on Lake Washington near the final bridge alignment, the project may also use existing facilities in the Ports of Grays Harbor, Olympia, Tacoma, Seattle, Everett, and Bellingham (Figure 2, p. 7), provided this use and activity is consistent with the current, established uses of those facilities. The FHWA has identified two site selection criteria:

- Only existing deep water berths with appropriate infrastructure; and,
- No needed improvements requiring in-water work.

Pontoon Storage, Transport, and Delivery

Finished pontoons will be transported along established shipping routes, between Grays Harbor, the Ports of Olympia and Tacoma, and existing port and industrial facilities in Grays Harbor, Olympia, Tacoma, Seattle, Everett, and Bellingham (Figure 2, p. 7). After outfitting, and when needed for the next phase of construction on Lake Washington, the project will again transport pontoons along established shipping routes and the Lake Washington Ship Canal (Ballard Locks through Montlake Cut). In the event that pontoons require temporary moorage in the Puget Sound, the same site selection criteria identified for outfitting (above) shall apply for temporary moorage locations (WSDOT 2010a, pp. 2-59 thru 2-61).

If stored for more than 6 months, pontoons constructed and/or outfitted in Grays Harbor will be inspected for marine growth prior to transport via open-water shipping routes (WSDOT 2010a, p. 2-57). Inspections will be completed at the Port of Grays Harbor (Terminals T1-T4), or other approved locations. If inspections find significant growth, the project will clean the pontoon(s) to reduce the risk of transporting invasive plants, algae, or invertebrates from Grays Harbor. Methods of invasive species control have not yet been determined, but are likely to include mechanical methods (e.g., power scrubbers and scrapers).

Portage Bay (Methods, Schedule, and Quantities)

The BA describes construction methods common to those portions of the project located in Portage Bay, Union Bay, and Lake Washington, including use of barges and temporary work bridges, temporary piling and permanent drilled casing installation, use of cofferdams and construction site water treatment systems, footing and column construction, demolition methods and procedures, etc. (WSDOT 2010a, pp. 2-18 thru 2-37, 2-43 thru 2-51). Those descriptions are relevant to this sub-section, and those that follow.

Replacement of the SR 520 bridges and ramps over Portage Bay will require six years of construction (2013-2018). All work below the Ordinary High-Water Mark (OHWM) will be completed between August 16 and April 30 of each construction year unless completely isolated from adjacent waters (e.g., with the use of cofferdams), with one exception. Some of the existing bridge and approach columns are located where they interfere with placement of the temporary work trestles. To avoid a lengthy delay in the construction timeline, the FHWA proposes approximately 50 working days of in-water work outside the work window described above demolish the columns. Controlled demolition and removal of these existing bridge and approach columns will be accomplished with the use of a concrete saw or shears operated at or near the mudline (Bloch, pers. comm. 2011b).

Any pile driving with an impact hammer will be completed between September 1 and April 30 (FHWA et al., pers. comm. 2011). Approximately 1,300 temporary steel piles will be installed during 2013, 2015, and 2017, and then removed during years 2016 and 2018. The project will install six cofferdams for the purpose of building three mudline footings, temporarily affecting approximately 14,000 ft^2 of substrate in total. The combined total over-water area of the existing, temporary, and new bridges, ramps, and trestles will peak during year 2015 at approximately 11.1 acres (Table 2). At completion of the project, and with removal of all existing and temporary structures, the new bridges and ramps will occupy approximately 7.6 acres (Table 2). The new bridges and ramps will have a simpler, but larger, permanent in-water footprint; approximately 53 in-water concrete columns and three mudline footings will occupy approximately 15,300 ft^2 of substrate (WSDOT 2010a, pp. 2-64 thru 2-74, 2-160, 6-8 thru 6-10, 6-19).

Montlake (Methods, Schedule, and Quantities)

Construction activities at the Montlake interchange, including construction of a new bascule bridge built parallel to the existing bascule bridge over the Montlake Cut, will require four or five years of construction (starting in 2013). Construction of the new bascule bridge will be an almost entirely land-based operation, with only a few activities (e.g., delivery of equipment and materials, placement of draw bridge spans) requiring temporary, short-duration use of barges positioned over adjacent waters. At completion of the project, the new and existing bascule bridges will occupy approximately 0.4 acre (Table 2) (WSDOT 2010a, pp. 2-74 thru 2-79, 6-42 thru 6-45).

Table 2. Combined total over-water structure, by location and year.

	Combined Total Over-Water Structure (Acres)							
	Current	2013	2014	2015	2016	2017	2018	Built
Portage Bay	3.1	8.9	8.9	11.1	9.3	5.2	9.6	7.6
Montlake Cut	0.2	0.2	0.2	0.2	0.2	0.4	0.4	0.4
Union Bay - Arboretum Vic.	5.9	9.2	12.3	16.6	16	12.7	12.7	8.4
West Approach	4.8	8.3	15.8	19.1	17.4	13.9	13.9	10.6
Sub-Total		**26.6**	**37.2**	**47.0**	**42.9**	**32.2**	**36.6**	
Floating Span (Begins 2012...)	12.1	29.5	34	21.9	21.9	21.9	21.9	21.9
East Approach (Begins 2012...)	0.3	2.4	2.4	2.4	1.3	1.3	1.3	1.3
Project Total	26.4	58.5	73.6	71.3	66.1	55.4	59.8	50.2
							Net =	Plus 23.8

Union Bay – Arboretum (Methods, Schedule, and Quantities)

Replacement of the SR 520 bridges and ramps over the Union Bay portion of Lake Washington will require six years of construction (2013-2018). Consistent with the findings and recommendations of an In-Water Work Technical Working Group convened by the WSDOT, work below the OHWM through this portion of the project area will not be subject to the constraints of a defined in-water work window (FHWA et al., pers. comm. 2011). However, pile driving with an impact hammer is an exception. Pile driving with an impact hammer will be completed between September 1 and April 30 of each construction year.

Approximately 1,100 temporary steel piles will be installed during 2013 and 2015, and then removed during years 2016 and 2018. The combined total over-water area of the existing, temporary, and new bridges, ramps, and trestles will peak during year 2015 at approximately 16.6 acres (Table 2). At completion of the project, and with removal of all existing and temporary structures, the new bridges and ramps will occupy approximately 8.4 acres (Table 2). The new bridges and ramps will have a simpler, but larger, permanent in-water footprint; approximately 104 in-water concrete columns will occupy approximately 8,400 ft^2 of substrate (WSDOT 2010a, pp. 2-80 thru 2-91, 2-160, 6-48 thru 6-50, 6-56, 6-63).

West Approach (Methods, Schedule, and Quantities)

Replacement of the fixed SR 520 bridges and ramps over Union Bay and Lake Washington will require six years of construction (2013-2018). All work below the OHWM will be completed between August 1 and April 30 of each construction year unless completely isolated from adjacent waters (e.g., with the use of cofferdams), with one exception. Some of the existing bridge and approach columns are located where they interfere with placement of the temporary work trestles. To avoid a lengthy delay in the construction timeline, the FHWA proposes approximately 10 working days of in-water work outside the work window described above to demolish the columns. Controlled demolition and removal of these existing bridge and approach columns will be accomplished with the use of a concrete saw or shears operated at or near the mudline (Bloch, pers. comm. 2011b).

Any pile driving with an impact hammer will be completed between October 1 and April 15 (FHWA et al., pers. comm. 2011). The project will place during years 2013 and 2015, and then remove during years 2016 and 2018, a total of approximately 950 temporary steel piles. The combined total over-water area of the existing, temporary, and new bridges, ramps, and trestles will peak during year 2015 at approximately 19.1 acres (Table 2). At completion of the project, and with removal of all existing and temporary structures, the new bridges and ramps will occupy approximately 10.6 acres (Table 2). The new bridges and ramps will have a simpler, but larger, permanent in-water footprint; approximately 129 in-water concrete columns will occupy approximately 10,320 ft^2 of substrate (WSDOT 2010a, pp. 2-80 thru 2-91, 2-160, 6-74 thru 6-76, 6-83. 6-86, 6-92).

Floating Span (Methods, Schedule, and Quantities)

Replacement of the floating bridge will require three or four years of construction starting in 2012. The new floating span will be assembled along an alignment located approximately 190 ft north of the existing alignment, and will require an interim west approach connection. The combined total over-water area of the new and existing bridges, ramps, and temporary connections will peak during year 2014 at approximately 34.0 acres (Table 2). At completion of the project, and with removal of all existing and temporary structures, the new bridge will occupy approximately 21.9 acres (Table 2).

The project will install approximately 58 fluke or gravity anchors for the new floating span; a few of the shallowest locations may require temporary or permanent pile anchors. Fluke anchors, positioned on soft substrates at depths in excess of 180 ft, will be installed with the use of high-pressure water jets. Gravity anchors, positioned on hard substrates at depths between 60 and 180 ft, will require minor excavation and/or fill placement with a crane-operated clamshell bucket. The project proposes to abandon in-place the existing bridge pontoon anchors. The new bridge pontoon anchors will occupy, and/or disturb during installation, approximately 3.3 acres of lake bottom substrate (WSDOT 2010a, pp. 2-38 thru 2-42, 2-47, 2-48, 2-91 thru 2-97, 2-161, 6-110, 6-111, 6-114, 6-116).

All in-water work, work below the OHWM, will be completed between July 16 and March 15 of each construction year. However, this work is mostly limited to the installation of bridge

pontoon anchors. Anchor installations nearest the east approach will be completed between September 1 and May 15 (FHWA et al., pers. comm. 2011). The vast majority of the work involved in replacing the floating span will be completed at the surface from temporary barges, and on top of the new and existing pontoons. This work may occur at any time of year, although unpredictable weather conditions make it unlikely that assembly will occur during winter months (WSDOT 2010a, pp. 2-97, 2-161).

East Approach (Methods, Schedule, and Quantities)

Replacement of the SR 520 bridges and ramps over the east shore of Lake Washington will require three or four years of construction starting in 2012. All in-water work, work below the OHWM, will be completed between July 1 and May 15 of each construction year, unless completely isolated from adjacent waters with cofferdams. Any pile driving with an impact hammer will be completed between August 16 and March 15 (FHWA et al., pers. comm. 2011). The project will place during years 2012 and 2013, and then remove during year 2015, a total of approximately 165 temporary steel piles. The project will install one or two cofferdams for the purpose of building two mudline footings, temporarily affecting approximately 8,900 ft^2 of substrate in total. The combined total over-water area of the existing, temporary, and new bridges, ramps, and trestles will peak during years 2013 to 2015 at approximately 2.4 acres (Table 2). At completion of the project, and with removal of all existing and temporary structures, the new bridges and ramps will occupy approximately 1.3 acres (Table 2). The new bridges and ramps will have a simpler, but larger, permanent in-water footprint. The east approach bridges and ramps, and adjacent maintenance dock, will have nine concrete columns, and a combined in-water footprint of approximately 8,500 ft^2 (WSDOT 2010a, pp. 2-98 thru 2-104, 2-161, 6-125 thru 6-127, 6-135 thru 6-139).

Off-Site Demolition and Final Disposition of Pontoons and Other Materials

The project will produce large quantities of concrete rubble and reinforcing steel waste. These materials have economic value and most, if not all, of the materials will be transported off-site for recycling, processing, and reuse. The FHWA expects that the project will use barge and rail transport methods, transfer facilities (including those at the north and south ends of Lake Washington), and material processing operators located at existing facilities (WSDOT 2010a, pp. 2-48, 2-49).

Upon disassembly of the floating span, the project will make the existing concrete pontoons available for private purchase. Any future use(s) of the pontoons shall comply with applicable local, State, and Federal laws, at the responsibility of the purchaser. If not sold for appropriate reuse, pontoons will be transported to existing port and industrial facilities for demolition and material recycling (WSDOT 2010a, p. 2-49).

Conservation Measures – Construction

The FHWA has identified a number of minimization measures and best management practices (BMPs) for construction (WSDOT 2010a, pp. 2-56, 2-149 thru 2-161, 6-11, 6-50). Those descriptions are incorporated here by reference, except where they have been revised or amended

as agreed to during the course of consultation and documented in correspondence between the FHWA and the Service. What follows is a brief summary of those conservation measures that were revised or amended during the course of consultation, or that are of particular relevance to the potential effects of the action.

- When isolating and dewatering areas below the OHWM (e.g., cofferdam installation), including when dewatering the CTC casting basin at the Port of Tacoma, the project will implement the WSDOT's *Fish Exclusion Protocols and Standards* (WSDOT 2009).

- The project will use a vibratory hammer when installing steel piles to the fullest extent practicable. Except for the purpose of proofing piles and determining load-bearing capacity, the project will not resort to use of an impact hammer(s) unless and until site conditions are encountered that prevent effective use of a vibratory hammer(s).

- Any pile driving with an impact hammer(s) will be completed during in-water work windows specific to the activity and location (FHWA et al., pers. comm. 2011).

- When impact driving and proofing steel piles, the project will implement a bubble curtain noise attenuation device. The bubble curtain shall meet all design and performance criteria outlined in specifications used for the SR 520 Test Pile project (Appendix A) (Bloch, pers. comm. 2011d).

- The project will limit the total number of unattenuated pile strikes (i.e., pile strikes without the use of a bubble curtain) to 500 strikes per day, when determining baseline sound levels along the east approach (Bloch, pers. comm. 2011b).

- The project will require use of vegetable-based fluids and fuels for equipment operating below the OHWM.

- The project Spill Prevention, Control, and Countermeasures plan(s) will identify designated refueling and equipment maintenance areas, specify physical and procedural BMPs, and provide for security and secondary containment of any stored fuels or other hazardous materials.

- Watertight curbs, bull rails, or toe boards will be installed around the perimeter of work bridges, platforms, and barges to contain potential spills and prevent materials, tools, and debris from leaving the over-water structure. These applications will be installed with a minimum vertical height of 10 inches.

- The project will not operate tug boats in depths shallower than 10 ft to reduce the potential for turbidity resulting from propeller wash.

- Mitigation sites will adhere to an integrated vegetation and pest management plan that includes both mechanical removal (cutting and/or mowing) and focused application of a non-residual herbicide with low non-target toxicity.

Mitigation Components

The proposed action includes compensatory mitigation for unavoidable impacts to wetlands, buffers, aquatic resources, and parks, tentatively planned for completion at multiple sites throughout the Lake Washington watershed (Table 1, p. 5). Off-site mitigation components will seek to replace in-kind the functions and values that are directly or indirectly affected by the action, including both temporary and permanent effects to aquatic resources (i.e., fish life and their habitat) (WSDOT 2010a, pp. 2-119 thru 2-147, 2-150 thru 2-152).

The BA provides a description of each proposed mitigation component. Those descriptions are incorporated here by reference, except where they have been revised or amended as agreed to during the course of consultation and documented in correspondence between the FHWA and the Service. Two revisions are summarized below.

The BA identifies one mitigation opportunity (Beer Sheva Park) which has been subsequently removed from the list of candidate sites (Bloch, pers. comm. 2011c). Instead, the FHWA now proposes compensatory mitigation at Taylor Creek, a site which offers better opportunities for functional up-lift.

The FHWA will report to the Service at a later date, the final list of compensatory mitigation sites and activities. The FHWA will make the Joint Aquatic Resource Permit Application plan submittals available to the Service for review and comment. The FHWA will monitor implementation, and adaptively manage all mitigation components to ensure attainment of anticipated functions and values.

ACTION AREA

The action area is defined as 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). In delineating the action area, we evaluated the farthest reaching physical, chemical, and biotic effects of the action on the environment.

The proposed action would improve safety and mobility along one of the region's most important commuter, transit, and freight corridors. In addition to the corridor improvements along SR 520, the proposed action includes compensatory mitigation activities elsewhere within the Lake Washington watershed, and activities at existing port and industrial facilities located across six counties in western Washington (Grays Harbor, King, Pierce, Snohomish, Thurston, and Whatcom Counties).

When performed at existing port and industrial facilities, floating bridge pontoon and anchor construction, pontoon outfitting and storage, and other off-site activities (e.g., waste material recycling, processing, and reuse) represent activities consistent with current, established uses. No temporary or permanent effects to the environment will extend from these facilities more than a few hundred ft.

For the period of construction, the aquatic component of the action area has been defined to include the following:

- The geographic extent of temporary increases in underwater sound;
- The geographic extent of temporary increases in turbidity and sedimentation; and
- The geographic extent of the open-water shipping routes along which the project will transport pontoons and materials (Figure 2, p. 7; including the Lake Washington Ship Canal).

Temporary increases in underwater sound are expected to have the farthest reaching effects in the aquatic environment during construction. Our assessment of underwater sound transmission finds that, at some locations (e.g., the east approach), temporary increased sound levels resulting from impact pile driving are likely to exceed ambient sound levels to a distance of several miles. However, the presence of landforms and shallow bathymetry will limit transmission to a portion of Lake Washington, Union Bay, and Portage Bay (Figure 3).

The proposed action includes mitigation components to compensate for unavoidable impacts to wetlands, buffers, aquatic resources, and parks. Construction of this off-site mitigation will include work in, and adjacent to, portions of Lake Washington and its shoreline, Union Bay and its shoreline, Portage Bay and its shoreline, and major tributaries (Cedar River, a tributary to Lake Washington; Bear Creek, a tributary to the Sammamish River). At each of these locations the FHWA has stated, and the Service expects, that temporary effects will not extend more than 300 ft from the site boundary (WSDOT 2010a, p. 3-11).

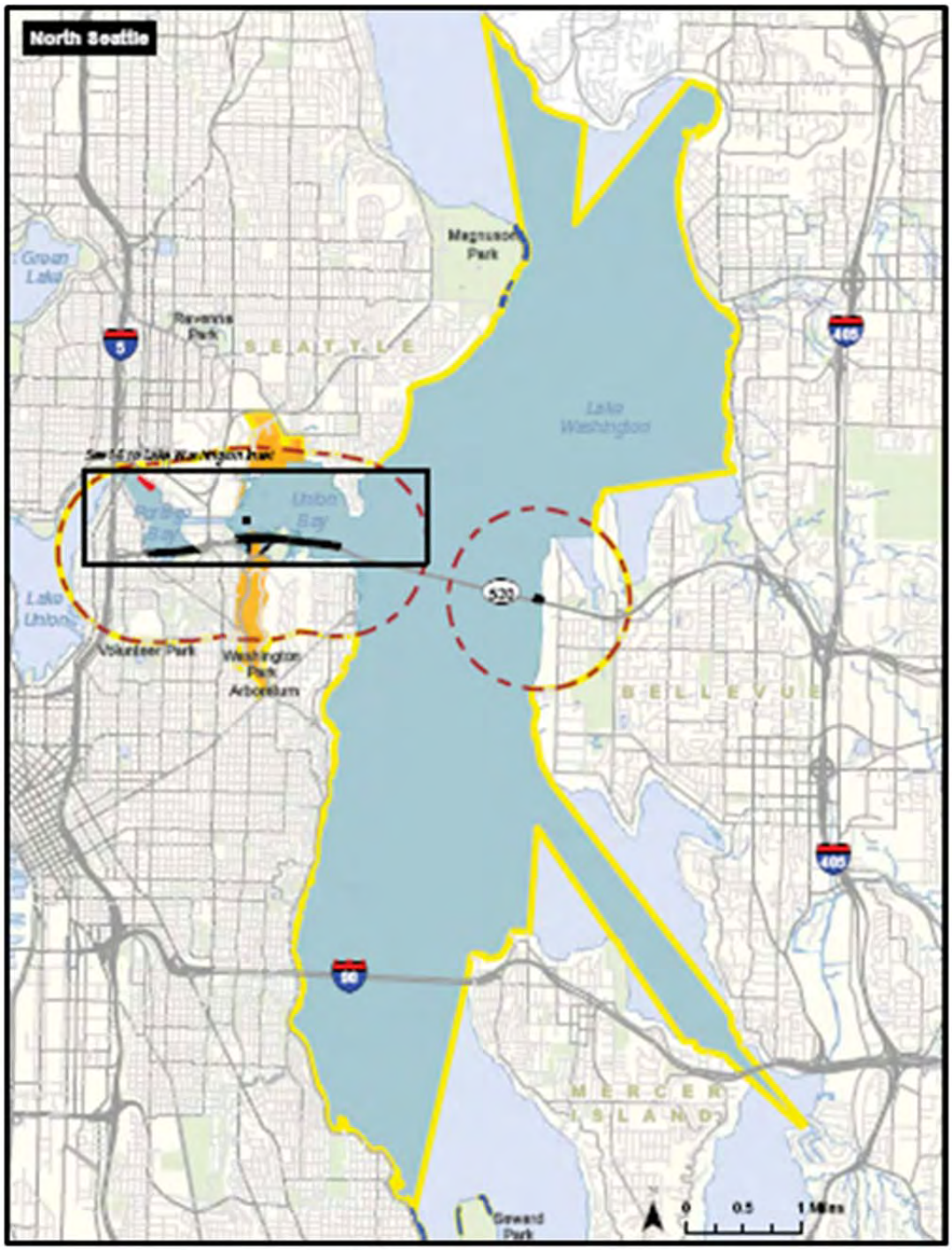


Figure 3. Extent of temporary underwater and in-air sound (WSDOT 2010a, p. 3-3).

Beyond the period of construction, the proposed action will have long term or permanent effects, including effects resulting from off-site mitigation performed at sites throughout the Lake Washington watershed. The terrestrial and aquatic components of the action area include the geographic extent of any measurable, potential effects to sediment or water quality; the geographic extent of any measurable effects to functions or processes important to maintaining

aquatic habitat over time; and, the geographic extent of any foreseeable, indirect effects to land use development (i.e., changes in development pattern, rate, or intensity), and resulting effects to the environment.

The Service expects that the proposed action will have a modest, but persistent, effect on sediment and surface water quality in Lake Washington (including Union and Fairweather Bays), Portage Bay, and Lake Union. The proposed action includes mitigation components which we expect will have long term beneficial effects to aquatic habitats and functions at the scale of the Lake Washington watershed.

The FHWA has assessed potential indirect effects to land use development (pattern, rate, or intensity). The BA finds that the action will alter traffic circulation patterns along a zone of influence extending from the I-5/SR 520 interchange in Seattle, to the SR 520/SR 202 interchange in Redmond (WSDOT 2010a, p. 6-182 and Appendix H). Our assessment of potential indirect effects to land use development focuses on the identified zone of influence.

ANALYTICAL FRAMEWORK FOR THE JEOPARDY AND ADVERSE MODIFICATION DETERMINATIONS

Jeopardy Determination

In accordance with policy and regulation, the jeopardy analysis in this Opinion relies on four components: (1) the *Status of the Species*, which evaluates the species' rangewide condition, the factors responsible for that condition, and its survival and recovery needs; (2) the *Environmental Baseline*, which evaluates the condition of the species in the action area, the factors responsible for that condition, and the relationship of the action area to the survival and recovery of the species; (3) the *Effects of the Action*, which determines the direct and indirect impacts of the proposed Federal action and the effects of any interrelated or interdependent activities on the species; and (4) *Cumulative Effects*, which evaluates the effects of future, non-Federal activities in the action area on the species.

In accordance with policy and regulation, the jeopardy determination is made by evaluating the effects of the proposed Federal action in the context of the species' current status, taking into account any cumulative effects, to determine if implementation of the proposed action is likely to cause an appreciable reduction in the likelihood of both the survival and recovery of the species in the wild.

The jeopardy analysis in this Opinion places an emphasis on consideration of the rangewide survival and recovery needs of the species and the role of the action area in the survival and recovery of the species as the context for evaluating the significance of the effects of the proposed Federal action, taken together with cumulative effects, for purposes of making the jeopardy determination.

Adverse Modification

This Opinion does not rely on the regulatory definition of "destruction or adverse modification" of critical habitat at 50 CFR 402.02. Instead, we have relied upon the statutory provisions of the Act to complete the following analysis with respect to critical habitat.

In accordance with policy and regulation, the adverse modification analysis in this Opinion relies on four components: (1) the *Status of Critical Habitat*, which evaluates the rangewide condition of designated critical habitat for the species in terms of primary constituent elements (PCEs), the factors responsible for that condition, and the intended recovery function of the critical habitat overall; (2) the *Environmental Baseline*, which evaluates the condition of the critical habitat in the action area, the factors responsible for that condition, and the recovery role of the critical habitat in the action area; (3) the *Effects of the Action*, which determines the direct and indirect impacts of the proposed Federal action and the effects of any interrelated or interdependent activities on the PCEs and how that will influence the recovery role of affected critical habitat units; and (4) *Cumulative Effects*, which evaluates the effects of future, non-Federal activities in the action area on the PCEs and how that will influence the recovery role of affected critical habitat units.

For purposes of the adverse modification determination, the effects of the proposed Federal action on critical habitat are evaluated in the context of the rangewide condition of the critical habitat, taking into account any cumulative effects, to determine if the critical habitat rangewide would remain functional (or would retain the current ability for the PCEs to be functionally established in areas of currently unsuitable but capable habitat) to serve its intended recovery role for the species.

The analysis in this Opinion places an emphasis on using the intended rangewide recovery function of critical habitat, and the role of the action area relative to that intended function as the context for evaluating the significance of the effects of the proposed Federal action, taken together with cumulative effects, for purposes of making the adverse modification determination.

STATUS OF THE SPECIES (BULL TROUT)

The rangewide status of the bull trout is provided in Appendix B.

STATUS OF CRITICAL HABITAT (BULL TROUT)

The rangewide status of bull trout critical habitat is provided in Appendix C.

ENVIRONMENTAL BASELINE

Regulations implementing the Act (50 CFR 402.02) define the environmental baseline as the past and present impacts of all Federal, State, or private actions and other human activities in the action area. Also included in the environmental baseline are the anticipated impacts of all proposed Federal projects in the action area that have undergone section 7 consultation, and the impacts of State and private actions which are contemporaneous with the consultation in progress. We describe here only those portions of the action area where we anticipate measurable effects to listed species, their prey base, or habitat.

Environmental Baseline in the Action Area

The BA provides extensive information to describe baseline conditions in the action area (WSDOT 2010a, pp. 4-3 thru 4-13):

- Lake Washington watershed conditions, including patterns of development;
- Lake Washington hydrology and altered hydrology;
- Shoreline and riparian conditions, and altered conditions;
- Water and sediment quality, including status as an impaired waterbody (Lake Washington; Ship Canal and Lake Union); and,
- Wetland and upland conditions and function.

The BA also compiles and presents data and literature to describe (WSDOT 2010a):

- Salmonid habitat function zones, from west of Portage Bay, through the Union Bay-Arboretum vicinity, and the west bridge and east bridge approach vicinities (pp. 4-13 thru 4-15);
- Salmonid migration and rearing in the Lake Washington watershed, including findings from hydroacoustic tracking studies (Appendix F, pp. F-1 thru F-17); and,
- Predator-prey interactions in Lake Washington, including the influence of non-native, predatory species (Appendix G, pp. G-1 thru G-9).

This information is too extensive to summarize here, and instead this Opinion incorporates the information by reference. Below we present, in summary form, our assessment of aquatic habitat function using the *Matrix of Diagnostics/Pathways and Indicators* (USFWS 1998). The *Matrix* is a tool for describing whether habitat is “functioning adequately”, “functioning at risk”, or “functioning at unacceptable levels of risk” at the scales of the action area and watershed (Table 3).

Table 3. Baseline aquatic habitat conditions and function.

Pathway	Indicator	Action Area	Watershed
Water Quality	Temperature	Unacceptable Risk	At Risk
	Sediment	Unacceptable Risk	At Risk
	Chemical Contamination & Nutrients	Unacceptable Risk	At Risk
Habitat Access	Physical Barriers	At Risk	At Risk
Habitat Elements	Substrate	At Risk	At Risk
	Large Woody Debris	Unacceptable Risk	At Risk
	Pool Frequency/Quality	At Risk	At Risk
	Large Pools	At Risk	At Risk
	Off-Channel Habitat	Unacceptable Risk	At Risk
	Refugia	At Risk	At Risk
Channel Conditions & Dynamics	Width/Depth Ratio	At Risk	At Risk
	Streambank Condition	At Risk	At Risk
	Floodplain Connectivity	Unacceptable Risk	At Risk
Flow/ Hydrology	Peak/Base Flows	Functioning Adequately	At Risk
	Drainage Network	Unacceptable Risk	Unacceptable Risk
Watershed Conditions	Road Density/Location	Unacceptable Risk	At Risk
	Disturbance History	At Risk	At Risk
	Riparian Reserve	Unacceptable Risk	At Risk

Status of the Species in the Action Area

Lake Washington FMO

Lake Washington and its tributaries, including the Cedar and Sammamish Rivers, provide FMO habitat for anadromous subadult and adult bull trout. The tributaries to Lake Washington are not believed to support local populations or spawning, but do provide FMO habitat located outside of the eight identified core areas of the Puget Sound Management Unit. Migratory bull trout use habitat located outside of their spawning and early rearing habitat to forage, migrate, and overwinter (Brenkman and Corbett, in litt. 2003a,b in USFWS 2004). FMO habitat is important to bull trout of the Puget Sound Management Unit for maintaining diversity of life history forms and for providing access to productive foraging areas (USFWS 2004).

Lake Washington is located outside of the eight bull trout core areas identified within the Puget Sound Management Unit, and the potential for spawning in the Lake Washington basin is low (USFWS 2004). We expect that subadult and adult bull trout foraging and migrating in the action area are most likely from the Puyallup, Snohomish-Skykomish, and/or Skagit River core areas, based on their proximity to Lake Washington, and the fact that they support robust bull trout populations and a significant anadromous component to the population.

Lake Washington FMO habitat consists of the lower Cedar River (below Cedar Falls), Sammamish River, Lake Washington, Lake Sammamish, Lake Union, the Lake Washington Ship Canal, and all accessible tributaries (USFWS 2004). Population status information and extent of use is poorly understood or known. Subadult and adult sized individuals have been observed infrequently in the lower Cedar River (below Cedar Falls), Carey Creek (a tributary to Upper Issaquah Creek), Lake Washington, and at the Chittenden Locks. No spawning activity or juvenile rearing has been observed and no distinct spawning populations are known to exist in Lake Washington outside of the upper Cedar River above Lake Chester Morse.

The potential for spawning in the Lake Washington basin is low because the majority of accessible habitat is low elevation, below 152 m (500 ft), and not expected to have the proper thermal regime to sustain successful spawning. There are, however, some coldwater springs and tributaries that may come close to suitable spawning temperatures and that may provide thermal refuge during warm summer periods. These include Rock Creek (tributary to the Cedar River below Landsburg Diversion) and Coldwater Creek, a tributary to Cottage Lake Creek immediately below Cottage Lake. Coldwater Creek is a major temperature modifier for both Cottage Lake and Big Bear Creeks. Cottage Lake Creek below Coldwater Creek exhibits a much lower temperature profile than any other tributary to Big Bear Creek. High temperatures in Big Bear Creek are moderated by this flow to its confluence with the Sammamish River. Both Coldwater and Rock Creeks are relatively short, 1.6 to 3.2 km (1 to 2 mi) in length, have high quality riparian forest cover, and are formed by springs from glacial outwash deposits.

Upper reaches of Holder and Carey Creeks, the two main branches of Issaquah Creek, have good to excellent habitat conditions and may hold potential for bull trout spawning due to their elevation and aspect. However, despite survey efforts by King County (Berge and Mavros 2001; KCDNRP 2002), no evidence of bull trout spawning or rearing has been found. Holder Creek drains the eastern slopes of Tiger Mountain, elevation of 914 m (3,000 ft), and the southwestern slopes of South Taylor Mountain. Coho are found in Holder Creek up to an elevation of about 360 m (1,200 ft) and cutthroat trout occur up to 427 m (1,400 ft) in elevation.

Carey Creek originates at an elevation of roughly 700 m (2,300 ft) in a broad saddle on the southeastern slopes of South Taylor Mountain. It is the only stream in the north Lake Washington/Sammamish drainage with a relatively recent char sighting. The single observation of a pair of native char in the fall of 1993 (WDFW 1998) was about 0.8 km (0.5 mi) downstream from an impassable, approximately 12-m (40-ft) high falls, which is at an elevation of approximately 256 m (840 ft). Thus, habitat in which the pair of char was observed was potentially too low for successful spawning.

A number of observations of subadult and adult bull trout have been made in Lake Washington (Berge, pers comm 2003; KCDNRP 2000; Shepard and Dykeman 1977). Connection with the Chester Morse Lake core area (population located in the upper Cedar River) is one-way only, and currently the level of connectivity with other core areas is unknown. Observations of bull trout in the Chittenden Locks suggest migration from other watersheds is likely occurring.

Bull trout were caught in Shilshole Bay and the Chittenden Locks during late spring and early summer in both 2000 and 2001. In 2000, up to eight subadult and adult fish (mean size 370 mm; 14.5 in) were caught between May and July in Shilshole Bay below the locks. These fish were found preying upon juvenile salmon (40 percent of diet) and marine forage fish (60 percent of diet) (Footen 2000; 2003). In 2001, five adult bull trout were captured from areas within the locks and immediately below the locks. One bull trout was captured in the large locks during June, and one adult was captured during May at the head of the ladder in the adult steelhead trap while migrating upstream through the fish ladder. Three adult bull trout were also captured below the tailrace during the peak of juvenile salmon migration on June 18 (Goetz, pers comm 2003).

Aside from spawning, the Lake Washington drainage has potential benefits and challenges to subadult and adult bull trout. Two large lakes with high forage fish availability are dominant parts of the lower watershed and provide significant foraging habitat. However, recent decades have seen development on a large scale, with an attendant decline in the quality of aquatic environments. The Washington State Conservation Commission has provided a good summary of limiting factors for salmonids in the Cedar-Sammamish (Lake Washington) basin (Kerwin 2001).

The BA compiles and presents data and literature to describe (WSDOT 2010a):

- Salmonid habitat function zones, from west of Portage Bay, through the Union Bay-Arboretum vicinity, and the west bridge and east bridge approach vicinities (pp. 4-13 thru 4-15);

- Salmonid migration and rearing in the Lake Washington watershed, including findings from hydroacoustic tracking studies (Appendix F, pp. F-1 thru F-17); and,

- Predator-prey interactions in Lake Washington, including the influence of non-native, predatory species (Appendix G, pp. G-1 thru G-9).

Adult and subadult bull trout may occupy these waters at any time of year. However, an estimate of the number of bull trout that forage, migrate, and overwinter in the action area is not available. Given the limited number of reported observations, and because current information suggests that Lake Washington and its tributaries do not support local populations or spawning, it is reasonable to assume that low numbers of bull trout are likely to forage, migrate, and overwinter in the action area. While it is difficult to discern a regular pattern of migration and distribution for these bull trout, available data and the species' life history requirements both suggest that bull trout are more likely to occur in these waters during months coinciding with

juvenile salmonid outmigration (spring and early summer), and least likely during those months when (most) anadromous bull trout return to their natal systems to spawn (late August through December).

Nearshore Marine Waters

The Ports of Grays Harbor, Olympia, Tacoma, Seattle, Everett, and Bellingham are located in developed nearshore marine waters. The content that follows is taken verbatim from the Service's *Draft Bull Trout Recovery Plan, Vol. I* (USFWS 2004, pp. 44-46, 134-137, and 179-182). While patterns of development, and resulting effects to the nearshore marine ecosystem, have undergone substantial changes over the past six or eight years, this document still provides the best available, most comprehensive, general discussion of bull trout marine FMO habitat functions and conditions.

Marine FMO habitat includes portions of Puget Sound and associated nearshore and estuarine areas. Puget Sound can be subdivided into five regions: 1) North Puget Sound; 2) Main Basin; 3) Whidbey Basin; 4) South Puget Sound; and 5) Hood Canal (NMFS 2000c). The Hood Canal basin is part of the Olympic Peninsula Management Unit.

The average depth of Puget Sound is 62.5 m (205 ft) at mean low tide, the average surface water temperature is 12.8 degrees Celsius (55.0 degrees Fahrenheit) in summer and 7.2 degrees Celsius (44.0 degrees Fahrenheit) in winter (Staubitz et al. 1997). Estuarine circulation in Puget Sound is driven by tides, gravitational forces, and freshwater inflows. Significant variability in tidal heights occurs throughout Puget Sound. The major sources of freshwater are the Skagit and Snohomish Rivers located in Whidbey Basin. Fresh water flows into the Sound at an average rate of four billion cubic m (140 billion cubic ft) per year. On average, the waters of Puget Sound are effectively replaced twice a year.

Nearshore and estuarine habitats are highly productive due to the complexity of habitats and nutrient inputs. Tidelands, salt marshes, sand- and mud flats, blind tidal channels, eelgrass, kelp and intertidal algal beds and marine shoreline areas within the photic zone are examples of nearshore and estuarine habitat. Kelp beds and eelgrass meadows cover the largest area of Puget Sound, almost 1,000 square kilometers (386 square miles) (NMFS 2000c).

Other major habitats include subaerial and intertidal wetlands (176 square kilometers; 68 square miles), and mudflats and sandflats (246 square kilometers; 95 square miles). The extent of some of these habitats has markedly declined over the last century. The nearshore habitat of Puget Sound has been modified by channelization, bank protection and land use in the estuarine zone. Overall losses since European settlement, by area, of intertidal habitat is estimated to be 58 percent for Puget Sound (Hutchinson 1988). The Duwamish, Lummi, Puyallup, and Samish river deltas have lost greater than 92 percent of their intertidal marshes (Schmitt et al. 1994; Simenstad et al. 1982). Substantial declines of mudflats and sandflats have also occurred in the deltas of these estuaries (Levings and Thom 1994).

The North Puget Sound region is demarcated to the north by the United States-Canadian border, to the west by a line due north of the Sekiu River, to the south by the Olympic Peninsula, and to the east by a line between Point Wilson (near Port Townsend) and Partridge Point on Whidbey Island and the mainland between Anacortes and Blaine, Washington (NMFS 2000c). The region is bordered primarily by rural areas with a few localized industrial developments (PSWQA 1988). About 71 percent of the area draining into North Sound is forested, 6 percent is urbanized, and 15 percent is used for agriculture. The main human population in this area centers around Port Angeles (2000 population census: 18,397), Port Townsend (8,334), Anacortes (14,557), and Bellingham (67,171). An estimated 21 percent of the shoreline in this area has been modified by human activities (WDNR 1998). Eelgrass is the primary vegetation in the intertidal areas of the Strait of Juan de Fuca, covering on average 42.2 percent (range 15 to 69.4 percent) of the intertidal area, and green algae is the second most common, covering on average 4.4 percent (range 0.7 to 8.1 percent) of the intertidal area (Bailey et al. 1988). About 45 percent of the shoreline of this region consists of kelp habitat, compared to only 11 percent of the shoreline of the other four Puget Sound regions (Shaffer 1998). Eelgrass is found in protected areas, such as Samish and Padilla Bays, while the densest kelp beds in Puget Sound are found in the Strait of Juan de Fuca.

The 75 kilometer (47 miles) long Main Basin is delimited to the north by a line between Point Wilson (near Port Townsend) and Partridge Point on Whidbey Island, to the south by Tacoma Narrows, and to the east by a line between Possession Point on Whidbey Island and Meadow Point (near Everett) (NMFS 2000c). The Main Basin includes Sinclair and Dyes inlets, Colvos and Dalco passages and the large embayments, Elliott and Commencement Bays.

Approximately 30 percent of the freshwater flow into the Main Basin is derived from the Skagit River. Seattle, Tacoma, and Bremerton border the Main Basin. Human population sizes for these cities are about 563,374, 193,556, and 37,259, respectively (2000 census). Approximately 70 percent of the drainage area in this basin is forested, 23 percent is urbanized, and 4 percent is used for agriculture (Staubitz et al. 1997). An estimated 52 percent of the shoreline in this area has been modified by human activities (WDNR 1998). The Main Basin has a relatively small amount of intertidal vegetation, with an average of 28.3 percent (range 17.9 to 38.7 percent) of the intertidal area containing predominantly green algae and eelgrass vegetation (Bailey et al. 1988). Most of the eelgrass is located on the western shores of Whidbey Island and the eastern shores of the Kitsap Peninsula (Puget Sound Water Quality Authority 1987).

The Whidbey Basin includes the marine waters east of Whidbey Island and is delimited to the south by a line between Possession Point on Whidbey Island and Meadowdale, west of Everett. The northern boundary is Deception Pass at the northern tip of Whidbey Island (NMFS 2000c). The Skagit River (the largest single source of freshwater in Puget Sound) enters the northeastern corner of the Basin, forming a delta and the shallow waters (less than 20 meters; 66 ft) of Skagit Bay. Most of the Whidbey Basin is surrounded by rural areas with low human population densities. About 85 percent of the drainage area of this Basin is forested, 3 percent is urbanized, and 4 percent is in agricultural production. The primary urban and industrial center is Everett, with a population of 78,000. Most waste includes discharges from municipal and agricultural activities and from a paper mill. An estimated 36 percent of the shoreline in this area has been modified by human activities (WDNR 1998). Vegetation, predominantly green algae, eelgrass,

and salt marsh, covers an average of 23.6 (range 14.8 to 32.4 percent) of the intertidal area of the Whidbey Basin (Bailey et al. 1988). Eelgrass beds are most abundant in Skagit Bay and in the northern portion of Port Susan (Puget Sound Water Quality Authority 1987).

The Southern Basin includes all waterways south of Tacoma Narrows (NMFS 2000c). This basin is characterized by numerous islands and shallow (generally less than 20 m; 66 ft) inlets with extensive shoreline areas. The largest river entering the basin is the Nisqually River which enters just south of Anderson Island. About 85 percent of the area draining into this basin is forested, 4 percent is urbanized, and 7 percent is in agricultural production. The major urban areas around the South Sound include Tacoma, University Place, Steilacoom, and Fircrest, with a combined population of about 100,000. Other urban centers in the South Sound Basin include Olympia with a population of 41,000 and Shelton with a population of 7,200. An estimated 34 percent of the shoreline in this area has been modified by human activities (WDNR 1998). Among the five regions of Puget Sound, the Southern Basin has the least amount of vegetation in its intertidal area (average of 12.7 percent coverage, range 0 to 28.2 percent), with salt marsh (average of 9.7 percent coverage, range 0 to 24.4 percent) and green algae (average of 2.1 percent coverage, range 0.2 and 4 percent) being the most common types (Bailey et al. 1988).

Within the Puget Sound Management Unit, anadromous bull trout require access to marine waters, estuaries, and lower reaches of rivers and lakes to forage and overwinter. It is generally believed that some level of mixing or interaction within marine waters occurs among anadromous individuals from the various core areas identified in Puget Sound. Although recent and past studies have documented bull trout from one major Puget Sound river basin moving into the downstream portions of another via marine waters (Goetz 2003; WDFW 1997), there is currently insufficient information to understand the full extent to which bull trout express this behavior. Although some level of basin to basin movement has been observed, there is currently no information that indicates anadromous bull trout spawn in basins which do not contain their natal stream.

Historically, anadromy could have played a role in establishing this species' distribution within Puget Sound. Anadromy may potentially function as an important means for the natural reestablishment of extirpated populations. Given that it is currently unclear to what degree this behavior actually influences population structuring within Puget Sound, we have chosen to define all marine and estuarine waters solely as important foraging, migration, and overwintering habitat at this time. These common marine habitats cannot be accurately linked with any specific core population(s) until additional information becomes available that can help further refine the migratory patterns of bull trout within core areas. Marine FMO habitat includes Puget Sound and associated nearshore and estuarine areas. These areas are important for maintaining life history diversity and for providing marine foraging within the management unit.

The current distribution of bull trout within Puget Sound marine waters is not completely known, but has been documented from the Canadian border to at least Commencement Bay to the south (Ballinger, in litt. 2000; KCDNRP 2002; Kraemer 1994; McPhail and Baxter 1996; PIE (Pacific International Engineering) 1999; WDFW 1998). As late as 1978, their marine distribution was still identified as far south as the Nisqually River Delta (Fresh et al. 1979). The more recent observation made at the Clear Creek Hatchery would indicate that bull trout still occasionally

migrate in marine waters to at least the Nisqually River. It is unknown if individuals from Puget Sound populations migrate as far west as the Kitsap Peninsula and the Strait of Juan de Fuca, or to what extent they may migrate up the coast of British Columbia. One bull trout tagged in the Squamish River in British Columbia was recaptured in the Skagit River (McPhail and Baxter 1996), and another tagged in the Nooksack River was later recovered in the Lower Fraser River (Kraemer 2003). It is thought that bull trout primarily use the shallower nearshore waters along the eastern shore of Puget Sound, and occasionally use or cross deeper waters to access nearshore locations along the west side of the sound (e.g., Whidbey Island). Currently few observations of bull trout have been reported in nearshore areas around the small islands of eastern Puget Sound. However, anadromous bull trout are presumed to use many of these nearshore areas based on their accessibility and the abundant forage fish populations they support. Although there has been only limited study of their diet in marine waters, bull trout appear to utilize these productive shallow waters to forage on a variety of prey items. Bull trout appear to target juvenile salmonids and small marine fish such as herring (*Clupea harengus pallasi*), sandlance (*Ammodytes hexapterus*), and smelt (var. spp.), especially keying in on their spawning beaches (Kraemer 1994). Bull trout have also been noted to feed heavily on shiner perch (*Cymatogaster aggregata*) at some locations (Berge, pers comm 2003; Castle, pers comm 2003).

Bull trout use of the marine environment is thought to be similar to that of other species, such as anadromous Dolly Varden (*Salvelinus malma*) and cutthroat trout (*Oncorhynchus clarki*). Thorpe's (1994) review of salmonid estuarine use found that anadromous Dolly Varden have an affinity to the shoreline. He also found clear evidence of a trophic advantage to estuarine residency (abundant prey). Aitkin (1998) reviewed the estuarine habitat of anadromous salmon, including native char. His literature review found that Dolly Varden pass through estuaries while migrating, like steelhead, and inhabit coastal neritic waters (nearshore marine zone extending to a depth of 200 m [656 ft], generally covering the continental shelf), like cutthroat trout. In Chignik, Alaska, Dolly Varden in the estuary preyed upon amphipods (81.1 percent), gastropods, and isopods, while sand lance were 1 percent of their diet (Roos 1959). From a sample of 145 Dolly Varden (121 to 490 mm; 4.7 to 19.3 inches), Armstrong (1965) found the principal foods by occurrence to be juvenile pink and chum salmon (21.6 percent), mysids (17.6 percent), amphipods (12.7 percent) and capelin (9.8 percent). Thorpe (1994) reported that Dolly Varden feed heavily on amphiphods, mysids, and various fish.

Bull trout may also use the estuaries and reaches of river systems that are historically or currently unlikely to support spawning populations of bull trout, such as the Samish River and Duwamish River. Bull trout are believed to be foraging on juvenile salmonid downstream migrants or other fish species while occupying these areas, and potentially overwintering there as well. The extent of past and current bull trout use of smaller independent creek drainages that discharge directly into Puget Sound is not well known, with only a few known reported observations.

In Bellingham Bay, bull trout were observed in Squalicum Creek in the late 1970's and in lower Whatcom Creek more recently (Currence, pers. comm. 2003). In 2002, three subadult bull trout approximately 203 to 229 millimeters (8 to 9 inches) in length entered the Maritime Heritage Fish Hatchery pond. These were reported to be the first bull trout observed at the facility in more than a decade, although formerly one to two a year were said to be observed at the facility.

In contrast, bull trout from coastal populations on the Olympic Peninsula have recently been documented using a number of small independent creek systems flowing into the Pacific Ocean (USFWS 2004). Even if it is determined that many of the small stream systems in Puget Sound are not commonly occupied by bull trout, these streams still provide an important contribution to the potential forage base for bull trout using adjacent nearshore marine waters or other parts of Puget Sound.

Significant development and urbanization has occurred within portions of most core areas. The greatest impacts have been to lower mainstem river channels, estuarine, and nearshore marine habitats, but many subbasins in the lower part of major watersheds have been altered as well. Some impacts have also occurred in spawning and rearing areas such as the lower portions of Canyon Creek, Glacier Creek, Racehorse Creek, and Hutchinson Creek in the Nooksack core area. More than 50 percent of the tidal flats and intertidal areas in major embayments of Puget Sound have been lost since 1850 (Bortleson et al. 1980 cited in PSWQAT 2000). Some highly urbanized areas, such as Commencement Bay, have lost more than 99 percent of historical marsh habitat and more than 89 percent of historical intertidal mudflats (USACOE et al. 1993). More recent reports state that over 98 percent of the historical intertidal and subtidal habitats in Commencement Bay have been lost (WSCC 1999b). Many estuarine and nearshore areas of Puget Sound have been filled or have had overwater structures installed to provide upland development sites for commercial/industrial, and to some extent residential, development. They have also been dredged extensively to maintain navigation and provide access to piers. Significant portions of nearshore and shoreline habitats have also been altered with vertical or steeply sloping bulkheads and revetments to protect various developments and structures (e.g., railroads, piers) from wave-induced erosion, to stabilize banks and bluffs, to retain fill, and to create moorage for vessels (BMSL et al. 2001). It has been estimated that one-third of Puget Sound's shoreline has been modified, with over half of the main basin of Puget Sound having been altered (PSWQAT 2000).

Nearly 100 percent of the Duwamish estuary and Elliott Bay shoreline has been modified by some type of armoring (BMSL et al. 2001). In areas where nearshore habitats currently remain intact or only partially modified, development continues to threaten these habitats (BMSL et al. 2001; WSCC 1999b). Functional estuarine and nearshore habitats are critical to anadromous bull trout for foraging and migration (WDFW 1997) and to their prey species (e.g., herring, surf smelt, sandlance) for spawning, rearing, and migration (BMSL et al. 2001; WDFW 2000).

Other impacts to shorelines include stormwater runoff from residential development and urbanization, which continues to be a significant contributor of non-point source water pollution in core areas and foraging, migration, and overwintering habitat areas (KCDNRP and WSCC 2000; WSCC 1999a; WSCC 1999b). Contaminants in this runoff may include oil, grease, and heavy metals from roadways and other paved areas, and pesticides from residential developments. Recent observations of high numbers of pre-spawn mortalities in coho salmon returning to small streams in urban and developing areas of Puget Sound have caused increasing concern over stormwater runoff (Ylitalo et al. 2004). Although the implications for bull trout are uncertain, some life stages of bull trout appear to have greater sensitivity than other salmonids to some contaminants (Cook et al., in litt. 1999; Guiney et al. 1996), and bull trout may be exposed numerous times to nonpoint sources due to their life history and migratory behavior. Other

sources of toxic contaminants are discharges of municipal and industrial waste water, leaching contaminants from shoreline structures, and channel dredging. Even though discharges from sewage treatment plants may be treated prior to discharge into receiving waters, according to the literature the treatment likely does not adequately remove potentially harmful compounds that are considered persistent, bioaccumulative, and toxic, or those that may have endocrine disrupting properties (Bennie 1999; CSTEE 1999; Daughton and Ternes 1999; Servos 1999). Estuarine and nearshore areas such as Bellingham Bay and Commencement Bay are on the State of Washington 303(d) list for a number of industrial and development related contaminants. Cherry Point within the Strait of Georgia supports the largest herring stock in Washington, and it has experienced a precipitous decline. In 1993 nearly 12,000 metric tons (13,000 short tons) of herring spawned, but by 1998 that number had dropped to just over 1,181 metric tons (1,300 short tons) (EVS Environment Consultants 1999). The stock has experienced a loss of older age classes, and the authors concluded that there is a moderate likelihood that organic contaminants are incrementally affecting this stock. The decline of this stock may be affecting the forage base for anadromous bull trout in this region of Puget Sound.

Lower river channels in many core areas have been significantly altered by dredging, channelization, and the construction of dikes and revetments for flood control and bank protection. These activities have simplified once complex stream channels, degrading and eliminating important foraging, migration, and overwintering habitat for bull trout. Many historical floodplain areas that were originally diked and drained for agricultural use have been or are now being converted to residential and industrial developments. These developments can reduce or preclude options for restoration of floodplain areas important for reestablishing off-channel habitats and maintaining groundwater recharge.

Scientific studies indicate there is a strong relationship between the amount of forest cover, levels of impervious and compacted surfaces in a basin, and the degradation of aquatic systems (Booth et al. 2002; Klein 1979). Impervious surface associated with residential development and urbanization creates one of the most lasting impacts to stream systems. Changes to hydrology (increased peak flows, increased flow duration, reduced base flows) as a result of loss of forest cover and increases in impervious surfaces and degradation or loss of riparian areas are typically the most common outcomes of intensive development in watersheds (Booth et al. 2002; May et al. 1997). Increased peak flows and flow duration often lead to the need to engineer channels to address flooding, erosion, and sediment transport concerns. Although recent changes have been made to most regional and local development regulations to provide protection (i.e., buffer zones) for riparian areas, the integrity of these areas is frequently compromised by encroachment (May et al. 1997). For many small stream systems, riparian areas are highly degraded or no longer exist, and their restoration is precluded by existing development. Although functional riparian areas have the capacity to mitigate for some of the adverse impacts of development (Morely and Karr 2002), they cannot effectively address significant impacts from changes to stream hydrology resulting from significant losses of forest cover (Booth et al. 2002; May et al. 1997).

Although an imperfect measure of human influence, basin imperviousness is commonly used as an indicator of basin degradation (Booth et al. 2002). Reduction in forest cover and conversion to impervious surfaces can change the hydrological regime of a basin by altering the duration

and frequency of runoff, and by decreasing evapotranspiration and groundwater infiltration (Booth et al. 2001; May et al. 1997). Such changes can be detected when the total percentage of impervious surface in the watershed is as low as 5 to 10 percent (Booth et al. 2002). Watershed degradation, however, likely occurs with incremental increases in impervious surfaces below these levels, and is exacerbated by other factors such as reduced riparian cover and pollution (Booth 2000; Booth et al. 2002; Karr and Chu 2000). Booth et al. (2002) state, "The most commonly chosen thresholds, maximum 10 percent effective impervious area and minimum 65 percent forest cover, mark an observed transition in the downstream channels from minimally to severely degraded stream conditions." They further assert, "Development that minimizes the damage to aquatic resources cannot rely on structural best management practices because there is no evidence that they can mitigate any but the most egregious consequences of urbanization. Instead, control of watershed land-cover changes, including limits to both imperviousness and clearing, must be incorporated."

To date, residential development and urbanization are believed to have primarily affected bull trout FMO habitats, and in some cases post-dispersal rearing habitats. Because of bull trout's proclivity for cold water, the continued loss and degradation of springfed and groundwater fed tributaries providing cool water refugia in FMO habitats will likely constrain migratory bull trout use of these areas. Generally, most past development has occurred in the lower elevations of watersheds where bull trout spawning and early rearing are not known to occur. This may change in the future as development pressures move further up into watersheds.

Status of Critical Habitat in the Action Area

The Service's recent final rulemaking revises the previous (2005) bull trout critical habitat designation (50 FR 63898 [October 18, 2010]). This final rule took effect on November 17, 2010. The action area includes marine and freshwater environments providing several of the bull trout critical habitat PCEs.

Lake Washington FMO

The action area includes portions of Lake Washington, Union Bay, Portage Bay, and major tributaries (Cedar River, tributary to Lake Washington; Bear Creek, tributary to Sammamish River; etc.), including nearshore freshwater environments less than 10 m in depth. These habitats provide six of the nine PCEs:

(2) *Migration habitats with minimal physical, biological, or water quality impediments between spawning, rearing, overwintering, and freshwater and marine foraging habitats, including but not limited to permanent, partial, intermittent, or seasonal barriers.*

The action area provides important migratory habitat for salmonids, including bull trout. The action area provides access to FMO habitat and a large prey base found throughout the greater Lake Washington basin. Throughout the action area, these habitats are functioning at risk and migration is impaired as result of altered hydrology, lock and lake level control operations, sediment and water quality impairment (including elevated temperatures), extensive shoreline

modification, artificial overwater structure, and the significant presence of nonnative, competitive and predatory species. A sub-section that follows will discuss in greater detail the baseline environmental conditions as they relate to migratory function, and the potential effects of the action (see *Permanent and Temporary Effects to Bull Trout Habitat*).

Within the action area this PCE still functions, but is moderately to severely impaired.

(3) *An abundant food base, including terrestrial organisms of riparian origin, aquatic macroinvertebrates, and forage fish.*

The Lake Washington FMO, including the Cedar River, Sammamish River, and their tributaries, provide significant foraging habitat and a large prey base. However, recent decades have seen development on a large scale, with an attendant decline in the quality and productivity of aquatic environments. Lake Washington FMO also supports native and nonnative predatory species, including largemouth and smallmouth bass (*Micropterus salmoides*, *Micropterus dolomieu)*, that compete with bull trout for the same resource. A sub-section that follows will discuss in greater detail the baseline environmental conditions as they relate to prey base, and the potential effects of the action (see *Effects to the Bull Trout Prey Base*).

Within the action area this PCE is functioning, but moderately impaired.

(4) *Complex river, stream, lake, reservoir, and marine shoreline aquatic environments, and processes that establish and maintain these aquatic environments, with features such as large wood, side channels, pools, undercut banks and unembedded substrates, to provide a variety of depths, gradients, velocities, and structure.*

Habitats are functioning at risk and exhibit significant impairment as result of altered hydrology, extensive shoreline modification, and artificial overwater structure. Within the action area this PCE still functions, but is moderately to severely impaired.

(5) *Water temperatures ranging from 2 to 15 °C (36 to 59 °F), with adequate thermal refugia available for temperatures that exceed the upper end of this range. Specific temperatures within this range will depend on bull trout life-history stage and form; geography; elevation; diurnal and seasonal variation; shading, such as that provided by riparian habitat; stream flow; and local groundwater influence*.

Water temperatures along the Lake Washington Ship Canal (Ballard Locks through Montlake Cut) are often substantially elevated during the summer and early-fall months, and the past three decades have evidenced a trend of increasing temperatures (Fresh et al. 1999, p. 14; Quinn et al. 2002, p. 594). It is believed that these temperatures present a thermal barrier to salmonid movements and migration, especially the return migration of adult Chinook salmon (City of Seattle and USACE 2008, pp. 83-84; Fresh et al. 1999, pp. 3, 12-13; NMFS 2008 LWSC Opinion, p. 27; WSDOT 2010a, pp. 5-20, 5-26, F-1, G-3). During summer, upper portions of the Lake Washington water column or epilimnion also frequently exceed the temperature range required or preferred by salmonids, including subadult and adult bull trout (City of Seattle and USACE 2008, p. 90; Newell and Quinn 2005, p. 1233; Quinn et al. 2002, p. 594; WSDOT

2010a, pp. 5-20, 5-23, 5-26). Throughout the lake's shallow littoral zones, temperatures and dissolved oxygen levels become stressful to salmonids, especially near dense macrophyte beds, by mid-June (Nowak et al. 2004, p. 631). However, Lake Washington also provides deeper waters where bull trout may find thermal refugia at any time of year.

Within the action area this PCE still functions, but is moderately to severely impaired.

(8) *Sufficient water quality and quantity such that normal reproduction, growth, and survival are not inhibited.*

The Lake Washington Ship Canal and Lake Union are listed on the WDOE 303(d) list of impaired water bodies and exceed water quality criteria for total phosphorus, lead, fecal coliform, and the banned insecticide aldrin; with respect to the temperature criteria, the Ship Canal is identified as a "water of concern" (WDOE 2008; WSDOT 2010a, p. 4-10). Lock and lake level control operations, and the resulting artificial hydrologic conditions of the Lake Washington Ship Canal, are known to cause large, abrupt changes in water quality parameters (salinity, temperature, and dissolved oxygen) (City of Seattle and USACE 2008, p. 87; Fresh et al. 1999, pp. 5-7). These conditions effectively compress the brackish-water transition zone at all times of year, with potential consequences for migrating salmonids (adults and juveniles) (NMFS 2008, pp. 12, 18, 20, 26, 27). During summer and early-fall months, these altered conditions may force fish to choose between cooler, less oxygenated waters near the bottom (i.e., layers under the biochemical influence of decaying sediment organics), and warmer, more oxygenated waters at mid-depths (City of Seattle and USACE 2008, p. 87; NMFS 2008, pp. 44-46).

Historical and on-going industrial uses in the Lake Washington basin contribute concentrations of persistent toxics to lake bottom sediments, including polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), and heavy metals (King County 1995). Portions of Lake Washington are on the 303(d) list and exceed water quality criteria for fecal coliform, as well as one or more fish tissue toxics criteria (2,3,7,8-TCDD, PCBs, total chlordane, 4,4′-DDD, and 4,4′-DDE) (WSDOT 2010a, p. 4-10).

Within the action area this PCE is functioning, but moderately impaired.

(9) *Sufficiently low levels of occurrence of nonnnative predatory (e.g., lake trout, walleye, northern pike, smallmouth bass); interbreeding (e.g., brook trout); or competing (e.g., brown trout) species that, if present, are adequately temporally and spatially isolated from bull trout.*

Lake Washington FMO supports both native and nonnative predatory species that compete with bull trout for the same prey resources (including large and smallmouth bass). Furthermore, water temperatures, shoreline modifications, and artificial overwater structure all tend to favor these nonnative predatory species. A sub-section that follows will discuss in greater detail the baseline environmental conditions as they relate to non-native species, and the potential effects of the action (see *Effects to the Bull Trout Prey Base*).

Within the action area this PCE is functioning, but moderately impaired.

Nearshore Marine Waters

The Ports of Grays Harbor, Olympia, Tacoma, Seattle, Everett, and Bellingham are located in developed nearshore marine waters. Nearshore marine waters less than 10 m in depth provide four of the nine PCEs of bull trout critical habitat (50 FR 63898 [October 18, 2010]):

(2) *Migration habitats with minimal physical, biological, or water quality impediments between spawning, rearing, overwintering, and freshwater and marine foraging habitats, including but not limited to permanent, partial, intermittent, or seasonal barriers.*

The Ports of Grays Harbor, Olympia, Tacoma, Seattle, Everett, and Bellingham are located in developed nearshore marine waters characterized by floodplain and estuarine fill, extensive bank modification and/or overwater structure, frequent physical disturbance (e.g., propeller wash; channel maintenance operations), and impaired sediment and water quality. These conditions have degraded, and continue to degrade nearshore environments, to the detriment of marine life.

Within the action area this PCE still functions, but is moderately to severely impaired.

(3) *An abundant food base, including terrestrial organisms of riparian origin, aquatic macroinvertebrates, and forage fish.*

The action area is characterized by floodplain and estuarine fill, extensive bank modification and/or overwater structure, frequent physical disturbance, and impaired sediment and water quality. These conditions have degraded, and continue to degrade nearshore environments, to the detriment of marine life.

Within the action area this PCE still functions, but is moderately to severely impaired.

(5) *Water temperatures ranging from 2 to 15 °C (36 to 59 °F), with adequate thermal refugia available for temperatures that exceed the upper end of this range. Specific temperatures within this range will depend on bull trout life-history stage and form; geography; elevation; diurnal and seasonal variation; shading, such as that provided by riparian habitat; stream flow; and local groundwater influence.*

Within the action area water temperatures vary in response to tide cycles and river discharge. The waters within the action area are not listed for temperature exceedances (although inner Grays Harbor and the Budd Inlet are identified as "waters of concern") (WDOE 2008), and temperatures generally fall within the range required by subadult and adult bull trout. Within the action area this PCE is fully functioning, with little or no significant impairment.

(8) *Sufficient water quality and quantity such that normal reproduction, growth, and survival are not inhibited.*

The action area exhibits severe sediment and water quality impairment (WDOE 2008). The Ports of Grays Harbor, Olympia, Tacoma, Seattle, Everett, and Bellingham are located in developed nearshore marine waters that exceed sediment quality, sediment bioassay, water

quality, and/or fish tissue toxics criteria for a long list of organic, inorganic, and synthetic compounds, including persistent toxics, PAHs, PCBs, and heavy metals.

Within the action area this PCE still functions, but is moderately to severely impaired.

Effects of Past and Contemporaneous Actions

Lake Washington and its tributaries present both potential opportunities and challenges to migratory bull trout. Two large lakes with high forage fish availability are dominant parts of the lower watershed and provide significant foraging habitat. However, recent decades have seen development on a large scale, with an attendant decline in the quality of aquatic environments. Perhaps most significant for bull trout utilizing Lake Washington, past and contemporaneous actions have led to significant impairment as result of extensive shoreline modification and artificial overwater structure. These conditions present a threat to the long term viability of the bull trout prey base, and also favor nonnative predatory species that compete with bull trout for the same prey resources.

The Ports of Grays Harbor, Olympia, Tacoma, Seattle, Everett, and Bellingham are located in developed nearshore marine waters characterized by floodplain and estuarine fill, extensive bank modification and/or overwater structure, frequent physical disturbance (e.g., propeller wash; channel maintenance operations), and impaired sediment and water quality. These conditions have degraded, and continue to degrade nearshore environments, to the detriment of marine life.

We have previously issued Opinions and granted incidental take for actions adversely affecting bull trout of the Puyallup, Snohomish-Skykomish, and Skagit River core areas. In each case we determined that these actions are not likely to jeopardize the continued existence of the bull trout and will not destroy or adversely modify designated bull trout critical habitat. Nevertheless, the combined effects of these past and contemporaneous Federal actions have resulted in short and long term adverse effects to bull trout and, in some instances, an incremental degradation of the environmental baseline.

EFFECTS OF THE ACTION

Regulations implementing the Act define “effects of the action” as “the direct and indirect effects of an action on the species or critical habitat, together with the effects of other activities that are interrelated or interdependent with that action that will be added to the environmental baseline” (50 CFR Section 402.02). This section details the anticipated effects of the proposed action on the bull trout and designated bull trout critical habitat.

To describe the potential effects of the action on bull trout and designated bull trout critical habitat, this Opinion applies in explicit terms an approach that seeks to describe first the effects to the physical, biotic, and chemical environment (potential stressors); the likelihood, intensity, and duration of exposure; the anticipated response(s) to exposure; and then, the biological relevance of those responses for individual bull trout and the PCEs, respectively. Effects at the

level of the individual (or group of individuals) are then translated or assessed for significance to numbers (abundance), reproduction (productivity), and distribution at the scale of the larger population(s). For critical habitat, we describe expected temporary and permanent effects to the PCEs and, relative to the recovery role for the larger Critical Habitat Unit and critical habitat rangewide, whether the affected critical habitat will remain functional or retain the current ability to establish (or reestablish) functioning PCEs.

Complex actions that include multiple project elements and/or project locations have the potential to cause a variety of exposures (or exposure scenarios). The sub-sections that follow refer to some of the previously described project elements and items of work as a means of organizing the discussion of potential stressors, exposures, responses, and effects. Complex actions occurring at multiple locations may affect a variety of habitat types (e.g., suitable habitat, unsuitable habitat, etc.) and/or bull trout life history stages. Although, for this action, the affected habitats represent non-core FMO habitat in each case, and only subadult and adult bull trout are likely to be exposed to stressors that elicit a response.

If an effect to the physical, biotic, and/or chemical environment (stressor) would occur at a place or time when exposure of an individual(s) is extremely unlikely, those potential exposures and effects are considered discountable. In general, it is more likely that temporary effects (stressors) and potential exposures can be found discountable. It is more difficult to conclude that permanent or long term effects (stressors) will not expose individuals over time.

If exposure is not discountable and an individual(s) may be exposed to a stressor, the intensity and duration of that potential exposure are important considerations. Some low-intensity and/or short-duration exposures may elicit no response in the individual. Other exposures will or may elicit a response(s), and the biological relevance of those responses must be assessed.

A response is biologically relevant if it measurably affects an individual or a PCE. For example, when stressors elicit an avoidance response and/or prevent or discourage free movement or exploitation of preferred habitats, these responses can have significance for the individual (e.g., reduced foraging success or efficiency, delayed migration). Behavioral responses represent a complex interaction with the affected environment. Determining their biological significance or relevance requires that we evaluate the condition and needs of the individual(s), the amount and quality of affected habitat, the duration and intensity of exposure, and the action or presence of other stressors.

Measurable adverse effects to individuals may reach the level of take. Take may result if the exposure and effect significantly disrupts normal or essential behaviors (e.g., feeding, moving, sheltering, migrating, spawning, rearing), if it results in significant sublethal physiological stress with potential consequences for growth or long term survival, or if it causes physical injury (e.g., gill abrasion, barotrauma) or mortality.

The sub-sections that follow discuss sequentially: insignificant and discountable effects (by project element and/or item of work), adverse effects to individuals and habitat (by project element and/or item of work), effects to the PCEs of critical habitat, and, a synthesis of effects and responses at the scale of the larger population(s) and Critical Habitat Unit.

Insignificant and Discountable Effects (Bull Trout)

This sub-section identifies and discusses in some detail those potential exposures and effects that we conclude are extremely unlikely to occur, and are therefore discountable. This section also identifies and discusses those potential exposures and effects that we conclude will not measurably affect individuals or their habitat, and are therefore insignificant.

Pontoon Construction at the Port of Olympia

The project will construct approximately 20 floating bridge pontoons at Port of Olympia facilities located on the inner Budd Inlet (WSDOT 2010a, p. 2-52). Pontoon construction will be a largely land-based operation, with the exception of launching of the finished pontoons. Submersible barges will be used to launch pontoons from deep water locations in the south Puget Sound.

All related activities are consistent with the current, established uses of this facility, and we expect that no temporary or permanent effects to the aquatic environment will extend from the facility more than a few hundred ft. With implementation of the proposed conservation measures and permanent design elements, we conclude that this project element and all associated items of work will have no measurable, adverse effects on bull trout individuals, their prey base, or habitat.

Anchor Construction and Pontoon Outfitting

The project will fabricate bridge pontoon anchors, and outfit finished floating bridge pontoons with their modular, over-water bridge components (or superstructure), at existing port and industrial facilities located in Grays Harbor, Olympia, Tacoma, Seattle, Everett, and Bellingham. Fabrication of bridge pontoon anchors is an entirely land-based operation. Pontoon outfitting will be conducted on-top of the finished pontoons while berthed at existing port and industrial facilities meeting two site selection criteria (WSDOT 2010a, p. 2-60):

- Only existing deep water berths with appropriate infrastructure; and,
- No needed improvements requiring in-water work.

All related activities are consistent with the current, established uses of these facilities, and we expect that no temporary or permanent effects to the aquatic environment will extend from these facilities more than a few hundred ft. With implementation of the proposed conservation measures and permanent design elements, we conclude that these project elements and all associated items of work will have no measurable, adverse effects on bull trout individuals, their prey base, or habitat.

Pontoon Storage, Transport, and Delivery

The project will transport floating bridge pontoons along established shipping routes, between Grays Harbor, the Ports of Olympia and Tacoma, and existing port and industrial facilities in

Grays Harbor, Olympia, Tacoma, Seattle, Everett, and Bellingham (Figure 2, p. 7). In the event that pontoons require temporary moorage in the Puget Sound, the same site selection criteria identified for outfitting (above) shall apply for temporary moorage locations. When needed for the next phase of construction on Lake Washington, the project will transport pontoons via the Lake Washington Ship Canal.

If stored for more than 6 months, pontoons constructed and/or outfitted in Grays Harbor will be inspected for marine growth prior to transport via open-water shipping routes. If inspections find significant growth, the project will clean the pontoon(s) to reduce the risk of transporting invasive plants, algae, or invertebrates from Grays Harbor.

Pontoon transport will result in temporary noise and vibration, but will otherwise have no incremental long term effects on the physical, biotic, or chemical environment. While bull trout may be exposed to temporary noise and vibration associated with pontoon transport, we do not expect that these intermittent exposures will result in measureable effects to normal bull trout behaviors. Vessels travel regularly between coastal harbors and the Puget Sound, and with implementation of the proposed measures (i.e., inspection and cleaning), we conclude that the risk of introducing or furthering the spread of any invasive species is extremely unlikely and therefore discountable.

Activities Associated with Mitigation Components

The project includes compensatory mitigation for unavoidable impacts to wetlands, buffers, aquatic resources, and parks, tentatively planned for completion at multiple sites throughout the greater Lake Washington watershed (WSDOT 2010a, pp. 2-119 thru 2-147, 2-150 thru 2-152). The project will monitor implementation and adaptively manage all mitigation components to ensure attainment of anticipated functions and values.

The project will schedule construction and maintenance activities during the established in-water work windows, when bull trout are not likely to be present. Based on the anticipated timing and duration of these activities, we do not expect that the project will capture, handle, or remove bull trout from work areas during construction.

Mitigation activities will include removal and control of noxious weeds and invasive plant species with implementation of integrated vegetation and pest management principles. Initial treatments will include both mechanical removal (cutting and/or mowing) and focused application of a non-residual herbicide with low non-target toxicity. The herbicide commonly used is glyphosate, in the form of trademarked products “Rodeo” and/or “Aquamaster”. Herbicide formulations and applications will comply with the herbicide’s FIFRA label requirements, the NPDES General Permit for Aquatic Noxious Weed Control (WDOE Permit No. WAG–993000), and local noxious weed requirements, including as these pertain to schedule, notification, monitoring, and compliance. The proposed activities do not include herbicide application to the open waters of any lake, natural or man-made impoundment. After weeds and invasive species are nearly or completely eradicated from the sites, and native plantings and seed have been successfully established, maintenance treatments will address any remaining problem locations on a case-by-case basis.

We expect that herbicide treatments will have no measurable, adverse effects on bull trout individuals, their prey base, or habitat. Glyphosate formulations exhibit low non-target toxicity, typically bind well to soils and sediment and therefore have low potential for leaching, readily breakdown and/or become inactivated by microbial degradation under varying field conditions, and exhibit no tendency toward bioaccumulation in the food chain (CDPR and Schuette 1998; USEPA 1993; 2002). (){{}}Kubena (1998) found no biologically relevant responses (behavioral or physiological), except when juvenile salmonids were exposed to grossly exaggerated concentrations (e.g., 1000 times or greater than likely real-world concentrations). Simenstad and Feist (1996) found no significant short or long term effects on estuarine invertebrates where field studies have investigated glyphosate applications around Willapa Bay, Washington.

With implementation of the proposed conservation measures and permanent design elements, we conclude that this project element and all associated items of work will have no measurable, adverse effects on bull trout individuals, their prey base, or habitat. Temporary, construction-related effects and resulting potential stressors (e.g., temporary increases in underwater sound, temporary increases in turbidity) will be limited in physical extent and duration. Given the location(s), the amount and quality of affected habitat, and with consideration for the timing, methods, and duration of construction, we conclude that exposure of bull trout individuals to construction activities is extremely unlikely and therefore discountable. This element's long term or permanent effects to the environment will restore habitat and habitat functions, with potential benefits for bull trout and their prey.

Upland Construction Activities

With implementation of the proposed conservation measures and permanent design elements, we conclude that upland construction activities, including all activities over or adjacent to the Montlake Cut, will have no measurable, adverse effects on bull trout individuals, their prey base, or habitat. Noise and vibration resulting from the work may extend into the immediately adjacent waters at levels detectable by fish. However, we do not expect that temporary sound will reach levels likely to cause significant behavioral disruption or physical injury. Any related temporary effects to normal bull trout behaviors (feeding, moving, and sheltering) will not be measurable and are therefore considered insignificant.

Vibratory Installation and Removal of Temporary Steel Piles

The project will install, and later remove, approximately 3,500 temporary steel piles for temporary work trestles and bridges spanning portions of Portage Bay, Union Bay, Lake Washington, and adjacent wetlands. The project will also install steel sheet piles for approximately eight large temporary cofferdams. The project will use a vibratory hammer when installing steel piles and sheet piles to the fullest extent practicable. The project will not resort to use of an impact hammer(s) unless site conditions are encountered that prevent effective use of a vibratory hammer(s).

Vibratory hammers produce average underwater peak pressures that are approximately 17 dB lower than those generated by impact hammers (Nedwell and Edwards 2002). Underwater sound produced by vibratory and impact hammers differs not only in intensity, but also in frequency

and impulse energy (i.e., total energy content of the pressure wave). This may explain why no documented fish kills have been associated with the use of vibratory hammers. Most of the sound energy produced by impact hammers is concentrated at frequencies between 100 and 800 Hz, across the range thought to be most harmful to exposed aquatic organisms, while sound energy produced by vibratory hammers is concentrated between 20 and 30 Hz. In addition, sound pressures produced by impact hammers rise much more rapidly than do the sound pressures produced by vibratory hammers (Carlson et al. 2001; Nedwell and Edwards 2002).

We do not expect that pile installation and removal with a vibratory hammer will produce sound pressures with a potential to kill or injure exposed bull trout. Furthermore, while bull trout individuals may be exposed to resulting temporary stressors (temporary underwater sound), we expect those exposures will be low-intensity, intermittent, and therefore will not measurably affect normal bull trout behaviors (feeding, moving, and sheltering). We conclude that temporary stressors resulting from pile installation and removal with a vibratory hammer will have no measurable effect on bull trout individuals, their prey base, or habitat, and are therefore insignificant.

Fish Entrainment in Cofferdams and Casings

The project will install, and later remove, approximately six large cofferdams in Portage Bay, and two large cofferdams in Lake Washington along the east approach, to allow for site dewatering and construction of five new mudline footings. Cofferdams of the size proposed typically require three to five working days to install and dewater. When isolating and dewatering cofferdams, the project will implement the WSDOT's *Fish Exclusion Protocols and Standards* (WSDOT 2009).

The project will install six temporary cofferdams, affecting approximately 14,000 ft^2 of substrate in total, at three locations along western portions of the south Portage Bay alignment (WSDOT 2010a, pp. 2-65 and 2-70). The affected area is shallow, supports dense macrophyte growth, is far removed from the primary salmonid migration route, and provides only low-quality habitat of limited value to salmonids (WSDOT 2010a, p. 4-13).

The project will install two temporary cofferdams, affecting approximately 9,000 ft^2 of substrate in total, at one location along the east approach (Pier 1), approximately 350 ft off Lake Washington's shore (WSDOT 2010a, pp. 2-98 and 2-100). The affected area is far removed from Lake Washington's primary salmonid migration routes, and is located approximately two miles from the nearest of Lake Washington's small- and moderate-sized eastern tributaries (Yarrow Creek).

Cofferdams will be installed at locations which provide low-quality habitat. We expect that these locations are not attractive to bull trout. In addition, the duration of these activities is brief (three to five working days). Accordingly, we do not expect that bull trout will be trapped inside individual cofferdams. Resulting temporary increases in turbidity are a separate consideration, addressed with a section that follows (see *Exposure to Elevated Turbidity and Degraded Water Quality*).

The project will also install a total of approximately 310 10-foot diameter steel casings for new drilled shafts (approximately 24,400 ft^2 of substrate in total). Because of their small size relative to the surrounding waters, because the casings will be lowered slowly, and bull trout are likely to avoid the casings as they are lowered into place, we do not expect that bull trout will be trapped inside individual casings. Resulting temporary increases in turbidity are a separate consideration, addressed with a section that follows (see *Exposure to Elevated Turbidity and Degraded Water Quality*).

Given the locations, the amount and quality of affected habitat, and with consideration for the timing, methods, and duration of these construction activities, we conclude that exposure of bull trout individuals is extremely unlikely and therefore discountable.

Off-Site Demolition and Final Disposition of Pontoons and Other Materials

The project will produce large quantities of waste concrete rubble and reinforcing steel. These materials will be transported via barge and rail transport methods for off-site recycling, processing, and reuse at existing facilities. The project will make concrete pontoons available for private purchase. Any future use(s) of the pontoons shall comply with applicable local, State, and Federal laws, at the responsibility of the purchaser (WSDOT 2010a, p. 2-49).

Off-site demolition, recycling, and reprocessing are activities consistent with current, established uses, and we expect that no temporary or permanent effects to the aquatic environment will extend from these facilities. While future reuses or applications for concrete pontoons cannot be known with any certainty, no related measurable effects to bull trout, their prey base, or habitat are foreseeable and reasonably certain to occur. With implementation of the proposed conservation measures and permanent design elements, we conclude that these project elements and all associated items of work will have no measurable, adverse effects on bull trout individuals, their prey base, or habitat.

Adverse Effects of the Action (Bull Trout)

While we expect that several of the included project elements, and many associated items of work, will have no measurable, adverse effects on bull trout individuals, their prey base, or habitat, we do nevertheless expect that measurable, adverse effects will result from the proposed action. Some exposures and adverse effects will be temporary (i.e., construction-related), while others will last in perpetuity (e.g., adverse stormwater effects).

When constructing pontoons at the Port of Tacoma, we expect that adverse effects to individual bull trout will result from fish entrainment and handling within the CTC casting basin. While completing work below the OHWM in Portage Bay, Union Bay, and Lake Washington, we also expect the project will result in temporary stressors with potential adverse effects to bull trout, their prey base, and habitat. These stressors include effects to water quality and temporary increases in underwater sound resulting from impact pile driving.

Temporary stressors resulting from work completed in Portage Bay, Union Bay, and Lake Washington have the potential to kill or injure a limited number of subadult and adult bull trout. Temporary exposures may also significantly disrupt normal bull trout behaviors (i.e., ability to successfully feed, move, and/or shelter). These exposures may temporarily cause bull trout to avoid the action area, may impede or discourage free movement through the action area, prevent individuals from exploiting preferred habitats, and/or expose individuals to less favorable conditions. Suitable bull trout rearing and spawning habitats are not present in the action area, and therefore the proposed action will have no effect on bull trout rearing or spawning habitat, or these essential behaviors.

We expect that the proposed action will result in potential adverse effects to bull trout and their habitat resulting from the discharge of treated and untreated highway stormwater runoff. The resulting effects to surface water and sediment quality will last in perpetuity, but will create only infrequent, episodic conditions with the potential to significantly disrupt normal bull trout behaviors (i.e., ability to successfully feed, move, and/or shelter). In the long term, we do not expect that the proposed action will worsen surface water or sediment quality trajectories at the scale of the action area or Lake Washington watershed. Furthermore, we do not expect that the project's long term, operational stormwater effects will cause or contribute to a measurable, incremental decline in the bull trout prey base.

The proposed action will have both temporary and permanent impacts to bull trout FMO habitat. However, the project also includes design measures and mitigation components which we expect will reduce permanent or long term impacts to aquatic resources, and maintain or restore important habitat functions over time. The new, permanent bridges and ramps over Portage Bay, Union Bay, and Lake Washington will have fewer in-water columns, will restore conditions that better approximate ambient incident light, and reduce, overall, the amount of artificial light cast onto adjacent waters and wetlands. We conclude that potential effects to bull trout movements and migration, foraging, and predation, resulting from temporary structures and associated stressors will not be measurable and are therefore insignificant. We also conclude that potential effects to bull trout movements and migration, foraging, and predation, resulting from new, permanent structures and associated stressors will not be measurable and are therefore insignificant. For fuller details regarding effects to bull trout habitat, see a section that follows (*Permanent and Temporary Effects to Bull Trout Habitat*).

The sub-sections that follow below discuss project elements and activities, resulting stressors, exposures, and adverse effects in greater detail.

<u>Pontoon Construction and Resulting Fish Entrainment at the Port of Tacoma</u>

At the existing Port of Tacoma facilities, the CTC casting basin opens directly to tidally-influenced portions of the Blair Waterway (Commencement Bay), and the FHWA has acknowledged a risk of fish entrainment during gate openings and float-out of finished pontoons. Pontoon construction at the Port of Tacoma facilities will require approximately 10 CTC casting basin gate openings, scheduled for between August 2012 and June 2014 (WSDOT 2010a, pp. 2-54 thru 2-57). Each opening and float-out may span several tide cycles.

After float-out of the finished pontoons, and in conjunction with subsequent dewatering of the closed casting basin (using screened pumps), the project will capture and release any entrained fish to adjacent waters. The project will implement the WSDOT's *Fish Exclusion Protocols and Standards* (WSDOT 2009) to minimize the risk of physical injury and lessen sources of stress during fish capture and handling operations:

- Implementation of the fish capture and removal protocols shall be planned and directed by a WSDOT biologist, or qualified biologist under contract to WSDOT, possessing all necessary knowledge, training, and experience (the directing biologist). All individuals participating in the operations shall have the training, knowledge, skills, and ability to ensure safe handling of fish, and to ensure the safety of staff conducting the operations.

- The directing biologist shall use his/her best professional judgment in deciding what sequence of activities is likely to minimize exposure of fish to conditions causing stress or injury, including stranding, exposure to extremes of temperature or reduced dissolved oxygen, risk of injury resulting from electrofishing, etc.

- Plans for dewatering shall proceed at a measured pace to encourage the volitional movement of fish and reduce the risk of stranding. Dewatering shall not proceed unless there are sufficient staff and materials on-site to capture and safely remove fish in a timely manner.

- The operations shall confirm success of fish capture and removal before completely dewatering or commencing with other work within the isolated work area.

- Seining and herding with seines shall be the preferred methods for fish capture. Dip Nets shall be used in conjunction with seining. Only dip nets and seines composed of soft, non-abrasive, nylon material shall be used.

- Electrofishing shall be performed only when other methods of fish capture and removal have proven impracticable or ineffective at removing all fish. Electrofishing methods and equipment shall comply with guidelines outlined by the NMFS (2000a).

- Fish capture and removal operations shall be planned and conducted so as to minimize the amount and duration of handling. The operations shall maintain captured fish in water to the maximum extent possible during seining/netting, handling, and transfer for release.

- The operations shall provide a healthy environment for captured fish, including low densities in holding containers to avoid effects of overcrowding. Bull trout shall not be held in containers for more than 10 minutes, unless those containers are dark-colored, lidded and fitted with a portable aerator.

- The directing biologist shall ensure that each fish is capable of remaining upright and has the ability to actively swim upon release.

We cannot rule out the possibility that a limited number of subadult and adult bull trout may become entrained during the anticipated ten CTC casting basin gate openings. The established in-water work window for the area is October 1 to April 14, but gate openings at the CTC casting basin may be scheduled for any time of year. The risk of entrainment will be greatest on those occasions when gate openings occur late in the in-water work window, or outside of the in-water work window. We assume here, for the purpose of this analysis, that the project will conduct at least five gate openings outside of the in-water work window.

Operating procedures will reduce, but not completely avoid, the stress and potential for injury resulting from entrainment, capture, and handling prior to release. We expect that adverse effects to individual bull trout will result from fish entrainment and handling within the CTC casting basin.

Sublethal Physiological Stress Resulting from Fish Handling

Studies investigating acute, sublethal physiological stress in captured and handled salmonids consistently document induced changes in blood chemistry (e.g., cortisol, corticosteroid, and blood sugar levels; lymphocyte numbers) (Barton and Iwama 1991, p. 3; Frisch and Anderson 2000, p. 23; Hemre and Krogdahl 1996, p. 249; Pickering et al. 1982, p. 229; Wydoski et al. 1976, p. 602). Even short and mild bouts of handling have been shown to induce protracted changes, lasting hours or days (Frisch and Anderson 2000, p. 23; Hemre and Krogdahl 1996, p. 249; Wydoski et al. 1976, p. 604). Pickering et al. (1982, p. 229) reports that the time course for recovery of individual parameters suggests a minimum 2-week period for full recovery, and return to normality.

Stress induced effects to blood chemistry may have consequences for metabolic scope, reproduction (i.e., altered patterns or levels of reproductive hormones), and immune system function or capability (Barton and Iwama 1991, p. 3; Frisch and Anderson 2000, p. 29; Pickering et al. 1982, p. 229). Pickering et al. (1982, p. 231) reports a marked reduction in feeding activity lasting three days after handling. Barton and Iwama (1991, p. 3) and Frisch and Anderson (2000, p. 23) both point to the possibility of increased disease susceptibility attributable to handling related physiological stress.

While few if any studies have tracked long term consequences for growth, survival, or reproductive success, there is strong evidence to suggest a causal link between fish handling stress and altered salmonid physiological function. Furthermore, these stress induced changes to physiology are, in and of themselves, relevant indicators for potential effects to growth, survival, and reproduction.

Estimate of the Extent of Effect

Adult and subadult bull trout may occupy the Blair Waterway at any time of year. Data to estimate the number of bull trout that forage, migrate, and overwinter in the area are not available. However, the Puyallup River core area, which is the most southerly core area in the Puget Sound Management Unit, supports a relatively small anadromous population, and therefore it is unlikely that large numbers of bull trout use the marine waters of Commencement

Bay. Furthermore, the Blair Waterway's industrialized condition lessens the likelihood that bull trout use the area frequently, in significant numbers, or for long durations. We expect that subadult and adult bull trout are most likely to occur in the Blair Waterway during early fall migration between marine foraging areas and freshwater environments along the lower Puyallup River.

With consideration for the amount and quality of adjacent habitat, the duration of direct contact with adjacent waters, variability in the risk of entrainment at different times of the year, and because we expect that bull trout occur in the Blair Waterway in very low numbers, we expect that bull trout will not be entrained within the CTC casting basin during most of the planned cycles. However, over the course of 10 gate openings between August 2012 and June 2014, we do expect that as many as three individual subadult or adult bull trout may become entrained. Entrainment of bull trout is most likely to occur during those few gate openings that coincide with early-fall migration.

With implementation of the WSDOT's *Fish Exclusion Protocols and Standards* (WSDOT 2009), we expect that no more than one subadult or adult bull trout will suffer physical injury or mortality, and no more than two subadult or adult bull trout will experience stress not reaching the level of physical injury. We do not expect that fish entrainment, capture, and handling at the CTC casting basin will have a measurable effect on the bull trout's available prey base. Related effects to the bull trout prey base will be insignificant.

Exposure to Elevated Turbidity and Degraded Water Quality

Construction of the new bridges and ramps over Portage Bay, Union Bay, and Lake Washington will require extensive in-water work, including installation of temporary piling, cofferdams, and drilled casings, operation of a bubble curtain(s), forming and pouring of mudline footings and in-water columns, pulling and removal of temporary piling, cofferdams, and casings, installation of floating bridge pontoon anchors, demolition and removal of existing columns, footings, piling, and armor, and other similar activities. The project's mitigation components will also require in-water work, including removal of hardened bank structure, levees, and piling, placement and grading of fine and coarse beach and lake bottom substrates, planting of emergent vegetation, mechanical control of invasive weeds, and other similar activities.

All work below the OHWM will be completed during the in-water work windows identified in previous sections (see *Description of the Proposed Action*), unless completely isolated from adjacent waters (e.g., with the use of cofferdams). This excludes approximately 60 working days in total, for the purpose of column demolition and removal along the existing west approach and Portage Bay alignments (Bloch, pers. comm. 2011b). The FHWA has stated that they expect all activities will comply with State of Washington surface water quality criteria, including aquatic life turbidity criteria (WSDOT 2010a, p. 2-149).

We expect that in-water work will produce measurable, temporary increases in turbidity and sedimentation. However, when completing in-water work where contaminated soils or sediment may be present, the project will take appropriate measures to minimize disturbance and properly contain and dispose of any waste (WSDOT 2010a, p. 6-12). Accordingly, we expect that the

proposed in-water work will release, or re-suspend, little or no contamination, and resulting temporary bull trout exposures are extremely unlikely and therefore discountable.

We expect that temporary increases in turbidity and sedimentation will significantly disrupt normal bull trout behaviors (i.e., ability to successfully feed, move, and/or shelter). In-water work may cause bull trout to temporarily avoid the area, may impede or discourage free movement through the area, prevent individuals from exploiting preferred habitats, and/or expose individuals to less favorable conditions.

Estimate of the Extent of Effect

Adult and subadult bull trout may occupy these waters at any time of year. However, data to estimate the number of bull trout that forage, migrate, and overwinter in the action area are not available.

Although few studies have specifically examined the issue as it relates to bull trout, increases in suspended sediment affect salmonids in several recognizable ways. The variety of effects of suspended sediment may be characterized as lethal, sublethal or behavioral (Bash et al. 2001; Newcombe and MacDonald 1991; Waters 1995). Lethal effects include gill trauma (physical damage to the respiratory structures), severely reduced respiratory function and performance, and smothering and other effects that can reduce egg-to-fry survival (Bash et al. 2001).

Sublethal effects include physiological stress reducing the ability of fish to perform vital functions (Cederholm and Reid 1987), increased metabolic oxygen demand and susceptibility to disease and other stressors (Bash et al. 2001), and reduced feeding efficiency (Bash et al. 2001; Berg and Northcote 1985; Waters 1995). Sublethal effects can act separately or cumulatively to reduce growth rates and increase fish mortality over time. Behavioral effects include avoidance, loss of territoriality, and related secondary effects to feeding rates and efficiency (Bash et al. 2001). Fish may be forced to abandon preferred habitats and refugia, and may enter less favorable conditions and/or be exposed to additional hazards (including predators) when seeking to avoid elevated concentrations of suspended sediment.

In order to assess the suspended sediment concentrations at which adverse effects will occur, and to determine the downstream extent to which these effects may extend as a result of the proposed project, we used the analytical framework attached as Appendix E (USFWS 2010b). This framework uses the findings of Newcombe and Jensen (1996) to evaluate the "severity-of-effect" (SEV) based on suspended sediment concentration, exposure, and duration. Factors influencing suspended sediment concentration, exposure, and duration include waterbody size, volume of flow, the nature of the construction activity, construction methods, erosion controls, and substrate and sediment particle size. Factors influencing the SEV include duration and frequency of exposure, concentration, and life stage. Availability and access to refugia are other important considerations.

The framework in Appendix E requires an estimate of suspended sediment concentration (mg/L) and exposure duration. In the absence of data to describe the relationship between suspended sediment concentration and nephelometric turbidity units (NTUs) for these waters, we rely instead on a regression equation developed by Packman et al. (1999). Packman et al. (1999)

developed a linear regression equation describing this relationship for urbanizing watersheds of the lowland Puget Sound. To determine exposure duration, we assumed that work below the OHWM would occur for as many as 18 hours a day, for the duration of the in-water work windows. It is important to note, we expect that any measurable increases in turbidity will be short-term (i.e., less than two days at a given location) and episodic.

Using this approach, we expect that adverse effects to subadult and adult bull trout are likely to occur under the following circumstances:

1. When background NTU levels are exceeded by 84 NTUs at any point in time.

2. When background NTU levels are exceeded by 40 NTUs for more than 1 hour, continuously, over an 18-hour workday.

3. When background NTU levels are exceeded by 18 NTUs for more than 3 hours, cumulatively, over an 18-hour workday.

4. When background NTU levels are exceeded by 9 NTUs for durations approaching two 24-hour days, continuously.

Based on the nature of the proposed work, and with implementation of the proposed conservation measures, we expect that suspended sediment concentrations resulting in adverse effects to bull trout are reasonably certain to occur as far as 300 ft from sediment-generating activity. We expect that most bull trout will avoid the area when elevated suspended sediment concentrations result from construction activities. Resulting turbidities, either alone or in conjunction with other aspects of construction in and over the water, may impede or discourage free movement through the area and/or expose individuals to less favorable conditions. We expect that elevated turbidity and sedimentation will result in a significant temporary disruption of normal bull trout behaviors (i.e., ability to successfully feed, move, and/or shelter). Suitable bull trout spawning and rearing habitats do not occur within the action area, and therefore these essential bull trout behaviors will not be exposed to in-water work or resulting temporary increases in turbidity and sedimentation.

Exposure to Elevated Underwater Sound Levels

Construction of the new bridges and ramps over Portage Bay, Union Bay, and Lake Washington will require that the project install, and later remove, approximately 3,500 temporary steel piles for work trestles and bridges. The project will use a vibratory hammer when installing steel piles to the fullest extent practicable. The project will not resort to use of an impact hammer(s) unless site conditions are encountered that prevent effective use of a vibratory hammer(s). The project will implement a sound attenuation system (i.e., bubble curtain) when impact pile driving or proofing steel piles, and will implement an underwater sound monitoring plan to document performance of the sound attenuation system and resulting sound levels (SLs).

Pile driving and proofing with an impact hammer has the potential to kill or injure a limited number of subadult and adult bull trout. Elevated underwater SLs resulting from pile driving and

proofing with an impact hammer may also significantly disrupt normal bull trout behaviors (i.e., ability to successfully feed, move, and/or shelter). Pile driving and proofing with an impact hammer may cause bull trout to temporarily avoid the area, may impede or discourage free movement through the area, prevent individuals from exploiting preferred habitats, and/or expose individuals to less favorable conditions.

Effects of Elevated Underwater SPLs - General

High underwater sound pressure levels (SPLs) are known to have negative physiological and neurological effects on a wide variety of vertebrate species (Hastings and Popper 2005; Turnpenny and Nedwell 1994; Yelverton et al. 1973; Yelverton and Richmond 1981). High underwater SPLs are known to injure and/or kill fishes, as well as cause temporary stunning and alterations in behavior (Hastings and Popper 2005; Popper 2003; Turnpenny and Nedwell 1994; Turnpenny et al. 1994).

Risk of injury appears related to the effect of rapid pressure changes, especially on gas-filled spaces in the bodies of exposed organisms (Turnpenny et al. 1994). Fish-kills have been among the most noticeable and well-documented adverse effects of in-water impact pile driving. With few exceptions, however, fish-kills are generally reported only when dead or injured fish are observed at the surface and therefore the frequency and magnitude of such kills are likely underestimated. High underwater SPLs can also cause a variety of behavioral responses, many of which have not been thoroughly studied.

The effects of elevated underwater SPLs on exposed organisms can vary substantially, ranging broadly from no noticeable effect to instantaneous mortality. Over this continuum of effect, there is no easily identifiable point at which behavioral responses transition to physical effects. We evaluated two types of exposure to elevated SPLs, those causing injury and/or mortality, and those causing significant behavioral responses or disruption.

Effects of Elevated Underwater SPLs - Injury and Mortality

Injury and mortality in fishes has been attributed to impact pile driving (Abbott et al. 2005; Hastings and Popper 2005; Stadler, pers comm 2002; Stotz and Colby 2001). The injuries associated with exposure to high SPLs are referred to as barotraumas, and include hemorrhage and rupture of internal organs, hemorrhaged eyes, and temporary stunning (Hastings and Popper 2005; Turnpenny and Nedwell 1994; Yelverton et al. 1973; Yelverton et al. 1975; Yelverton and Richmond 1981). Death as a result of barotrauma can be instantaneous, occurring within minutes after exposure, or can occur several days later (Abbott et al. 2002). Necropsy results from Sacramento blackfish (*Othodon microlepidotus*) exposed to high SPLs showed fish with extensive internal bleeding and a ruptured heart chamber were still capable of swimming for several hours before death (Abbott et al. 2002). Sublethal injuries can interfere with the ability to carry out essential life functions such as feeding and predator avoidance (Popper 2003).

The potential for injury and/or mortality depends on several factors, including the type of sound and intensity of sound produced. These, in turn, are strongly influenced by the type of hammer, characteristics of the substrate and subsurface conditions, depth of water, and the presence or

absence of channel (bed and bank) formations that might serve to naturally intercept and attenuate SPLs. Firmer substrates are more resistant to penetration, generally require more force and energy when pile driving, and therefore usually produce more intense sound pressures. In addition to the type of sound and intensity of sound produced, other factors that influence the potential for injury and/or mortality include the size of the exposed organism(s), anatomical variation, and location in the water column (Gisiner et al. 1998). Sound energy from an underwater source readily enters the bodies of exposed organisms because the acoustic impedance of animal tissue nearly matches that of water (Hastings 2002).

Gas-filled structures are particularly susceptible to the adverse effects of elevated underwater sound (Gisiner et al. 1998). Examples of gas-filled structures found in vertebrate species include swimbladders, bowels, sinuses, and lungs. As sound travels from a fluid medium into a gas-filled structure there is a dramatic drop in pressure, which can cause rupture of the hollow organs (Gisiner et al. 1998). This has been demonstrated in fishes with swimbladders (including salmonids). As a sound pressure wave passes through a fish, the swimbladder is rapidly compressed due to the high pressure and then rapidly expanded by the underpressure. Exposure to this type of pneumatic pounding can cause rupture of capillaries in the internal organs, as observed in fishes with blood in the abdominal cavity, and maceration of kidney tissues (Abbott et al. 2002; Stadler, pers comm 2002).

Yelverton and Richmond (1981) and Yelverton et al. (1973) exposed a variety of fish species, various birds, and terrestrial mammals to underwater explosions. Common to all the species were injuries to air- and gas-filled organs, as well as eardrums. These studies identified injury thresholds in relation to the size of the charge, the distance at which the charge was detonated, and the mass of the exposed animal. Yelverton et al. (1973) and Yelverton and Richmond (1981) found that the greater the fish's mass, the greater impulse level needed to cause an injury. Conversely, a fish with smaller mass would sustain injury from a smaller impulse.

At Bremerton, Washington, approximately 100 surfperch (*Cymatogaster aggregata*, *Brachyistius frenatus* and *Embiotoca lateralis*) were killed during impact driving of 30-inch diameter steel pilings (Stadler, pers comm 2002). The size of these fish ranged from 70 mm to 175 mm fork length. Dissections revealed that the swimbladders of the smallest of the fishes (80 mm fork length) were completely destroyed, while those of the largest individual (170 mm fork length) were nearly intact. Damage to the swimbladder of *C. aggregata* was more severe than to similar-sized *B. frenatus*. These results are suggestive of size and species-specific differences and are consistent with those of Yelverton et al. (1975) who found size and/or species differences in injury from underwater explosions.

Another mechanism of injury and mortality resulting from high SPLs is rectified diffusion, or the formation and growth of bubbles in tissue. Rectified diffusion can cause inflammation and cellular damage because of increased stress and strain (Stroetz et al. 2001; Vlahakis and Hubmayr 2000) and blockage or rupture of capillaries, arteries, and veins (Crum and Mao 1996). Crum and Mao (1996) analyzed bubble growth caused by sound signals at low frequencies (less than 5,000 Hz), long pulse widths, and atmospheric pressure. Their analysis indicates that underwater SPLs exceeding 190 dB_{peak} can cause bubble growth.

Due to differences between species and from variation in exposure type and duration, uncertainty remains as to the degree of potential adverse effect from SPLs between 180 and 190 dB_{peak}. Turnpenny et al. (1994) exposed brown trout (*Salmo trutta*) to SPLs greater than 170 dB using pure tone bursts for a duration of 90 seconds. This resulted in a mortality rate of 57 percent (after 24 hours) in brown trout; 50 percent mortality (after 24 hours) was observed in bass (*Dicentrarchus labrax*) and whiting (*Merlangius merlangus*) exposed to SPLs greater than 176 dB. The authors suggest that the threshold for continuous sounds is, or ought to be, lower than for pulsed sounds, such as seismic airgun blasts. Sound pressures produced by impact pile driving are more similar to those produced by airgun blasts. As such, we conclude that the 170 dB threshold for injury to brown trout identified by Turnpenny et al. is likely lower than the injury threshold associated with underwater SPLs produced by impact pile driving.

In 2008, the Service, FHWA, WSDOT, and other signatory agencies endorsed application of interim criteria for estimating onset of injury developed by the Fisheries Hydroacoustic Working Group (FHWG 2008). These interim criteria apply a sound exposure level (SEL) framework for assessing fish injury. For further details, see a sub-section that follows (*Estimate of the Extent of Effect*).

Effects of Elevated Underwater SPLs - Behavioral Responses

Elevated underwater SPLs can elicit a variety of behavioral responses. In general, there is much uncertainty regarding the response of organisms to sources of underwater sound, and there are no experimental data specific to bull trout exposed to underwater sound from impact pile driving. Further confounding the issue, most of the information on behavioral effects of underwater sound is obtained from studies examining pure tone sounds. Sounds generated by impact pile driving are impulsive and are made up of multiple frequencies, making comparisons with existing data difficult.

Knudsen et al. (1992) studied spontaneous awareness reactions (consisting of reduced heart beat frequency and opercular movements), and avoidance responses to sound in juvenile Atlantic salmon. This study evaluated responses to frequencies ranging from 5 to 150 Hz. With increasing frequency, the difference between the threshold for spontaneous awareness reaction and the estimated hearing threshold also increased. At 5, 60 and 150 Hz, the signal had to exceed the hearing thresholds by 25, 43 and 73 dB, respectively, to elicit reactions. Most of the sound energy produced by impact pile hammers is concentrated at frequencies between 100 and 800 Hz. Salmonids can detect sounds at frequencies between 10 Hz (Knudsen et al. 1997) and 600 Hz (Mueller et al. 1998). Optimal salmonid hearing is thought to be at frequencies of 150 Hz (Hawkins and Johnstone 1978). Therefore, impact pile installation produces sounds within the range of salmonid hearing.

Exposure to elevated SPLs can result in temporary hearing damage referred to as Temporary Threshold Shift (TTS). Most bioacoustic specialists consider TTS to be physiological fatigue and not injury (Popper et al. 2006). However, an organism experiencing TTS may be unable to detect biologically relevant sounds such as approaching predators or prey, and/or mates attempting to communicate. Mesa (1994) examined predator avoidance ability and physiological response of Chinook salmon subjected to various stressors. Test subjects were agitated to cause

disorientation. When equal numbers of stressed and unstressed fish were exposed to predators, there was significantly more predation of stressed fish. Shin (1995) reports that impact pile driving may result in agitation of fish, manifested as a change of swimming behavior.

Turnpenny et al. (1994) attempted to determine a level of underwater sound that would elicit behavioral responses in brown trout, bass, sole, and whiting. In brown trout an avoidance reaction was observed above 150 dB_{rms}, and other reactions (e.g., a momentary startle) were observed at 170-175 dB_{rms}. The report references Hastings' safe limit recommendation of 150 dB_{rms} and concludes that the Hastings' safe limit provides a reasonable margin below the lowest levels where fish injury was observed. In an associated literature review, Turnpenny and Nedwell (1994) also state that the Hastings' 150 dB_{rms} limit did not appear overly stringent and that its application seemed justifiable.

More recently, Fewtrell (2003) held fish in cages in marine waters and exposed them to seismic airgun impulses. The study detected significant increases in behavioral response when SPLs exceeded 158-163 dB_{rms}. Responses included alarm, faster swimming, tighter grouping, and movement toward the lower portion of the cage. It is difficult to discern the significance of these behavioral responses. The study also evaluated physiological stress response by measuring plasma cortisol and glucose levels and found no statistically significant changes. Conversely, Santulli et al. (1999) found evidence of increased stress hormones after exposing caged European bass to seismic survey noise.

Popper (2003) suggests that the behavioral responses of fishes may include swimming away from the sound source, thereby decreasing potential exposure to the sound, or freezing (staying in place), thereby becoming vulnerable to possible injury. Feist et al. (1992) found that impact pile driving affected juvenile pink and chum salmon distribution, school size, and schooling behavior. In general, on days when impact pile driving was not conducted, fish exhibited a more polarized schooling behavior (i.e., movements in a more definite pattern). On days when impact pile driving was conducted, fish exhibited an active milling behavior (i.e., movement in an eddying mass); fish did appear to change their distributions about the site, more commonly orienting and moving towards an acoustically-isolated cove, on days when impact pile driving was conducted. Observations by Feist et al. (1992) suggest that SPLs in excess of 150 dB_{rms} may disrupt normal migratory behavior in juvenile salmon.

Clearly, there is a substantial gap in scientific knowledge on the topic of significant behavioral responses to elevated underwater SPLs. The most recent study by Fewtrell (2003) presents some experimental data on behavioral responses of fishes to impulsive sounds above 158 dB_{rms}. However, given the large amount of uncertainty that lies not only in extrapolating from experimental data to the field, but also between sound sources (airguns vs. pile driving), and from one species to another, we believe it is appropriate to utilize the most conservative known threshold. As such, for the purposes of this analysis, we expect that SPLs in excess of 150 dB_{rms} will cause significant behavioral changes in bull trout and will or may disrupt normal bull trout behaviors (i.e., ability to successfully feed, move, and/or shelter).

Estimate of the Extent of Effect

In 2008, the Service, FHWA, WSDOT, and other signatory agencies endorsed application of interim criteria for estimating onset of injury developed by the Fisheries Hydroacoustic Working Group (2008). These interim criteria apply a SEL framework for assessing fish injury.

The interim criteria for fish injury identify a single-strike SPL of 206 dB_{peak} and 183 dB accumulated SEL for fish less than two grams. The interim criteria identify a single-strike SPL of 206 dB_{peak} and 187 dB accumulated SEL for fish greater than two grams (FHWG 2008).

We use the practical spreading model (Davidson 2004) to estimate the distance from piling installation operations (R; range) at which transmission loss (TL) can be expected to attenuate SELs and SPLs to below thresholds for injury and significant behavioral interference. The calculation [TL = 15*Log(R)] assumes that sound levels decrease at a rate of 4.5 dB per doubling distance. This method also assumes that single-strike SELs less than 150 dB do not accumulate to cause injury (effective quiet) (Stadler, pers comm 2009).

During the winter of 2009-2010 the WSDOT performed a pile installation test program in support of the project (WSDOT 2010a, Appendix D pp. D-12 and D-13). The WSDOT collected geotechnical, underwater sound, and turbidity data while installing steel piles with vibratory and impact hammers. Locations in Portage and Union Bays were selected to represent typical conditions along the proposed bridge and approach alignments. The test pile program monitored peak, unattenuated SPLs, and effectiveness of three sound attenuation systems (confined and un-confined bubble curtains, and double-walled noise attenuation pile), while installing piles to load bearing capacity. No test piles were driven along the proposed east approach.

Results from the pile installation test program are reported in Illingworth and Rodkin (2010). Bubble curtain sound attenuation systems performed well, reducing peak SPLs by as much as 30 dB in Portage Bay and the Union Bay – Arboretum vicinity, and by as much as 19 dB along the west approach east of Foster Island.

Based, in part, upon this site-specific data obtained from the test pile program, the BA describes anticipated sound exposure levels resulting from impact pile driving operations in: 1) Portage Bay; 2) the Union Bay – Arboretum vicinity and near west approach; 3) the west approach east of Foster Island; and, 4) the east approach (WSDOT 2010a, Appendix D). We consider the set of assumptions used in applying the model to be appropriately conservative. With respect to performance of the sound attenuation system (i.e., bubble curtain), these analyses assume that the system will achieve an approximately 30 dB reduction when implemented in Portage Bay and the Union Bay – Arboretum vicinity, and an approximately 19 dB reduction when implemented along the west approach east of Foster Island (measured at 10 m from the pile). Where the project has no site-specific data (i.e., along the east approach), these analyses more conservatively assume peak sound levels and attenuation (10 dB) consistent with the range reported in the literature for similar operations (CALTRANS 2007).

Based on the studies and findings presented here and in previous sub-sections, we expect that subadult and adult bull trout exposed to an accumulated SEL of 187 dB will be injured or killed.

We also expect that subadult and adult bull trout, when exposed to single-strike SPLs of 150 dB_{rms} or above, may experience a significant disruption of their normal behaviors (i.e., ability to successfully feed, move, and/or shelter).

Behavioral responses are variable, and therefore when interpreting the significance of SPLs above 150 dB_{rms}, we consider both the intensity and duration of exposure. Pile driving activities conducted at each location (Portage Bay, the Union Bay – Arboretum vicinity and near west approach, etc.) will be of long duration; in each case, the project will install and proof hundreds of piles with an impact hammer, over the course of many consecutive weeks or months. We expect that exposure to SPLs of 150 dB_{rms} or above will cause bull trout to temporarily avoid the area, impede or discourage free movement through the area, prevent individuals from exploiting preferred habitats, and/or expose individuals to less favorable conditions. Exposed bull trout will suffer sub-lethal physiological stress, and are likely to experience reduced foraging success and efficiency. Over the durations involved, these exposures will significantly disrupt normal bull trout behaviors, with potential consequences for individual growth and long term survival.

Applying the methods of analysis summarized here, Table 4 below summarizes the expected distances over which resulting sound levels may exceed injury and disturbance thresholds.

In Portage Bay, and in Union Bay surrounding the Arboretum, where injurious SELs will extend less than 10 ft, we conclude that bull trout injury or mortality resulting from impact pile driving and proofing is extremely unlikely and therefore discountable.

Along the west approach east of Foster Island, where injurious SELs will extend approximately 62 ft, we cannot fully discount the possibility that a few bull trout individuals may be injured or killed. The vicinity of the west approach east of Foster Island is considered the primary route for salmonid migration to and from south Lake Washington and the Cedar River (WSDOT 2010a, p. 4-15).

Table 4. Zones of potential effect resulting from impact pile driving and proofing.

Project Segment or Location	Radius Distance (ft) to Injury Threshold			Disturbance Threshold
	206 dB_{peak}	**187 dB SEL**	183 dB SEL	**150 dB_{rms}**
Portage Bay	< 3	6.5	6.5	72
Union Bay – Arb.	< 3	6.5	6.5	72
West Approach	< 3	62	72	450
East Approach With Curtain	16	1,800	1,800	7,100
East Approach Without Curtain*	82	1,800	1,800	15,000+

[*__Note__: maximum 500 pile strikes per day.]

Along the east approach, injurious SELs will extend approximately 1,800 ft with the use of a bubble curtain and we cannot fully discount the possibility that bull trout individuals may be injured or killed. The project will limit the total number of unattenuated pile strikes (i.e., pile strikes without the use of a bubble curtain) to 500 strikes per day, when determining baseline SLs. We expect that this limit on the number of unattenuated pile strikes per day will prevent bull trout from being injured or killed to a distance greater than 1,800 ft.

Impact driving and proofing of steel piles will also significantly disrupt normal bull trout behaviors, to a distance of approximately 72 ft in Portage Bay and in Union Bay surrounding the Arboretum, to a distance of approximately 450 ft along the west approach east of Foster Island, and to a distance of approximately 7,100 ft along the east approach.

We do not expect that unattenuated pile strikes will significantly disrupt normal bull trout behaviors to a greater distance. Along the east approach, the project will limit the total number of unattenuated pile strikes to 500 strikes per day, and resulting SLs will be of very short duration (i.e., less than 30 minutes). Resulting episodic, short-duration exposures will not prevent bull trout from moving and foraging through portions of Lake Washington at a greater distance, and therefore will not significantly disrupt normal bull trout behaviors.

Table 5 quantifies the areas where we expect underwater sound will measurably and adversely affect bull trout, by project segment or location, and year of construction.

In south Portage Bay, and in south Union Bay surrounding the Arboretum, these areas provide low-quality habitat which we expect is not very attractive to bull trout. Accordingly, we expect very few bull trout will experience significant behavioral disruption as a result of impact pile driving and proofing conducted in Portage Bay and in Union Bay surrounding the Arboretum.

Table 5. Area (in acres) of elevated underwater SLs with potential for behavioral disruption or injury.

Project Segment/ Location	2012	2013	2014	2015	2016	2017
Portage Bay	N/A	10.2	N/A	6.6	N/A	6.6
Union Bay – Arboretum	N/A	9.7	N/A	10.0	N/A	N/A
West Approach*	N/A	42.8 (4.0)	N/A	41.7 (3.8)	N/A	N/A
East Approach*	1,810 (150)	1,760 (134)	N/A	N/A	N/A	N/A

[***Note**: areas appearing in parentheses represent zones of potential injury.]

Along the west approach east of Foster Island, we expect that impact pile driving and proofing has the greatest potential to affect bull trout. This portion of Union Bay and Lake Washington functions as the principle migratory route for fish traveling to and from south Lake Washington and the Cedar River sub-basin. As such, we expect that a greater number of individual bull trout may use this area when migrating and/or foraging in Lake Washington. Impact pile driving and proofing along the west approach east of Foster Island has the potential to kill or injure a limited number of bull trout. Pile driving at this location may also significantly disrupt the normal behaviors of a greater, but still relatively small, number of individual bull trout.

Along the east approach, where we lack site-specific data and have instead used a set of very conservative assumptions regarding peak sound levels and attenuation, the zones of potential effect represent a reasonable worst-case scenario. There are few or no data to suggest that bull trout make regular or extensive use of habitats along the east shore, or out over the deepest portions, of Lake Washington. Accordingly, we expect that few bull trout will experience significant behavioral disruption, or will be killed or injured, as a result of impact pile driving and proofing conducted along the east approach.

With full implementation of the agreed upon conservation measures, we expect that only those bull trout present within 62 ft of the west approach pile driving locations, or within 1,800 ft of the east approach pile driving locations, will be physically injured or killed (Table 4). Based upon the presumed low numbers and infrequent occurrence of bull trout in these waters, we expect that the total number of injured or killed bull trout will be very low (i.e., a few individuals at most). We expect that impact pile driving operations will also significantly disrupt the normal behaviors of a greater number of subadult and adult bull trout. Impact pile driving operations conducted along the Portage and Union Bay-Arboretum alignments, the west approach, and east approach will significantly disrupt all bull trout present within 72 ft, 450 ft, and 7,100 ft, respectively (Table 4). Impact pile driving and proofing may prevent individuals from exploiting preferred habitats and could expose individuals to less favorable conditions. Suitable bull trout rearing and spawning habitats are not present in the action area, and therefore these operations will have no effect on bull trout rearing and spawning habitat or these essential behaviors.

Stormwater Effects – Pollutant Loadings & Dilution Zones

The proposed project will create a net increase of approximately 13 acres of “effective” PGIS, which excludes non-pollution-generating portions of the lids and roadways beneath lids. Most of the net-new PGIS will be located within three threshold discharge areas (TDAs), and will drain and discharge after treatment at three distinct locations (WS-D, WS-PR or MOHAI, and WS-BR4 along the floating bridge span). Effective PGIS will remain roughly unchanged, or will decrease, in three additional, comparatively large TDAs (East Allison Street, WS-C, and WS-J). These six TDAs will account for approximately 90 percent of the total, post-project PGIS by area.

The project’s proposed stormwater treatment design will provide basic or enhanced treatment for stormwater runoff originating from approximately 69 acres of PGIS. This represents a stormwater treatment retrofit for more than 500 percent of the net-new PGIS by area, and is

expected to achieve measurable reductions in post-project annual stormwater loadings of total suspended solids (TSS), total copper (Cu), and total zinc (Zn) (WSDOT 2010a, p. 6-164, 6-165).

Nevertheless, we expect that the proposed action will still result in potential adverse effects to bull trout and their habitat resulting from the discharge of treated and untreated highway stormwater runoff. The resulting effects to surface water and sediment quality will last in perpetuity, but will create only infrequent, episodic conditions with the potential to significantly disrupt normal bull trout behaviors (i.e., ability to successfully feed, move, and/or shelter).

In the long term, we do not expect that the proposed action will worsen surface water or sediment quality trajectories at the scale of the action area or Lake Washington watershed. Furthermore, we do not expect that the project's long term, operational stormwater effects will cause or contribute to a measurable, incremental decline in the bull trout prey base (or greater Lake Washington native forage fish prey base).

Because all stormwater runoff originating from within the project limits will discharge to flow control exempt waterbodies, we also conclude that the proposed action is unlikely to have any discernible effect on local hydrology. The project will influence patterns of runoff and infiltration on a local scale, but will have no discernible effect on the size or frequency of peak, high, low or base flows, or on day-to-day or seasonal fluctuations of the natural hydrograph within the project's receiving waters. The proposed stormwater design is not expected to cause or contribute to measurable increases in surface water temperature, and will not degrade thermal refugia within the action area.

The sub-sections that follow provide background information to describe stormwater pollutants (contaminants of concern), highway stormwater runoff treatment systems, acute physiological and behavioral effects exhibited in fish (lethal and sub-lethal), and the significance of pollutant loadings as a potential vector for chronic effects.

The potential effects of the action are then discussed with specific reference to performance of the proposed stormwater treatment design, combined sewers and storm design exceedances, exposure to treated discharges and resulting dilution zones, exposure to untreated discharges, and annual pollutant loadings and potential chronic stormwater effects.

Stormwater Pollutants / Contaminants of Concern

Untreated highway runoff contains a variety of pollutants that impair water quality and pose a risk to aquatic organisms (Herrera Environmental Consultants 2007). Table 6 identifies the variety of pollutants typically found in untreated highway runoff. Sources of pollutants found in untreated highway runoff include atmospheric deposition, direct and indirect deposition and application, and vehicles and vehicular traffic (Herrera Environmental Consultants 2007). Factors that influence the types and amounts of pollutants found in untreated highway runoff include average daily traffic and traffic conditions, weather and precipitation patterns, road conditions and maintenance, and surrounding land uses. One particularly important factor is the buildup of solids and other pollutants on pavement and in stormwater conveyances between storm events (Herrera Environmental Consultants 2007).

Data obtained from a variety of sources indicate that pollutant concentrations in untreated highway runoff are highly variable (Herrera Environmental Consultants 2007). Table 7 reports mean pollutant concentrations obtained from studies examining highway runoff in western Washington and nationwide.

Highways can be significant contributors to overall pollutant loads in receiving waterbodies (Wheeler et al. 2005). Pollutants that are dissolved in, or mobilized by highway runoff, are easily transported to wetlands, streams, and rivers if the runoff is not intercepted and passively treated by vegetation, infiltrated, or conveyed to engineered treatment systems.

Some pollutants and contaminants of concern have a strong affinity for suspended solids and the particulate-phase or fraction of treated and untreated highway runoff (Grant et al. 2003; Wong et al. 2000). As a result, a large fraction of the toxic (inorganic and non-polar organic) contaminant load in treated and untreated stormwater is in particulate form, either sorbed onto, or complexed with solids (Fan et al. 2001; Grant et al. 2003, pp. viii, x; Marsalek et al. 1999, p. 34; Muthukrishnan and Selvakumar 2006, pp. 2, 5; Wong et al. 2000, p. 11). The heavy metals, especially Cu, chromium (Cr), lead (Pb), and nickel (Ni) are closely associated with the particulate fraction (Grant et al. 2003, p. 5-7; Wong et al. 2000, p. 32); and Zn and cadmium (Cd) are to a somewhat lesser extent. PAHs, oils and petroleum hydrocarbons generally, and other non-polar organic contaminants, such as pesticides and their decomposition products, are also closely associated with the particulate-phase or fraction. Most of the PAH load in treated and untreated stormwater is bound to solids.

PAHs are often ubiquitous in urban and developed environments, but the dissolved-phase or fraction sometimes represents as little as 10 percent of the whole-water concentration, total burden or load (Grant et al. 2003, p. 5-6; Marsalek et al. 1997; Wong et al. 2000, p. 11). For these and other reasons, some experts in the field have identified TSS as an appropriate indirect measure or indicator of toxic contaminant load (Grant et al. 2003, p. 1-4; Hallberg et al. 2007, p. ab). Where sampling and monitoring are concerned, TSS is a decidedly easier and cheaper parameter to sample and measure.

Table 6. Typical pollutants in highway runoff (Herrera Environmental Consultants 2007).

Pollutant Parameter Category	Parameter
Suspended Solids	Total suspended solids
	Volatile suspended solids
Metals	Arsenic
	Cadmium
	Chromium
	Copper
	Iron
	Lead
	Mercury
	Nickel
	Zinc
Nutrients	Ammonia nitrogen
	Nitrate nitrogen
	Total Nitrogen
	Total Kjeldahl nitrogen
	Total Phosphorus
	Orthophosphate phosphorus
Organic Compounds	Polycyclic aromatic hydrocarbons
	Oil and grease
	Total petroleum hydrocarbons
	Pesticides
	Herbicides
Bacteria	Total coliform bacteria
	Fecal coliform bacteria
Oxygen Demand	Biological oxygen demand (5-day)
	Chemical oxygen demand
Conventional Parameters	Sodium (if deicing performed)
	Chloride (if deicing performed)
	pH
	Turbidity
	Conductivity Hardness

Table 7. Constituents in untreated highway runoff (Herrera Environmental Consultants 2007): comparison of site mean concentrations.

Constituent	Western Washington Sites [a]	National Data [b]
Solids (mg/L)		
Total	No data	437 to 1,147
Dissolved	No data	356
Suspended	3 to 295 (27)	45 to 798
Volatile (dissolved)	No data	131
Volatile (suspended)	19 to 460 (5)	4.3 to 79
Volatile (total)	No data	57 to 242
Metals, total (µg/L)		
Antimony	1.2 to 8.7 (2)	Not reported
Arsenic	2.2 to 2.6 (2)	58
Barium	81 to 84 (2)	Not reported
Chromium	7.5 to 18 (2)	Not detected to 40
Cadmium	0.9 to 2.8 (2)	Not detected to 40
Cobalt	1.9 to 4.4 (2)	Not reported
Copper	4.6 to 72 (29)	22 to 7,033
Iron	No data	2,429 to 10,300
Lead	24 to 1,065 (10)	73 to 1,780
Lead[c]	24 to 61 (3)	73 to 1,780
Magnesium	No data	1,062
Mercury	0.02 (1)	3.22
Molybdenum	1.5 to 9.5 (2)	Not reported
Nickel	8.6 to 12.9 (2)	53
Vanadium	6.3 to 14.8 (2)	Not reported
Zinc	26 to 394 (29)	56 to 929
Metals, dissolved (µg/L)		
Copper	3.1 to 18.1 (21)	Not reported
Lead	1.0 to 3.2 (2)	Not reported
Lead[c]	3.2 (1)	Not reported
Zinc	13 to 134 (22)	Not reported
Nutrients (mg/L)		
Ammonia nitrogen	1.0 to 2.7 (2)	0.07 to 0.22
Nitrite nitrogen	No data	0.013 to 0.25
Nitrate nitrogen	No data	0.306 to 1.4
Nitrite+nitrate nitrogen	0.51 to 3.0 (6)	0.15 to 1.636
Organic nitrogen	No data	0.965 to 2.3
Total Kjeldahl nitrogen	0.38 to 3.4 (6)	0.335 to 55.0
Total nitrogen	0.78 to 21.7 (2)	4.1
Orthophosphate phosphorus	0.01 to 0.42 (9)	Not reported
Total phosphorus	0.03 to 0.57 (24)	0.113 to 0.998

Table 7 (continued). Constituents in untreated highway runoff (Herrera Environmental Consultants 2007).

Constituent	Western Washington Sites [a]	National Data [b]
Organic Compounds (mg/L)		
TPH-oil	0.42 to 7.9 (12)	Not reported
TPH-diesel	Not detected to 2.75 (8)	Not reported
Oil and grease	11.8 to 187 (4)	2.7 to 27
Bacteria		
Total coliform bacteria (CFU/100 mL)	9,350 (1)	570 to 6,200
Fecal coliform bacteria (CFU/100 mL)	35 to 11,775 (16)	50 to 590
E. coli bacteria (CFU/100 mL)	130 to 1,670 (3)	Not reported
Oxygen Demand (mg/L)		
Chemical oxygen demand	32 to 1377 (11)	14.7 to 272
Biological oxygen demand (5-day)	9.5 to 71 (2)	12.7 to 37
Conventionals		
pH	5.8 to 6.8 (5)	7.1 to 7.2
Specific conductivity (µS at 25 °C)	71.6 (1)	337 to 500
Total organic carbon (mg/L)	2.0 to 139.0 (8)	24 to 77
Turbidity (NTU)	16.3 to 86.7 (3)	19
Hardness (mg/L as $CaCO_3$)	11.1 to 86.1 (19)	Not reported
Alkalinity (mg/L as $CaCO_3$)	19.3 to 23.4 (2)	Not reported

Particle size distribution exerts a strong influence on contaminant-particulate dynamics and association. Heavy metals, PAHs, and other non-polar organic contaminants are generally bound in greatest concentration to the smallest of particles and colloids. For non-polar organic contaminants, particulate organic matter content also exerts a strong influence, but total particulate surface area is probably of greater significance. The smallest particles have the greatest "surface area to volume ratio", and therefore provide a comparatively larger total surface area to which contaminants may bind, sorb, and complex (Fan et al. 2001; Herngren et al. 2005, p. 150; John and Leventhal 1995, p. 13; Pettersson 2002, p. 1).

Highway Stormwater Runoff Treatment Systems

There are a variety of engineered stormwater treatment systems and technologies. These systems and technologies vary with regard to which pollutants or pollutant categories they are best capable of treating, and the effectiveness with which they treat specific pollutants. Treatment efficiency and effectiveness depend both on the specific treatment systems and technologies employed, and on how well these systems are designed, operated, and maintained. Studies indicate significant variation among different treatment technologies and facilities (Schueler 1987; WSDOT 2006; Young et al. 1996).

The WSDOT designs and constructs stormwater runoff treatment facilities and BMPs according to guidelines and criteria set forth in the Highway Runoff Manual (HRM) (WSDOT 2008). These guidelines are approved by the WDOE and meet State requirements for stormwater

management. Facilities and BMPs designed, constructed, and managed according to the Highway Runoff Manual represent the controls deemed necessary to reduce discharge of pollutants to the "maximum extent practicable" (WDOE 2010a).

Stormwater conveyance, treatment, and flow control facilities require routine maintenance to ensure proper function (WDOE 2010a; WDOE 2010b; WSDOT 2008). Failure to adequately maintain facilities and structural BMPs almost inevitably leads to reduced performance and efficiency. Anderson et al. (2002, p. 280) have pointed to excessive sediment accumulation, and (related) shortened hydraulic residence time, as factors that reduce settling pond performance. In addition, long-neglected facilities and structural BMPs can become a source, rather than a sink, of some pollutants found in highway stormwater runoff. Re-suspension and hydraulic flushing of accumulated sediments from facilities and BMPs have been implicated as a cause of failure and a significant maintenance concern (Anderson et al. 2002, p. 281; Fan et al. 2001; Starzec et al. 2005, p. ab); this concern is heightened where accumulated sediments contain levels of metal or organic contamination sufficient to exert toxicological effects (Marsalek et al. 2002, pp. ab,9).

Where practicable, given siting and other considerations, the proposed project will provide enhanced treatment for improved solids and metals control in the form of constructed stormwater treatment wetlands. The stormwater treatment design also includes an innovative treatment method for runoff originating from the floating bridge. This method, which includes at a minimum, a maintenance program of monthly high-efficiency sweeping and twice-annual catch basin cleaning, was developed in cooperation with the WDOE through a study and evaluation of "All Known, Available and Reasonable Technologies" for treatment (WSDOT 2010b).

Acute Physiological and Behavioral Effects (Lethal and Sub-Lethal)

Stormwater pollutants can affect the physiology and/or behavior of exposed salmonids in ways that disrupt normal behaviors (i.e., free movement, feeding, and sheltering), reduce growth, migratory success, and reproduction. In sufficient concentrations, stormwater pollutants can also result in acute toxicity and death. Acute effects to aquatic life are influenced by the size and dilution capacity of the receiving waterbody, background water quality conditions, concurrent discharges and/or background levels of other contaminants, frequency and duration of exposure, concentration and relative toxicity of the pollutant(s), biological uptake and availability, and life stage of the organism.

Potential acute effects from exposures that may occur in and around points of highway stormwater discharge, such as outfalls, are of primary concern. On an event basis, pollutant concentrations contained in stormwater discharges may exceed the State's criteria for the protection of freshwater aquatic life and/or other criteria associated with adverse sub-lethal effects. Upon entering the receiving waterbody, stormwater discharges will typically mix with and be diluted by flow and the ambient water quality conditions. In order to assess the potential for adverse effects stemming from acute exposures, it is necessary to know something of the physical and temporal extents of the pollutant mixing zone(s).

Highway runoff is a complex chemical mixture. Even during the course of a single discharge event, physical and chemical properties (including pollutant concentrations) can vary by orders

of magnitude (Glenn et al. 2002, p. 3). Conditions in the receiving waterbody are also dynamic, and therefore estimates of the probable extent or duration of resulting mixing zones are imprecise and subject to uncertainty. Additional sources of uncertainty include the effect of intermittent, episodic, or transient exposures (Burton et al. 2000, p. ab; Marsalek et al. 1999, p. 34); variations in tolerance among exposed individuals and/or populations (Ellis 2000, p. 89; Hodson 1988, p. ab; Lloyd 1987, p. 502); and the potential for synergistic or additive effects among pollutants with similar or the same modes of toxic action (Burton et al. 2000, p. ab; Ellis 2000, p. 88; Lloyd 1987, p. 494). Burton et al. (2000, p. ab) warn that traditional toxicity tests may not lead to reliable predictions or conclusions if not tailored to reflect real-world patterns of exposure. Lloyd (1987, pp. 492, 501) has expressed concern that pollutants may have increased toxicity to salmonids under conditions of reduced dissolved oxygen, and has advised that aquatic life criteria (i.e. water quality standards) should apply to whole groups of contaminants with common modes of action, rather than individual contaminants.

The Service relies on toxicity data for other salmonids when specific information on toxicity to bull trout is not available. Due to taxonomic similarity, species in the Salmonidae family are expected to be better surrogates for bull trout than non-salmonids. However, Hansen et al. (2002) demonstrate that even among the members of Salmonidae specific sensitivities to chemical contaminants and mixtures of contaminants may differ. The Service has relied on toxicity data for species in the following preferential order: species (bull trout) > genus (*Salvelinus*) > family (Salmonidae). Rainbow trout are the primary freshwater fish species used by the U.S. Environmental Protection Agency (EPA) when developing toxicity data for regulatory purposes; therefore, the majority of data available in the literature have been generated from studies using rainbow trout as test subjects (family Salmonidae).

The most commonly reported end points in the toxicity literature are concentrations at which 50 percent of the test subjects died (LC50). Concentrations that result in the death of a smaller percentage of the test population (e.g., LC10) are likely to be somewhat lower. Bull trout and other salmonids would be adversely affected if exposed to lethal concentrations with the potential to result in acute toxicity and death, or if exposed to contaminant concentrations known to result in sub-lethal effects with consequences for normal behavior (i.e., effects that disrupt the ability to successfully feed, move, and/or shelter).

A variety of stormwater pollutants exhibit toxic mechanisms of action, including volatile organic compounds, organic herbicides and pesticides, and metals. Volatile organics and organic herbicides and pesticides may be present in untreated highway stormwater runoff at concentrations sufficient to cause adverse effects (Kayhanian et al. 2003; Van Metre et al. 2000). However, for the purpose of this consultation, it is assumed that metals originating from vehicular sources pose the greatest risk of acute lethal and sub-lethal effects to bull trout. Traffic residues contain several metals, including Zn, Pb, Cd, Ni, Cu, and Cr, with toxic mechanisms of action (Wheeler et al. 2005). These metals originate from disintegrating tires, brake pads, and other vehicle parts and frequently accumulate in roadside dust and soil (Wheeler et al. 2005).

Acute (Lethal and Sub-Lethal) Effects – Dissolved Metals

There are three known physiological pathways by which salmonids may be directly exposed to and/or may uptake metals: 1) uptake of ionic metals at the gill surfaces (Niyogi et al. 2004), 2)

dietary uptake, and 3) olfaction (sense of smell) involving receptor neurons (Baldwin et al. 2003). Of these three pathways, the mechanism of dietary uptake is least understood. For dissolved metals, the most direct pathway is through the gill surfaces.

Measurements of total recoverable metal concentration include a fraction that is bound to suspended solids and/or complexed with organic matter or other ligands; this fraction is not available to bind to gill receptor sites. As such, most metal toxicity studies have examined the dissolved metal fraction which is more bioavailable and therefore of greater significance for acute exposure and toxicity.

The relative toxicity of a metal or metal species can be altered by hardness, water temperature, pH, organic content, phosphate concentration, suspended solid concentration, the presence of other metals or contaminants (i.e., synergistic effects), and other factors. Eisler (1998) and Playle (2004) found that dissolved metal mixtures exhibit greater than additive toxicity. Water hardness affects the bio-available fraction of metals; as hardness increases, metals become less bio-available for uptake at the gill surfaces and therefore less toxic (Hansen et al. 2002; Niyogi et al. 2004). However, Baldwin et al. (2003) found water hardness did not influence the inhibiting effects of Cu on salmon olfactory functions.

Copper (Cu)

Even at low concentrations, Cu is acutely toxic to fish. Effects of Cu exposure include 1) weakened immune function and impaired disease resistance, 2) impaired respiration, 3) disruptions to osmoregulation, 4) impaired function of olfactory organs and brain, 5) altered blood chemistry, 6) altered enzyme activity and function, and 7) pathology of the kidneys, liver, and gills (Eisler 1998).

Sprague (1964) and Sprague and Ramsay (1965) reported Incipient Lethal Levels for dissolved Cu of 48 µg/L and 32 µg/L at water hardnesses of 20 and 14 mg/L, respectively. The Incipient Lethal Level is that concentration which is required to kill half of the fish tested within 1 week of exposure. Sprague and Ramsay (1965) found that higher concentrations of Cu killed juvenile salmon much more rapidly than did lower concentrations at 14 mg/L hardness.

Baldwin et al. (2003) found that short pulses of dissolved Cu, at concentrations as low as 2 µg/L, reduced olfactory sensory responsiveness by approximately 10 percent within 10 minutes, and by 25 percent within 30 minutes. At 10 µg/L responsiveness was reduced by 67 percent within 30 minutes. Baldwin et al. (2003) identified a Cu concentration neurotoxic threshold of an increase of 2.3 to 3.0 µg/L, when background levels are 3.0 µg/L or less. When exceeded, this threshold is associated with olfactory inhibition. The authors also reference three other studies examining long-duration Cu exposures (i.e., exceeding 4 hours); these studies found that long-duration exposures resulted in cell (olfactory receptor neuron) death in rainbow trout and Atlantic and Chinook salmon. Baldwin et al. (2003) found that water hardness did not influence the toxicity of Cu to coho salmon sensory neurons.

More recently, Sandahl et al. (2007) documented sensory physiological impairment, and related disruption to predator avoidance behaviors, in juvenile coho at concentrations as low as 2 µg/L dissolved Cu.

The effects of short-term Cu exposure may persist for hours and possibly longer. Although salmonids may actively avoid surface waters containing an excess of dissolved Cu, those individuals that are exposed may experience olfactory function inhibition within minutes of exposure. Furthermore, avoidance of a chemical plume may cause fish to leave refugia or preferred habitats in favor of less suitable or less productive habitats. This, in turn, can make fish more vulnerable to predation and can impair foraging success, feeding efficiency, and thereby growth.

Folmar (1976) observed avoidance responses in rainbow trout fry when exposed to a Lowest Observed Effect Concentration of 0.1 µg/L dissolved Cu (hardness of 90 mg/L). The EPA (1980a) also documented avoidance by rainbow trout fry of dissolved Cu concentrations as low as 0.1 µg/L during a 1 hour exposure, as well as a LC10 for smolts exposed to 7.0 µg/L for 200 hours, and a LC10 for juveniles exposed to 9.0 µg/L for 200 hours.

Zinc (Zn)

Zn occurs naturally in the environment and is an essential trace element for most organisms. However, in sufficient concentrations and when bioavailable for uptake by aquatic organisms, excess Zn is toxic. Toxicity in the aquatic environment and for exposed aquatic organisms is influenced by water hardness, pH, organic matter content, levels of dissolved oxygen, phosphate, and suspended solids, the presence of mixtures (i.e., synergistic effects), trophic level, and exposure frequency and duration (Eisler 1993). Bioavailability of Zn increases under conditions of high dissolved oxygen, low salinity, low pH, and/or high levels of inorganic oxides and humic substances. Most of the Zn introduced into aquatic environments is eventually partitioned into sediments (Eisler 1993).

Effects of Zn exposure include 1) weakened immune function and impaired disease resistance (Ghanmi et al. 1989), 2) impaired respiration, including potentially lethal destruction of gill epithelium (Eisler 1993), 3) altered blood and serum chemistry, and enzyme activity and function (Hilmy et al. 1987a; Hilmy et al. 1987b), 4) interference with gall bladder and gill metabolism (Eisler 1993), 5) hyperglycemia, and 6) jaw and branchial abnormalities (Eisler 1993).

Hansen et al. (2002) determined 120-day lethal concentrations of Zn for test subjects that included bull trout and rainbow trout fry. Multiple pairs of tests were performed with a nominal pH of 7.5, hardness of 30 mg/L, and at a temperature of 8 °C. Bull trout LC50 values measured under these conditions ranged from 35.6 to 80.0 µg/L, with an average of 56.1 µg/L. Hansen et al. (2002) found that rainbow trout fry are more sensitive to Zn (i.e., exhibit a lower LC50) than are bull trout fry. The authors also report that older, more active juvenile bull trout are more sensitive than younger, more docile juvenile bull trout based on observed changes in behavior at the juvenile life stage. The authors argue that the timing of Zn and Cd exposure and the activity level of the exposed fish are germane to predicting toxicity in the field.

The mode of action for Zn toxicity relates to net loss of calcium. Studies suggest that Zn exposure inhibits calcium uptake, although it appears this effect is reversible once fish return to clean water. The apparent difference in sensitivity between rainbow trout and bull trout may be due to the lesser susceptibility of bull trout to calcium loss. Hansen et al. (2002) state that differences in sensitivity between these two salmonids may reflect different physiological strategies for regulating calcium uptake. These strategies may include gills that differ structurally, differences in the mechanisms for calcium uptake, and/or variation in resistance to or tolerance for calcium loss.

There are no known studies or data describing adult bull trout response to lethal or near-lethal concentrations of Zn. Active feeding and increased metabolic activity are apparently related to sensitivity. It is unknown whether sensitivity to Zn varies between adult, subadult, and juvenile bull trout. Activity level may be a better predictor of sensitivity than age.

In addition to the physiological effects of Zn exposure, studies have also documented a variety of behavioral responses. Among these, Eisler (1993) includes altered avoidance behavior, decreased swimming ability, and hyperactivity. The author also suggests Zn exposure has implications for growth, reproduction, and survival.

Sub-lethal endpoints have been evaluated with test subjects that include both juvenile and adult rainbow trout (Eisler 1993; USEPA 1980b; USEPA 1987). Some of these test results clearly indicate that juvenile rainbow trout are more sensitive than adult rainbow trout. Using juvenile rainbow trout as test subjects, studies have found that sub-lethal effects occur at concentrations approximately 75 percent lower (5.6 µg/L) than the concentrations that result in lethal effects (24 µg/L) (Eisler 1993; Hansen et al. 2002). Sprague (1968) found that at concentrations as low as 5.6 µg/L juvenile rainbow trout exhibit avoidance behavior.

Although salmonids may actively avoid surface waters containing an excess of dissolved Zn, it can generally be assumed that highway runoff contains a mixture of pollutants, including some known to affect the olfactory system, such as dissolved Cu. Bull trout exposed to these mixtures may not always be capable of detecting and avoiding elevated levels of dissolved Zn. Furthermore, avoidance of a chemical plume may cause fish to leave refugia or preferred habitats in favor of less suitable or less productive habitats. This can make fish more vulnerable to predation and can impair foraging success, feeding efficiency, and thereby growth.

Pollutant Loadings and Chronic Effects

Pollutant loads bound or complexed with the particulate-phase or fraction of highway stormwater runoff represent a persistent, long-term source of potential chronic exposures and effects (Chen et al. 1996, p. ab; Fan et al. 2001; Glenn et al. 2002, p. 2; Grant et al. 2003, p. 4-3; Pettersson 2002, p. 1). Heavy metals do not degrade in the environment (Glenn et al. 2002, p. 2; Muthukrishnan and Selvakumar 2006, p. 2), and organic contaminants easily persist for durations that exceed the life spans of individual fish or multiple generations of fish (Heintz et al. 2000, p. 214). Chronic effects to individuals stem from repeated exposures over time, through multiple exposure pathways, and from multiple stressors and combinations of stressors (Burton et al. 2000, p. ab; Ellis 2000, p. 86; Heintz et al. 2000, p. 214). Ellis (2000, p. 89) has argued

that sediment-mediated exposures and effects have not yet been given adequate attention, and furthermore that "…procedures for the identification of chronic, sub-lethal no effects limits are still to be achieved." Emphasizing the tendency for accumulation in sediments, both Hodson (1988, p. ab) and Pettersson (2002, p. 1) have argued that loads and not simply water concentrations should be a focus for management where discharges of metals and persistent organic pollutants are concerned.

Fate and Transport of Contaminants Present in Stormwater Runoff

As highway runoff moves from the edge-of-pavement, through drainage/conveyance structures, and treatment and flow control facilities and BMPs, it passes through a succession of varying physical and chemical environments. Treatment facilities and BMPs use controlled conditions to remove pollutants through adsorption, complexation, settling, and filtration. However, upon release to the receiving waterbody, stormwater discharges enter a more complex and dynamic environment. Contaminant fate and transport in the aquatic environment is influenced by a host of factors, including the unique chemical and physical properties of the contaminant of concern, the chemical and physical properties of particulates/ solids present in both runoff and the receiving waterbody, and changing ambient chemical, physical, and biological conditions in the receiving waterbody.

The factors influencing metal and non-polar organic contaminant fate and transport in the aquatic environment, including the important role of solids and the particulate fraction of stormwater runoff, are described thoroughly elsewhere (Glenn et al. 2002; Grant et al. 2003; John and Leventhal 1995; Lloyd 1987). However, to more fully appreciate the significance of pollutant loadings, and the nature of sediment-mediated exposures and effects, it is essential to understand a few fundamental premises: 1) partitioning of metals between the solid and aqueous phases has a strong influence on mobility, storage, export, and ultimate fate, 2) solids, whether particulates in discharge or sediments in the natural environment, can act as both sinks and sources for metals and non-polar organic contaminants, and 3) the ambient conditions which govern whether solids will act as sources or sinks are dynamic and can change over time.

Solid/liquid-phase dynamics and partitioning have a strong influence on the fate and transport of metal contaminants present in highway stormwater runoff. These processes begin when road solids are first brought into contact with precipitation. They continue as runoff passes through treatment and flow control facilities, and once highway stormwater runoff is released to the environment (Grant et al. 2003). Within stormwater conveyance and treatment systems, partitioning coefficients, residence time (i.e., how long road solids and runoff remain in contact), and the degree of mixing exert a strong influence on equilibrium concentrations in the particulate (solid) and dissolved (liquid) phases (Glenn et al. 2002, p. 3). Upon release to the environment, metal speciation, pH, redox potential, temperature, organic matter content, and other factors influence partitioning amongst six fractions present in suspended solids, soils, and sediment (John and Leventhal 1995, pp. 10, 11). These metal fractions exhibit widely-varying mobilities in the environment; exchangeable (dissolved) cations exhibit high mobility, while iron-manganese and organically-bound fractions exhibit medium mobilities; crystalline fractions are relatively immobile (John and Leventhal 1995, p. 10).

Solids can act as both sinks and sources for metals and non-polar organic contaminants. Contaminants are "…reversibly bound to suspended particles….", and these particles can act as a "…source of water column toxicity or interstitial (pore) water toxicity." (Grant et al. 2003, p. 4-3) Adsorption and complexation are physiochemical processes that would tend to remove contaminants from the liquid-phase and sequester them in the solid-phase (Lloyd 1987, p. 491, 499). Redox potential (i.e., oxidizing or reducing conditions) and pH influence how contaminants are bound and, under varying conditions, can act to either keep contaminants bound in the solid-phase, or conversely, to release or desorb contaminants to the dissolved (liquid) phase (Bostick et al. 1998, p. 1; John and Leventhal 1995, p. 13). Some contaminated sediments constitute a persistent, continuing source of toxic contamination (Fan et al. 2001).

There is considerable evidence to illustrate how urban stormwater and highway runoff can create accumulations of metals and non-polar organic contaminants in receiving waters. Carr et al. (2000, p. ab) and Rhoads and Cahill (1999, p. ab) both found that quality was degraded, and conditions potentially toxic where sediments were located close to stormwater outfalls. Similarly, Maltby et al. (1995, p. ab) observed toxicity in sediments, attributable to metals and PAHs, downstream of highway runoff discharges. Chalmers et al. (2007, p. ab) found that urban lakes exhibited metal and PAH contaminant accumulation rates that were orders of magnitude greater than reference lakes, and concluded that sediment concentrations were attributable to local sources. Lester and Wilson (2002, p. ab) and Moshenberg (2004, p. 27), investigating sediment quality and toxic potential in urban lakes of the Seattle metropolitan area, found that samples exceeded sediment quality guidelines (SQGs) for metals and PAHs at some locations, including the vicinity of stormwater discharges to Lake Sammamish. Because contaminated sediments are recognized as potential sources of toxic exposure and effects, the development of reliably predictive SQGs is an area of continuing interest for researches and resource managers alike.

Ambient conditions determine whether contaminated sediments will act as continuing sources or sinks for toxic metals and non-polar organic contaminants. Because ambient conditions are dynamic and can change over time and space, equilibrium levels of metals and organic contaminants in sediments, in interstitial/pore water, and the water column, are also variable. "Bioavailability is a complex function of many factors ... Many of these factors vary seasonally and temporally, and most factors are interrelated." (John and Leventhal 1995, p. 10) Changes in ambient water and sediment chemistry, including redox state, dissolved oxygen concentration, pH, temperature, and buffering capacity/carbonate concentration/hardness, can release sequestered contamination to interstitial pore water or the water column (Chen et al. 1996, p. ab; Marsalek et al. 2002, p. 7; Muthukrishnan and Selvakumar 2006, p. 10; Wong et al. 2000, p. 10). Bostick et al. (1998, pp. 2, 4), Chen et al. (1996, p. ab), and John and Leventhal (1995, pp. 14, 17) each describe changes in Zn partitioning and bioavailability in response to altered chemical environments. Bostick et al. (1998, pp. 2, 4) found that changes in redox state within a contaminated wetland influenced the size of fractions complexed to sorbents with varying properties. Chen et al. (1996, p. ab) found that 74 percent of Zn from bottom sediments of urban reservoirs was in easily remobilized fractions. John and Leventhal (1995, p. 14, 17) found that contaminated sediments can release significant amounts of Zn to the dissolved phase when oxidized or exposed to acidic conditions.

In fluvial environments, hydrology and fine and coarse sediment dynamics also exert a strong influence on patterns of sediment contamination. Rhoads and Cahill (1999, p. ab) describe variation in levels of sediment metal contamination reflecting distance from the source (outfalls), reach-scale variation in geomorphic conditions, and the degree of bed material sorting. Foster and Charlesworth (1996, p. ab) and Marsalek et al. (2002, pp. ab, 9) also emphasize the role of sediment deposition, accumulation, and remobilization. Baun et al. (2003, p. 4-4) and Chen et al. (1996, p. ab) suggest that hydraulic resuspension of contaminated sediments, and sporadic disturbance and release of contaminated interstitial pore water, influences bioavailability. Ellis (2000, p. 86) has argued that understanding the "…probability of biotic uptake and ecosystem response … requires incorporation of water quality effects with impacts on sediment and pore waters as well as habitat impairments resulting from flow hydraulics".

Bioavailability and Toxicity of Contaminated Sediments

Contaminated sediments are widely recognized as potential sources of toxic exposure and effects. This concern has created interest in the development of predictive (non-regulatory) SQGs and of analytical tools for the assessment of bioavailability and toxicity (e.g., bioassays, AVS/SEM ratios, etc.). Grant et al. (2003, p. 4-12) have provided a concise summary and review of current methods for the measurement of sediment toxicity.

SQGs are "…numerical limits recommended to support and maintain aquatic life", and generally reflect the sensitivities of sediment-dwelling organisms (MacDonald et al. 2000, p. 20; Marsalek et al. 2002, p. 6). The EPA has published guidance for the derivation of sediment benchmarks (USEPA 2011), and the WDOE implements several programs (e.g., Aquatic Lands Clean-Up, Water Quality, Environmental Assessment, etc.) engaged in the development and refinement of SQGs. MacDonald et al. (2000) provide a good summary of published freshwater SQGs; SQGs derived using an effects level approach are in fairly wide use.

Marsalek et al. (1997; 2002; 2006) have evaluated the toxic potential of accumulated bottom sediments and suspended particulates found in urban stormwater ponds through comparisons of measured sample concentrations with Canadian SQGs. Marsalek et al. (1997, p. ab) report "marginal-to-significant" pollution for six heavy metals. More recent work has documented widespread "marginal-to-intermediate" pollution of heavy metals (80 to 100 percent of samples), and several instances of "severe" Zn pollution, including in sediments from oil and grit separators (Marsalek et al. 2006, p. ab). Marsalek et al. (2002) found that sample concentrations for five metals, including Cu and Zn, frequently exceeded Threshold Effect Levels (TELs), and occasionally exceeded Probable Effect Levels (PELs). Applying the same TELs and PELs that are in use in the State of Washington (i.e., as interim SQGs), the authors found that the highest incidence of biological effects would result from concentrations of Cu and Zn. The incidence of adverse biological effects associated with Cu concentrations present in accumulated bottom sediments and suspended particulates may be as high as 38 percent, and does not account for potential additive or synergistic effects (Marsalek et al. 2002, p. 7). Marsalek et al. (2002, p. ab) have concluded that "…suspended solids passing through stormwater ponds (are) polluted and could cause toxic effects in downstream waters." These findings suggest that the suspended

solid fractions not settled and retained in stormwater treatment facilities, or the fractions discharged to the receiving waterbody, sometimes contain metal concentrations sufficient to cause toxicological effects in exposed biota.

Lester and Wilson (2002, p. ab) report findings from an evaluation of sediment quality in Lake Sammamish, Washington. Using comparisons of measured sample concentrations with the State of Washington's interim SQGs, the authors report the following: both heavy metal and organic contaminant concentrations exceed guidelines; some observed concentrations indicate severe pollution and a high probability of adverse effects to biota; and, "…the highest levels of sediment associated contaminants were found in the vicinity of stormwater discharges." However, Lester and Wilson (2002, p. ab) also note that benthic community structure in the study area reflects the influence of nutrient enrichment, and it is difficult to separate effects associated with enrichment and sediment associated contaminants.

Baun et al. (2003) report findings from a study evaluating toxicity of interstitial pore water and sediment suspensions collected from an urban stream receiving large inputs of untreated runoff. Undiluted pore water samples were toxic to an algal test subject, but no statistically significant correlations were found between individual metal or organic parameters and observed pore water toxicity. Prepared sediment suspensions exhibited toxicities approximately 50 times greater than pore waters from the same sediment samples. The authors conclude that contaminated "…sediments may contribute significantly to toxic effects in receiving waters" as a result of "…release of pore water and/or suspension of particles." (Baun et al. 2003, p. 4-5)

Maltby et al. (1995, p. ab) report findings from a study evaluating toxicity of ambient water and sediments collected from locations downstream of highway runoff discharges. Ambient water did not exhibit toxicity in the test subject, a benthic amphipod, but a reduction in survival was found to result from exposure to the same water spiked with sediment. Hydrocarbons, Cu, and Zn were identified as potential toxicants, with most of the observed toxicity attributable to PAHs.

Chronic Effects to Aquatic Community Composition, Function, and Productivity

Sediments are an essential component of healthy, properly functioning aquatic ecosystems. Sediments function as both the physical growth medium and source of energy for benthic communities. Most of the organisms responsible for primary production in fluvial ecosystems, whether autotrophic (i.e., the green plants and algae) or heterotrophic (i.e., bacteria), rely crucially on sediments; in turn these organisms "…represent the foundation of food webs upon which all other aquatic organisms depend." (MacDonald and Ingersoll 2002, p. 74)

Numerous studies have investigated aquatic community composition and structure in disturbed systems. These communities frequently exhibit a decline in species diversity and changes to the relative representation of various taxa; species that are tolerant of varying environmental conditions usually dominate communities subject to frequent disturbance. In urban settings conditions favor species tolerant of stormwater pollutants (Wong et al. 2000, p. 17), low-quality food sources and/or reduced organic matter inputs, and hydrological extremes of erosion and deposition (Ellis 2000, p. 86).

Maltby et al. (1995, p. ab) found that abundance of *Gammarus pulex*, a benthic amphipod, was greatly reduced downstream of highway runoff discharges. Carr et al. (2000, p. ab) conducted a triad study where chemical analyses, controlled toxicity tests, and field benthic indicators were used to assess impairment of sediment quality, and found that "…four of the five most degraded (locations) were stormwater outfall sites." Scoggins et al. (2007, p. ab) characterized biological communities above and below stormwater discharges and found reduced invertebrate diversity and density, and a relative increase in tolerant taxa at downstream sites. Scoggins et al. also found that "…increases in PAH sediment-toxicity units between upstream and downstream sites explained decreases in taxon richness and density".

Moshenberg (2004, p. 27) reports the findings of a triad study investigating sediment and benthic community impairment in Lake Union, Lake Washington, and Lake Sammamish. The study found widespread impairment of sediment quality. The State of Washington's interim SQGs (King County 2010; Smith et al. 1996) were frequently exceeded for PCBs (70 percent of stations), metals (50 percent), phthalates (46 percent), and PAHs (23 percent). Zn and Cu were found to exceed their respective SQGs more frequently than any pollutant except Aroclor 1254 (Moshenberg 2004, p. 54). The study found that observed toxicity more closely correlated with organic contaminant concentrations than metal concentrations (Moshenberg 2004, p. 58), and there were only weak to moderate correlations between contaminant concentrations and most indicators of benthic community alteration. However, metal and PAH pollutant concentrations were a significant predictor of the Shannon-Weaver invertebrate diversity index (Moshenberg 2004, p. 56). In discussing potential sources of impairment, the author suggests that stormwater and transportation-related land uses are potential sources of Zn, Cu, and PAH contamination (Moshenberg 2004, pp. 58, 59).

Heintz et al. (2000) have reported findings that suggest a link between PAH exposure during egg incubation and subsequent rates of marine survival and growth for salmonids. The study found that statistically significant reductions in marine survival, or increases in delayed rates of mortality, resulted from exposure to concentrations as low as 5.4 ppb total PAH. The study also found that juvenile salmon surviving embryonic exposure exhibited reduced growth in response to doses as low as 18 ppb total PAH. The authors suggest that reductions in marine survival and growth are most likely attributable to biochemical impairment of gene and/or enzyme function, and that fish populations whose natal habitats are contaminated with PAHs "…can be expected to experience the compound effects of mortality during exposure, reduced survivorship afterwards, and reduced reproductive output at maturity." (Heintz et al. 2000, pp. 213, 214)

McCarthy et al. (2008) have examined three case studies which provide an excellent summary of current research and our evolving understanding of potential stormwater effects on fish and fisheries of the Pacific Northwest. One of these case studies summarizes current investigations of coho salmon pre-spawn mortality in urban streams of the Seattle metropolitan area. The authors argue that high temperature, low dissolved oxygen, overcrowding, disease, and accidental spills have all been ruled out as causal mechanisms, and "…the weight of evidence suggests that adult coho are acutely sensitive to … stormwater runoff from urban landscapes." (McCarthy et al. 2008, p. 6) The authors acknowledge uncertainty as to whether the observed pre-spawn mortalities result from exposure to a single contaminant, to a mixture of contaminants, and/or the additive effect of toxicological and other environmental stressors. The

authors observe that while "…pollution occasionally causes fish kills, most contaminant exposures are sublethal", a fact that heightens our need to understand how toxic exposures influence reproductive success (McCarthy et al. 2008, p. 2).

Another of the case studies described by McCarthy et al. (2008) examines PAH developmental toxicity, modes of action, and consequences for exposed embryonic fish. The authors summarize work identifying effects to cardiac development, form, and function (McCarthy et al. 2008, p. 13). These effects to the embryonic heart may explain the common malformation syndrome and reduced growth and survival frequently documented where embryonic exposures to PAH contamination have been investigated. The authors observe that while we know the "…developing fish heart is vulnerable … to multiple members of the PAH family", "…there are still a large number of PAH compounds whose individual toxicity is unknown, and PAH mixtures in stormwater are more complicated." (McCarthy et al. 2008, p. 13)

These findings, and others reported in the literature, demonstrate that where urban/highway stormwater discharges cause or contribute to sediment metal and PAH contamination, they may exert an influence on aquatic community composition and structure. These findings do not address whether observed shifts in aquatic community composition and structure have significance for primary production, or nutrient and organic cycling and dynamics. In this sense, it is difficult to know how completely or fundamentally aquatic food webs may be affected. However, these findings and others reported in the scientific literature do indicate that toxic constituents found in highway stormwater runoff can exert a direct adverse effect on exposed fish with implications for growth, development, long-term survival, and reproductive fitness.

Performance of the Proposed Stormwater Treatment Design

The project's proposed stormwater treatment design will provide basic or enhanced treatment for stormwater runoff originating from approximately 69 acres of PGIS. This represents a stormwater treatment retrofit of more than 500 percent of the net-new PGIS by area, and is expected to achieve measurable reductions in post-project annual stormwater loadings of TSS, total Cu, and total Zn (WSDOT 2010a, pp. 6-164, 6-165).

Table 8 presents existing (pre-project) and proposed (post-project) annual stormwater pollutant loadings for six TDAs which account for approximately 90 percent of the total, post-project PGIS. Table 8 identifies significant, measurable reductions in post-project annual stormwater pollutant loadings for each TDA, and approximate 68, 45, and 51 percent reductions in annual project total TSS, total Cu, and total Zn loadings, respectively (WSDOT 2010a, p. 6-164, 6-165).

Table 8. Existing and proposed annual pollutant loadings for select TDAs and project total; median and range (25th-75th percentiles) (WSDOT 2010a, pp. 2-104 thru 2-109, 6-161 thru 6-165).

Threshold Discharge Area (proposed treatment)	Existing / Proposed	PGIS (acres)	TSS (lbs./yr)	Total Cu (lbs./yr)	Total Zn (lbs./yr)
East Allison Street (4.00 ac)	Existing	14.25	6445 (3148-13253)	1.68 (0.95-2.94)	10.0 (5.6-17.9)
	Proposed	14.30	5066 (2619-10042)	1.40 (0.86-2.30)	8.2 (4.9-14.0)
WS-C (2.94 ac)	Existing	3.34	1526 (746-3110)	0.39 (0.22-0.69)	2.33 (1.32-4.16)
	Proposed	2.94	122 (53-281)	0.11 (0.07-0.16)	0.52 (0.34-0.80)
WS-D (8.70 ac)	Existing	6.47	2946 (1430-6005)	0.76 (0.43-1.33)	4.56 (2.56-8.13)
	Proposed	9.06	758 (419-1397)	0.41 (0.29-0.58)	2.10 (1.40-3.00)
WS-PR or MOHAI (21.31 ac)	Existing	12.60	5748 (2792-11713)	1.48 (0.84-2.61)	8.81 (4.95-15.70)
	Proposed	21.31	981 (428-2244)	0.86 (0.58-1.30)	4.20 (2.7-6.40)
WS-BR4 Floating Bridge Span (20.56 ac)	Existing	17.28	7894 (3859-16090)	2.02 (1.15-3.57)	12.10 (6.83-21.50)
	Proposed	20.56	850 (371-1962)	0.75 (0.51-1.10)	3.70 (2.40-5.60)
WS-J (4.48 ac)	Existing	5.42	2,476 (1210-5054)	0.63 (0.36-1.11)	3.84 (2.15-6.83)
	Proposed	4.48	184 (80-422)	0.16 (0.11-0.24)	0.80 (0.52-1.20)
Project Total (14 TDAs; 69 ac)	Existing	71.06	30,004 lbs.	7.86 lbs.	46.85 lbs.
	Proposed	83.25	9,480 lbs. (-68%)	4.31 lbs. (-45%)	22.88 lbs. (-51%)

Available methods for stormwater runoff treatment are inherently less effective at removing and controlling dissolved metals. Accordingly, annual dissolved Cu and dissolved Zn loadings are projected to increase, or remain largely unchanged despite stormwater treatment retrofit, in approximately 6 of the 14 TDAs: East Garfield Street, East Allison Street, WS-D, WS-BR2, RWB-C, and WS-PR (or MOHAI) (WSDOT 2010a, p. 6-163). However, two of these TDAs are very small (WS-BR2; RWB-C), and a third (East Garfield Street) is both relatively small and only included in the project for the purpose of I-5 lane-restriping (delineation).

When used to describe and compare the existing (pre-project) and proposed (post-project) conditions, the best available, analytical methods suggest that annual project total dissolved Cu and dissolved Zn loadings will be reliably reduced (WSDOT 2010a, Appendix J "HI-RUN Loading Sub-Routine for Project Total"). However, in three of the largest, most intensively built-out TDAs (East Allison Street; WS-D; WS-PR or MOHAI) the proposed, preliminary, stormwater treatment design will not prevent increases in dissolved metal loadings.

In each of the TDAs where the project achieves a net reduction of effective PGIS and/or provides stormwater treatment retrofit, post-project stormwater pollutant concentrations are likely to be reduced at the point of discharge (WSDOT 2010a, p. 6-165 and Appendix J "HI-RUN Loading Sub-Routine for Individual TDAs"). This is true for each of the project's largest TDAs.

Combined Sewers and Storm Design Exceedances

A portion of the stormwater runoff originating from within the project limits will continue, at completion of the project, to enter the City of Seattle's combined sewer system (CSS). Stormwater which enters the City of Seattle's CSS is routed to the West Point Wastewater Treatment Plant, which ultimately discharges treated wastewater to the Puget Sound (WSDOT 2010a, pp. 2-18, 2-104 thru 2-114).

Seven combined sewer system overflows (CSOs) managed by the City of Seattle and King County are located within the project area. The impervious surface within the project limits represents a small fraction (less than 3 percent) of the combined, total basin area draining to these seven CSOs (WSDOT 2010a, p. 6-168). These CSOs direct discharge without treatment to Lake Union, Portage Bay, the Montlake Cut, and Union Bay whenever large storm events exceed capacity of the CSS. The FHWA reports that between 2005 and 2009 these seven CSOs resulted in approximately 70 overflow events, with a combined volume in excess of 400 million gallons (WSDOT 2010a, pp. 2-109, 6-166, 6-167).

The proposed project must comply with City of Seattle CSO discharge requirements (peak control standard) (WSDOT 2010a, Appendix J p. J-48). To ensure compliance with these requirements, the project has been designed to reduce the amount of surface runoff contributed to the CSS, and will likely provide flow control or detention facilities for some areas that drain to the CSS. Compared to the pre-project conditions, the post-project condition will contribute runoff from less impervious surface (WSDOT 2010a, p. 2-109). The project will take a net 1.25 acres of impervious surface off-line, routing that runoff to constructed highway stormwater

treatment facilities, rather than the CSS. The FHWA expects that highway stormwater runoff from the project area will not cause or contribute to a greater number, frequency, or size of future CSO events (WSDOT 2010a, p. 6-167).

The same storm events that produce surface runoff sufficient to exceed the CSS capacity and cause CSO events are also likely to exceed the storm design criteria used by the WSDOT, FHWA, and WDOE to size stormwater collection, conveyance, and treatment systems (WSDOT 2010a, p. 6-166). Under conditions exceeding the storm design event, stormwater runoff originating from the Portage and Union Bay bridges and approaches will release through scuppers placed at short intervals along the lengths of these structures, and directly discharge to the adjacent waters without treatment (WSDOT 2010a, p. 2-114).

We expect that the proposed stormwater design will reduce CSS contributions and thereby avoid increasing the frequency or size of future CSO events. However, we also expect that untreated stormwater runoff from the project area will still discharge to and temporarily affect surface water quality conditions during major storm events. A sub-section that follows discusses exposure to untreated stormwater discharges in greater detail.

Exposure to Treated Discharges and Resulting Dilution Zones

Bull trout may be exposed to pollutant concentrations contained in treated stormwater discharge from the project area. On an event basis, pollutant concentrations may exceed the effect levels associated with adverse sub-lethal effects. Acute exposures and effects are expected to occur in mixing (or dilution) zones located in close proximity to points of stormwater discharge.

The proposed stormwater treatment facilities and outfalls will discharge, for the most part, to low quality habitats along heavily developed and disturbed portions of Lake Union, and Portage, Union, and Fairweather Bays. Among the six TDAs which account for approximately 90 percent of the total, post-project PGIS, one will discharge to the east shore of Lake Union (East Allison Street), two will discharge to south Portage Bay (WS-C, WS-D), one will discharge to west Union Bay, south of the Montlake Cut in the vicinity of the Washington Park Arboretum (WS-PR or MOHAI), and another will discharge to south Fairweather Bay along the east shore of Lake Washington (WS-J).

The new SR 520 floating bridge span across Lake Washington is the final of the six largest, most significant TDAs (WS-BR4) (WSDOT 2010a, pp. 2-105. 2-106). Along the floating bridge span, collected stormwater runoff will be treated with the conditionally-approved AKART enhanced treatment method before discharging to approximately 44 stormwater and spill control lagoons impounded by the supplemental stability pontoons (WSDOT 2010a, pp. 2-112. 2-113). Each of these supplemental stability pontoons will impound approximately 550 square ft of Lake Washington's surface waters, corresponding to a volume of approximately 8,000 cubic ft (or 60,000 gallons) per stormwater and spill control lagoon.

For these six TDAs, post-project median effluent discharge concentrations are expected to range between 17 and 26 µg/L dissolved Zn, and between three and four µg/L dissolved Cu at the points of discharge (WSDOT 2010a, Appendix J "HI-RUN Loading Sub-Routine for Individual

TDAs"). Expected dissolved Cu concentrations range as high as seven µg/L for the 75th percentile storm event.

Expected post-project dissolved Zn concentrations exceed the threshold concentration found to elicit avoidance behavior (behavioral disruption) (Sprague 1968). The expected post-project dissolved Cu concentrations exceed the sub-lethal neurotoxic threshold of an increase of 2.0 µg/L over background (Sandahl et al. 2007). Both Eisler (1998) and Playle (2004) found that dissolved metal mixtures exhibit greater than additive toxicity (i.e., synergistic effects). We therefore conclude that bull trout exposed to these treated discharges and resulting mixing zones are likely to suffer measurable adverse effects, including reduced olfactory sensory responsiveness (i.e., olfactory inhibition). Temporary, acute exposures have the potential to significantly disrupt normal bull trout behaviors (i.e., ability to feed, move, and/or shelter).

The BA describes the frequency and size of resulting outfall mixing zones (WSDOT 2010a, pp. 6-165, 6-166, Appendix J). The analytical methods employed consider both seasonal highway runoff and receiving water conditions (effluent discharge rates; effluent discharge Zn and Cu concentrations; ambient hydraulic conditions; ambient Zn and Cu concentrations). Table 9 reports the size of anticipated dissolved metal mixing zones for the six largest, most significant TDAs.

For five of the six modeled TDAs, with the exception of the floating bridge span, dissolved Zn concentrations will intermittently exceed effect levels associated with adverse sub-lethal effects in mixing zones extending between five and 20 ft from points of discharge (WSDOT 2010a, p. 6-166). For these same five TDAs, dissolved Cu concentrations will intermittently exceed effect levels associated with adverse sub-lethal effects in mixing zones extending between two and 10 ft from points of discharge.

Table 9. Dissolved metal mixing-zones for select TDAs (WSDOT 2010a, p. 6-166).

Threshold Discharge Area (and/or Outfall)	Receiving Waterbody	Mixing or Dilution Zone **Dissolved Zn (ft)**	Mixing or Dilution Zone **Dissolved Cu (ft)**
East Allison Street	Lake Union	7.9	4.4
WS-C	Portage Bay	10.3	2.2
WS-D	Portage Bay	13.2	4.9
WS-PR or MOHAI	Union Bay	11.1	6.7
WS-BR4 Floating Bridge Span	Lake Washington	< 70 (approx.)	< 20 (approx.)
WS-J	Fairweather Bay	17.0	2.0

These same methods describe mixing zones along the floating bridge span (WS-BR4), which are likely to be somewhat larger (Table 9). Along the floating bridge span, dissolved Zn concentrations and dissolved Cu concentrations will intermittently exceed effect levels associated with adverse sub-lethal effects in mixing zones extending approximately 70 ft, and 20 ft, respectively (WSDOT 2010a, p. 6-166). We interpret these model results to mean that during moderately-large to large stormwater events the stormwater lagoons along the floating bridge span will contain sizable pools of water exceeding effect levels associated with adverse sub-lethal effects.

Although the outfalls discharge to low quality habitats along heavily developed and disturbed portions of Lake Union, and Portage, Union, and Fairweather Bays, and the anticipated size of resulting dissolved metal mixing zones are relatively small, we still cannot entirely discount the risk of bull trout exposures and adverse sub-lethal effects. The resulting mixing zones are likely to be largest along the floating bridge span, but here the risk of exposure is partially offset by location and design configuration.

The floating span's stormwater and spill control lagoons will be located in waters greater than 50 ft deep. With a draft of more than 20 ft below the water surface, we expect that the supplemental stability pontoons will serve to both enhance dilution and limit the possibility of exposure. While the stormwater lagoons will be open to the water column below, and fish could conceivably swim into the lagoons themselves, we expect that it is unlikely that bull trout would be exposed in this manner. The configuration of the pontoons and lagoons will result in mixing zones positioned 20 ft below the lake surface, at intervals along the floating bridge span. We expect that this configuration will enhance dilution, resulting in mixing zones dispersed over relatively short distances extending from the bottom of each stormwater lagoon.

In general, winter stormwater discharges (October to April) are likely to be more frequent, of longer duration, and greater in magnitude compared to summer stormwater discharges (May to September). Nevertheless, we expect that acute exposures and potential adverse effects could occur at any time of year.

We expect that adult and subadult bull trout will be exposed to dissolved Zn and Cu at concentrations that cause adverse sub-lethal effects and significant disruption to normal bull trout behaviors. These exposures will be episodic, occurring whenever bull trout are present near the outfalls or stormwater and spill control lagoons coincident with discharge from storm events. Dissolved metal mixing-zones will vary based on flow and discharge conditions, but are unlikely to exceed the dimensions described in Table 9 under any foreseeable conditions. Exposures may be more frequent, and exposure durations somewhat longer, during winter months.

Adult and subadult bull trout will be exposed to concentrations of dissolved metals sufficient to result in adverse sub-lethal effects, including avoidance response and reduced olfactory sensory responsiveness. These exposures will significantly disrupt normal bull trout behaviors. Bull trout may avoid the vicinity of outfalls when stormwater discharges are sufficient to result in elevated pollutant concentrations. However, bull trout exposed at sufficient concentrations, and for sufficient durations, are likely to experience olfactory inhibition. Avoidance behavior and olfactory inhibition will impair bull trout movement through the action area, may temporarily

displace individual bull trout from refugia or preferred habitats, and is likely to reduce foraging success and feeding efficiency. Because suitable spawning and rearing habitats are not present in the action area, exposure to dissolved metal concentrations will not interfere with these essential behaviors. The Service expects that sub-lethal effects to individual bull trout will be episodic and of limited duration, but will still significantly disrupt normal bull trout behaviors. Some bull trout may be exposed repeatedly as a result of regular movements through the action area.

Exposure to Untreated Discharges

Long stretches of the Portage and Union Bay bridges and approaches have been designed to convey surface runoff to land-based stormwater treatment facilities for treatment and discharge. This configuration enables the project to use proven, conventional methods for treating most stormwater runoff from the project area. Only where surface runoff cannot be made to drain towards land (i.e., along the floating bridge span), does the project propose to use a conditionally-approved AKART method.

Conveyance systems are designed according to requirements of the WSDOT HRM. These require that storm inlets and gutters, and storm drain laterals accommodate flows associated with a 10-year storm event (WSDOT 2010a, Appendix J p. J-48). The FHWA has acknowledged that under conditions exceeding the storm design event, stormwater runoff originating from the Portage and Union Bay bridges and approaches will release through scuppers placed at short intervals along the lengths of these structures, and direct discharge to the adjacent waters without treatment (WSDOT 2010a, p. 2-114).

We expect that the proposed stormwater design will prevent direct discharge from the Portage and Union Bay bridges and approaches, except under the extreme conditions presented once, or perhaps twice, per year on average (i.e., the largest winter storm events). On those rare occasions when surface runoff rates exceed the bridge and approach conveyance system capacities, we expect that untreated stormwater runoff will discharge to Portage and Union Bay and may, on a temporary basis, measurably affect surface water quality conditions.

However, these same storm events are likely to exceed CSS capacity for large portions of the surrounding developed, urban landscape (WSDOT 2010a, p. 6-166). Given the coincident, ambient conditions in the project's receiving waters under this scenario, we expect that any incremental effects to bull trout resulting from direct discharges along the Portage and Union Bay bridges and approaches will not be measurable and are therefore insignificant.

In general, we expect that the project will dramatically reduce the frequency and size of direct stormwater discharges to the project's receiving waters. Under the existing (pre-project) condition, very little stormwater runoff from the project area is captured for treatment prior to discharge. The project will provide a stormwater treatment retrofit of more than 500 percent of the net-new PGIS by area, and will also reduce CSS contributions and thereby avoid increasing the frequency or size of future CSO events.

While on rare occasions, we expect that untreated stormwater runoff will still discharge to and temporarily affect surface water quality conditions, it is not possible to meaningfully characterize the transient exposures that might result. Therefore, we do not expect that untreated stormwater discharges resulting from the proposed project will result in a measurable, significant disruption of normal bull trout behaviors.

Annual Pollutant Loadings and Potential Chronic Stormwater Effects

Chronic effects stem from repeated exposures over time, through multiple exposure pathways, and from multiple stressors and combinations of stressors. The assessment of chronic effects, including cumulative toxicity, requires consideration of exposure sequences, post-exposure stress, and their accumulative effects and significance for growth, reproductive fitness, and rates of mortality (Ellis 2000, pp. 86, 87; Grant et al. 2003, p. 4-2; McCarthy et al. 2008, p. 2).

The proposed project is located in an urbanized watershed where existing functional impairments, including pervasive water and sediment quality degradation, are a source of adverse effects to bull trout, their habitat, and prey base. These conditions present stressors and combinations of stressors that diminish habitat suitability and function. Baseline conditions in the action area expose adult and subadult bull trout to stressors which are likely to result in measurable adverse effects, such as reduced growth and reproductive fitness, with implications for long-term survival and productivity.

However, the best available, scientific information suggests that the proposed action will measurably reduce annual project total stormwater pollutant loadings (TSS, total and dissolved Cu, total, and dissolved Zn). The estimated 68 percent reduction in annual project total TSS loadings is particularly relevant, as an indirect measure of the project's control of total toxic pollutant load. Pollutant loads bound or complexed with the particulate-phase (or fraction) represent a persistent, long-term source of potential chronic exposures.

It is difficult to accurately quantify the total toxic pollutant load present in highway stormwater runoff originating from the project area. Furthermore, in the absence of quantitative information to describe the assimilative capacity of these waters, it is not possible to say definitively that these loadings will contribute to an exceedance of a system limit or threshold.

Nevertheless, we conclude that pollutant loadings resulting from the post-project condition are unlikely to further degrade surface water and sediment quality in the action area. In the long term, we do not expect that the proposed action will worsen surface water or sediment quality trajectories at the scale of the action area or Lake Washington watershed. Furthermore, we do not expect that the project's long term, operational stormwater effects will cause or contribute to a measurable, incremental decline in the bull trout prey base, or greater Lake Washington native forage fish prey base.

Available information does not allow us to predict how exposures within the action area will or might add incrementally to the accumulative effect of multiple exposures over the lives of individual fish. These sub-lethal exposures are often coincident with other stressors (e.g., reduced dissolved oxygen availability), making evaluation of their ultimate significance for

growth and reproductive fitness more difficult. Adult and subadult bull trout in the action area will be exposed to chronic stressors that may have significance for growth and reproductive fitness, but it is not possible to describe quantitatively how the proposed action will incrementally change the pattern, frequency, or intensity of these chronic toxic exposures. The Service cannot, at this time, describe how chronic exposures resulting incrementally from the proposed action will affect normal bull trout behaviors, growth, or reproductive fitness.

Permanent and Temporary Effects to Bull Trout Habitat

Throughout Lake Washington and the Lake Washington Ship Canal salmonid habitat conditions and functions are moderately to severely impaired, reflecting a century-long history of disturbance and development. This results from altered hydrology, sediment and water quality impairment, extensive shoreline modifications and loss of littoral and lake fringe wetland habitats, artificial overwater structure, the significant presence of nonnative species (plant and animal), and other factors.

The existing SR 520 bridges and ramps over Portage Bay, Union Bay, and Lake Washington, are large, artificial over-water and in-water structures. These features are part of the surrounding urban infrastructure and development which today degrades or impairs important habitat functions. However, available information suggests that the SR 520 bridges and ramps play only a modest role in shaping these habitat conditions and functions, certainly in comparison to a number of other large-scale actions (e.g., lock and lake level control operations), and system-wide processes operating at the scale of the watershed.

The proposed action will have both temporary and permanent impacts to bull trout FMO habitat. However, the project also includes design measures and mitigation components which we expect will reduce permanent or long term impacts to aquatic resources. Previous sections have discussed the project's mitigation components and enhanced stormwater controls.

Our focus here is on the proposed permanent and temporary over-water and in-water structures, the potential stressors these structures may present, and the likely response to those stressors. The major sub-sections that follow provide a summary of design measures, and description of permanent and temporary impacts; a literature review and description of stressors, exposure, and responses to existing conditions; an assessment of temporary stressors, exposure, and responses during construction; and an assessment of the project's permanent features, long term impacts, resulting stressors, and likely responses. Where appropriate these sections describe stressors, exposure, and responses with reference to discrete portions of the action area (e.g., the Ship Canal, Union Bay west of Foster Island, the vicinity of the east approach, etc.). These discrete portions of the action area provide unique functions and/or exhibit varying degrees of existing functional impairment.

While our focus here is on bull trout and bull trout habitat functions, these sections discuss stressors with reference to their broader significance for salmonids (especially Chinook salmon, sockeye salmon, and trout). A section that follows focuses on the action's potential effects to the bull trout prey base (see *Effects to the Bull Trout Prey Base*). Of necessity, that section is more

deliberate in its discussion of potential effects to salmonids, and interspecific interactions and dynamics (e.g., predation).

Summary of Conservation Measures, Permanent, and Temporary Impacts

The project includes design measures which we expect will reduce permanent impacts to aquatic resources and maintain or restore important habitat functions over time. In addition to treatment for highway stormwater runoff, the proposed action includes other environmental enhancements, including a carefully selected and refined corridor alignment, taller bridges and approaches, and a lighting design which reduces artificial light levels cast on to adjacent waters and wetlands (see *Conservation Measures – Design*).

With the use of increased bridge span lengths, the new, permanent bridges and ramps over Portage Bay, Union Bay, and Lake Washington will require fewer in-water columns than the existing structures. The new structures require approximately 290 in-water columns (and 5 mudline footings), whereas the existing structures are supported by more than 500 in-water piles, columns, and shafts. Excluding the new floating bridge anchors, which the project will install at depths of 60 to 180 ft, the combined, total in-water footprint of the proposed structures (approximately 42,500 ft^2) is only modestly larger than the existing in-water footprint (approximately 8,500 ft^2); much of this difference is attributable to the new mudline footings required in Portage Bay and along the east approach.

To the extent practicable, the new, permanent bridges and approaches will be substantially elevated, so as to lessen the shade effect on adjacent waters and wetlands. Long stretches of the proposed Portage Bay, Union Bay, and Lake Washington bridges and approaches will span the waters below with 5 to 15 ft, or more, of additional vertical clearance (WSDOT 2010a, pp. 6-23, 6-59, 6-89). We expect that these designs will substantially mitigate residual shade effects, and restore conditions that better approximate ambient incident light for adjacent waters and wetlands.

The proposed lighting design will reduce the amount of artificial light cast onto adjacent waters. This improvement upon the existing conditions will be most evident along the west approach and floating bridge, where the number of roadway light fixtures will be reduced by more than 50 percent (WSDOT 2010a, p. 2-115). No roadway lighting is proposed for the fixed portions of the bridge east of Foster Island, including the floating span. Recessed lighting will illuminate the proposed bicycle and pedestrian path along these structures, but will be shielded to reduce incident light on the adjacent waters. Along the proposed maintenance dock below and adjacent to the east approach, the lighting design includes on-demand overhead lighting, and only low-intensity path lighting would remain on at all times (WSDOT 2010a, pp. 2-18, 2-14 thru 2-117).

Similar to the current roadway lighting configuration, the project will install continuous lighting from I-5 to Foster Island, and on bridges crossing the Montlake Cut (Figure 4). With the exception of those areas below and adjacent to the new bascule bridge over the Montlake Cut, these portions of southern Portage and Union Bays provide only low-quality habitat, which we expect is not very attractive or important to bull trout.

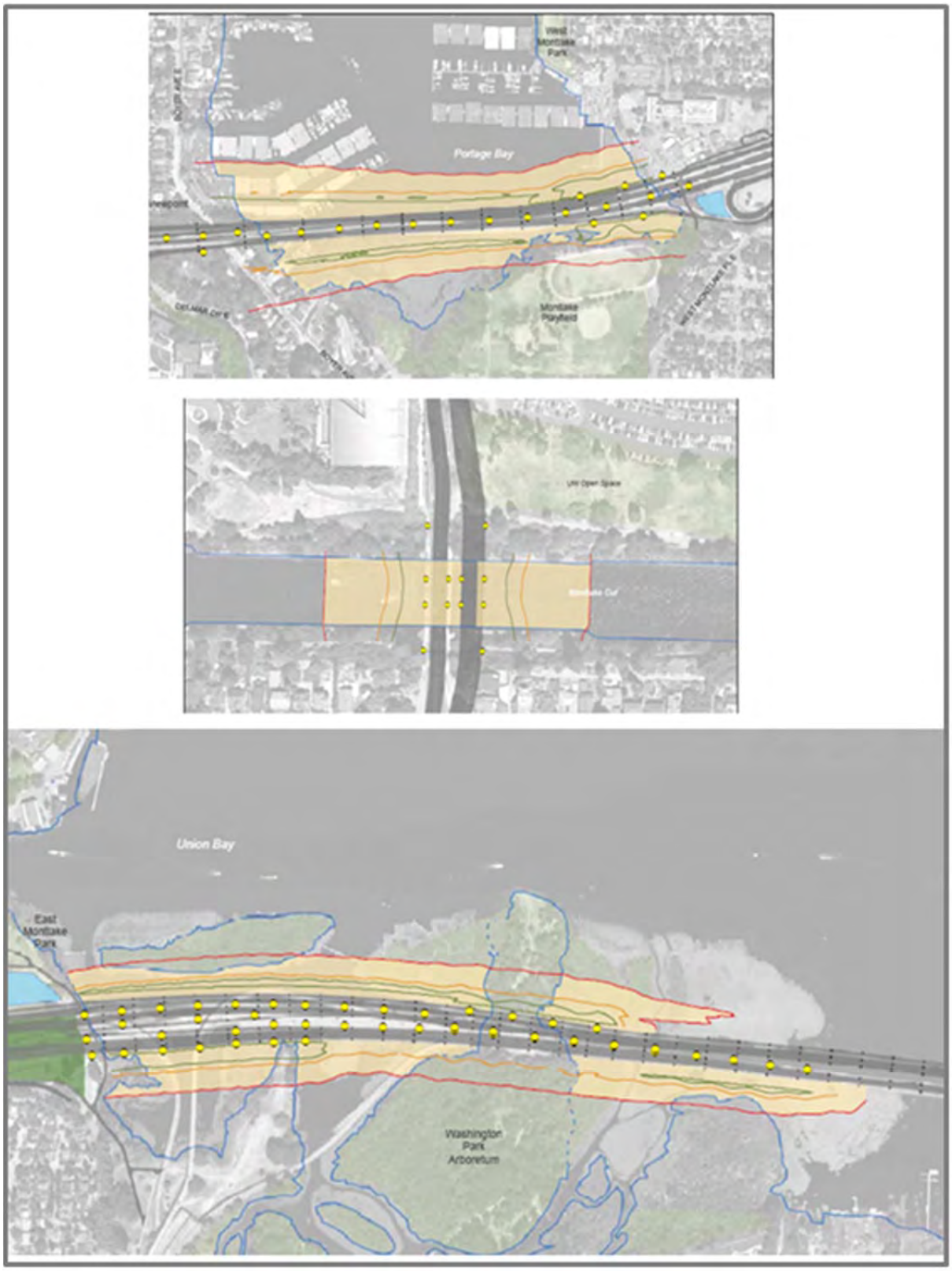


Figure 4. Projected nighttime light spillage in Portage Bay, the Montlake Cut, and Union Bay (WSDOT 2010a, pp. 6-153 thru 6-155).

The proposed action will increase the amount of over-water structure by approximately 50 percent, a permanent impact with potential effects to bull trout. The existing bridges and ramps over Portage Bay, Union Bay, and Lake Washington present approximately 26.4 acres of over-water structure. By comparison, the new, permanent bridges and ramps over Portage Bay, Union Bay, and Lake Washington will present approximately 50.2 acres of over-water structure (Table 2, p. 14). We expect, that along the elevated fixed bridges and approaches, additional vertical clearance will partially, but not fully, offset residual shade effects.

There are also important differences between the existing and proposed floating bridge spans. The existing floating bridge span has a total over-water area of approximately 12.1 acres and most of the existing bridge pontoons have a draft of approximately 8 ft below the water surface. The new, permanent floating bridge span will have a total over-water area of approximately 21.9 acres, with a draft of approximately 21.5 ft below the water surface (WSDOT 2010a, p. 6-119). These are sizable changes in dimension, and could significantly affect shading, incident light levels, and localized water column conditions. However, the overall significance of these changes and potential effects are at least partially offset by location. The floating bridge span is located over some of Lake Washington's deepest contours (60 to 180 ft).

Construction of the new bridges and ramps over Portage Bay, Union Bay, and Lake Washington will require that the project install large, temporary work bridges, ramps, and trestles, both to gain access for equipment and materials, and to maintain traffic operations through the project limits during construction. These temporary structures will greatly increase the combined total over-water structure spanning portions of Portage Bay, Union Bay, and Lake Washington for a period of several years. This temporary increase in over-water structure will result in stressors, including shade, artificial lighting, artificial light contrast and in-water complexity, with the potential to significantly disrupt normal bull trout behaviors (i.e., ability to successfully feed, move, and/or shelter).

Table 2 (p. 14), reports in acres the combined total over-water structure associated with all existing, temporary, and new bridges, ramps, and trestles, during each year of construction. Whereas pile driving and temporary increases in turbidity create transient stressors, these extensive, over-water structures will result in persistent stressors which may influence bull trout behavior for several years. Furthermore, while the project includes design measures that will reduce permanent effects resulting from the new bridges and ramps (e.g., elevated bridge spans to lessen shade effects, and a focused lighting design to reduce artificial light cast onto adjacent waters), the project has less flexibility to accommodate these concerns where temporary structures are concerned.

Existing, Baseline Habitat Conditions

The sub-sections that follow expand upon an earlier section's discussion of baseline conditions and function of Lake Washington FMO, with specific reference to the Lake Washington Ship Canal, Union Bay, and portions of Lake Washington along the proposed corridor improvements. Throughout Lake Washington and the Lake Washington Ship Canal salmonid habitat conditions and functions are moderately to severely impaired. However, discrete portions of the action area provide unique functions, and exhibit varying degrees of existing functional impairment.

Therefore, we begin by briefly examining ship canal migratory conditions and function, before offering a fuller characterization of migratory and foraging conditions and functions in Union Bay and Lake Washington.

Aquatic resources of the Lake Washington watershed have been studied intensively, and an extensive body of literature describes the ecological community. We do not provide a comprehensive synthesis of this literature. Instead we review relevant literature and examine those potential stressors, exposures, and responses which are most important to explaining current function and functional impairment.

Ship Canal Migratory Conditions and Function

The Ship Canal drains the epilimnion of Lake Washington, and daily and monthly mean surface temperatures collected between 1972 and 2000 have been used to document a significant trend toward increasing average temperatures in the months of August, September, October, and November (Quinn et al. 2002, pp. 592, 594). Hodgson et al. (2006, p. ab) have documented what appears to be a thermoregulatory behavioral pattern, wherein adult sockeye have adjusted the timing of their return to Lake Washington to avoid the warmest surface water temperatures.

Lock and lake level control operations, and the resulting artificial hydrologic conditions of the Ship Canal, are known to cause large, abrupt changes in water quality parameters (salinity, temperature, and dissolved oxygen) (City of Seattle and USACE 2008, p. 87; Fresh et al. 1999, pp. 5-7). Fresh et al. (1999, p. 7) describe a 10 degree Celsius (10 ^{o}C) difference in temperature during August between the bottom of the fish ladder located at the locks (12 ^{o}C), and the surface of the Ship Canal (22 ^{o}C). Lock operations effectively compress the brackish-water transition zone, requiring that fish passing through the area of the locks move "…from fresh water to salt water (or *vice versa*) almost instantaneously." (NMFS 2008, pp. 18, 26, 27) Large portions of Lake Union and the Ship Canal exhibit low dissolved oxygen (DO) conditions from June through October, especially throughout lower portions of the water column (hypolimnion) (City of Seattle and USACE 2008, p. 87; NMFS 2008, p. 32). Decay of vegetation and sediment organic material creates significant biological oxygen demand, resulting in pervasive near zero DO levels (NMFS 2008, p. 32).

These conditions provide at least a partial explanation for three distinct patterns witnessed in the behavior of adult salmonids: (1) adult salmonids exhibit a lengthy migration delay in the vicinity of the Ship Canal locks; (2) they frequently exhibit a pattern of back-and-forth movements across the locks, apparently seeking to optimize conditions; and (3) in response to environmental cues, adult salmonids typically make a rapid migration through the length of the Ship Canal upstream of the locks.

It is believed that Ship Canal temperatures present a thermal barrier to salmonid movements and migration, especially the return migration of adult Chinook salmon (City of Seattle and USACE 2008, pp. 83-84; Fresh et al. 1999, pp. 3, 12-13; NMFS 2008, p. 27; WSDOT 2010a, pp. 5-20, 5-26, F-1, G-3). Fresh et al. (1999, pp. 12, 13) report that adult Chinook returning during August spent an average of 19.14 days (range 1.92 - 45.92 days) in the vicinity of the locks, and did not move from the area upstream until temperatures along the Ship Canal dropped below 22 ^{o}C.

Tagging studies indicate that many adults hold near the lock's salt water drain (Eric Warner Pers. Comm. in NMFS 2008, p. 27).

Fresh et al. (1999, p. 14) also report that approximately one in three returning adults were seen to drop-back below the locks, and were sometimes tracked to a distance of 2 km downstream of the locks. Both Fresh et al. (1999, p. 15) and NMFS (2008, p. 40) interpret these back-and-forth movements as a possible behavioral response to the abrupt changes in water quality in the vicinity of the locks, and to the stressful, or even near lethal, water quality conditions further upstream.

It is noteworthy that the Ship Canal locks are the location of the greatest concentration of bull trout observations recorded anywhere in the greater Lake Washington watershed. Bull trout have been captured or observed in the area of the locks on at least a half-dozen occasions since 2000, mostly during March to June (USFWS 2006). This pattern of observations coincides with juvenile salmonid outmigration from Lake Washington, which we attribute to the well-documented opportunistic foraging strategies of bull trout. It appears that mature bull trout exploit the lock's artificial constriction of the migratory channel and forage there more intensively than anywhere else along the Ship Canal.

From June through October, water quality conditions upstream of the locks are a source of stress for migrating salmonids. Lock and lake level control operations, and the resulting artificial hydrologic and water quality conditions of the Ship Canal, force fish to choose between cooler, less oxygenated waters near the bottom (i.e., layers under the biochemical influence of decaying sediment organics), and warmer, more oxygenated waters at mid-depths (City of Seattle and USACE 2008, p. 87; NMFS 2008, pp. 44-46).

In apparent response to these conditions, adult salmonids typically make a rapid migration through the length of the Ship Canal upstream of the locks. Newell and Quinn (2005, p. 1235) report that 89 percent of adult sockeye returning to Lake Washington during June to August did not spend extended periods in the Ship Canal; only four tagged fish appeared to spend any significant time in the warm waters of the Ship Canal. Fresh et al. (1999, p. 15) report that adult Chinook returning during August spent an average of 0.67 days (range 0.15 – 7.73 days) in the Ship Canal, and only 11 percent of individual travel times were greater than one day in duration.

Fayram and Sibley (2000, p. 87) estimate that smallmouth bass densities are more than 30 times greater in the Ship Canal than in Lake Washington. Tabor et al. (2007, pp. 1179-1180) have estimated the Ship Canal bass population at nearly 6,000 individuals, and report that during months coinciding with juvenile salmonid outmigration from Lake Washington (February to June) salmonid smolts represented approximately half of the overall diet of smallmouth bass. Clearly, predation pressures are a source of stress and mortality through the Ship Canal migratory corridor.

However, the subadult and adult bull trout documented around the Ship Canal locks, or elsewhere throughout the Lake Washington watershed, have all been mature individuals ranging in size between 330 and 604 mm (12 - 24 inches) (USFWS 2006). We expect that bull trout in

this size range are not a focus for foraging nonnative fish predators, and rates of predation of bull trout along the Ship Canal are very low.

The FHWA has concluded that the existing bridges and ramps over Portage Bay, and existing bascule bridge over the Montlake Cut, have no apparent effect on the migrating behavior of adult salmonids (WSDOT 2010a, p. 6-37, 6-47). We can find no information contrary to that conclusion, and we also therefore conclude that any stressors associated with the existing structures, including shade, artificial lighting and light contrast, have an insignificant effect on adult migration.

Union Bay and Lake Washington (Migratory and Foraging Functions)

During summer, upper portions of the Lake Washington water column or epilimnion frequently exceed the temperature range required or preferred by salmonids, including subadult and adult bull trout (City of Seattle and USACE 2008, p. 90; Newell and Quinn 2005, p. 1233; Quinn et al. 2002, p. 594; WSDOT 2010a, pp. 5-20, 5-23, 5-26). Quinn et al. (2002, pp. 592, 594) used daily and monthly mean surface temperatures collected between 1972 and 2000 to document a significant trend of increasing average temperatures in the months of August – November.

As a result of summer thermal stratification, epilimnion temperatures of 18 to 25 ^{o}C, a thermocline at 10 to 20 m (33 to 65 ft), and hypolimnion temperatures of 8 to 10 ^{o}C typically prevail (Newell and Quinn 2005, p. 1233). The trend toward thermal stratification begins seasonally as early as April, and persists through November (Fayram and Sibley 2000, p. 82). Throughout the lake's shallow littoral zones, temperatures and dissolved oxygen levels become stressful to salmonids, especially near dense macrophyte beds, by mid-June (Nowak et al. 2004, p. 631). However, Lake Washington also provides deeper waters where bull trout may find thermal refugia at any time of year.

Much of the existing and proposed bridge alignment over south Union Bay, extending from south of the Montlake Cut to east of Foster Island, lies over and adjacent to an expansive, shallow littoral zone (Figure 5). The area supports dense growths of macrophytes and provides habitat better suited for warm water species such as bass than salmonids (WSDOT 2010a, p. 4-13).

The expansive, shallow littoral zone along south Union Bay provides little migratory or foraging function of significance to bull trout. We reach this conclusion based on the area's baseline environmental condition, but also with consideration for the migrating and foraging behaviors we expect bull trout exhibit while residing in Lake Washington.

Nearly all bull trout captures reported in Lake Washington have been from depths of 5 to 15 m (16 to 50 ft), many of them clustered in south Lake Washington (USFWS 2006). This pattern of observations would again suggest that opportunistic bull trout are foraging most intensively where they reliably find concentrations of outmigrating juvenile salmonids (e.g., around the Cedar River delta).

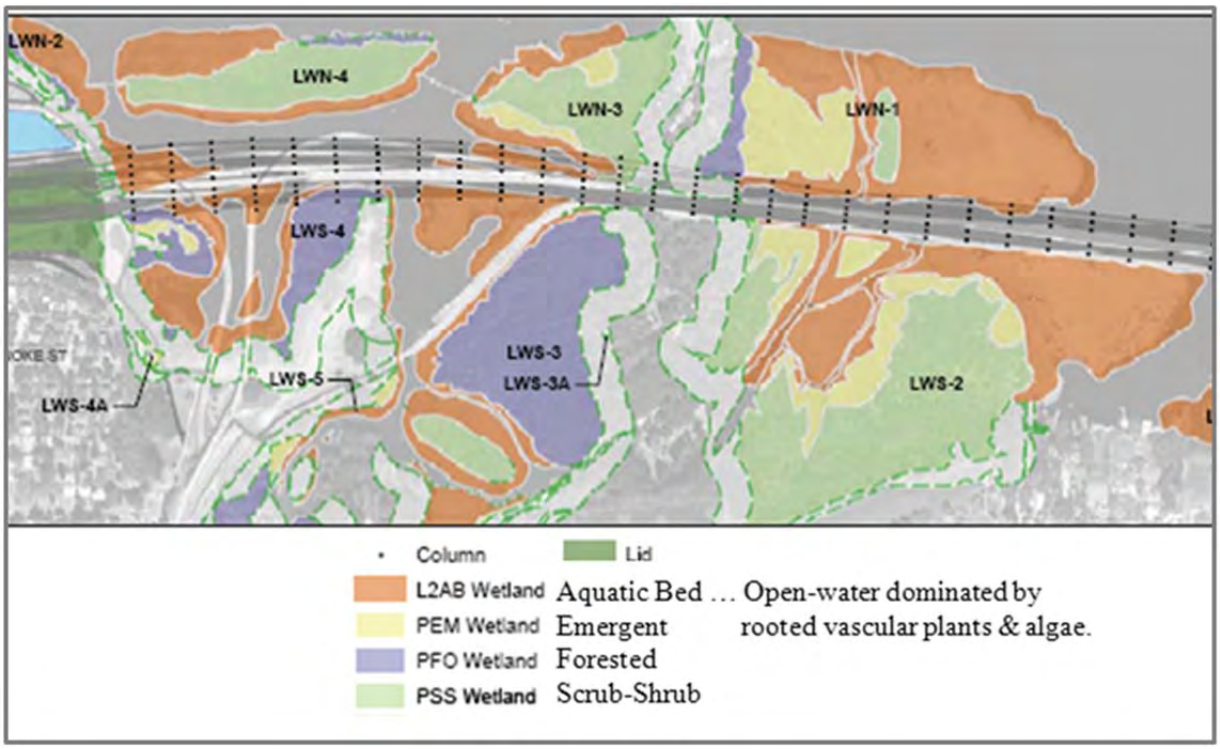


Figure 5. South Union Bay wetlands and littoral zone (WSDOT 2010a, p. 4-12).

With regard to depth selection when migrating and foraging in lakes, years of research conducted with bull trout populations from Flathead Lake, Montana provide valuable insights. Under isothermal conditions, these bull trout exploit a full range of water depths. However, after thermal stratification, bull trout much more commonly occupy the meta- and hypolimnion (MBTSG 1998, p. 16). Bull trout are frequently caught in Flathead Lake with the use of sinking gill nets, suggesting "…a tendency to be associated with the bottom at depths less than 34 m." Collection records from Flathead Lake indicate a bull trout preference for moderate depths, and while they exhibit some use of littoral foraging strategies, that appears to be more common of small bull trout inhabiting the lake (less than 300 mm) (MBTSG 1998, pp. 16-17).

While earlier during the 20th century, the northern pikeminnow (*Ptychocheilus oregonensis*) was considered the dominant piscivore in Lake Washington, cutthroat trout now appear to be the dominant predator in the system (Nowak et al. 2004, pp. 625, 633). This has significance as a factor influencing bull trout behaviors because, as demonstrated by Northcote (1995, pp. 53, 57, 64) and Jonsson et al. (2008, pp. 557, 558), where they co-occur with dominant cutthroat, char are consistently displaced from littoral zones and foraging strategies in favor of limnetic zones and open-water or benthic foraging strategies. Allopatric char populations, that is char populations that coexist with cutthroat, exhibit anatomical specialization for foraging under the comparatively low-light conditions of middle water column depths (Northcote 1995, pp. 60-63).

Extending east from Foster Island, the existing and proposed bridge alignments pass over and adjacent to deepening portions of Lake Washington. The west approach area east of Foster Island to a depth of 10 m is considered the primary route for salmonid migration to and from south Lake Washington and the Cedar River (WSDOT 2010a, p. 4-15). This portion of Lake

Washington has been the geographic focus for a series of hydroacoustic tracking studies initiated with the purpose of describing juvenile salmonid (and predator) patterns of movement and response to the existing bridge and approach structures (WSDOT 2010a, Appendix F pp. F-3 thru F-8, Appendix G pp. G-5 and G-6). Below we summarize important findings from three recent reports describing results of tracking performed during 2004-2005 and 2007-2008 (Celedonia et al. 2008; Celedonia et al. 2008; Celedonia et al. 2009).

Celedonia et al. (2008, Executive Summary pp. ii-iv) report findings from tracking studies performed in Lake Washington and the Ship Canal during May, June, and July of 2004 and 2005:

- Juvenile Chinook movement patterns varied within each site, from site to site, and from year to year. Each site was used differently by juvenile Chinook, and considerable individual variability was observed.

- Juvenile Chinook showed two predominant migratory behaviors: “active migration”, where they moved as quickly as possible from one destination to the next; and “holding”, where they appeared paused in their migration.

- At the one site studied in both years (Portage Bay) juvenile Chinook movement patterns were different in the two sample years. In 2004, most fish spent several hours to several days at the site, whereas in 2005 most fish actively migrated spending less than one hour at the site. Differences in timing of moon apogee relative to tagged fish release appeared to be the primary contributing factor to these differences.

- Distinct diel patterns were observed. In Lake Washington, juvenile Chinook were close to shore in shallow water (1 to 5 m) during the day, and far offshore in limnetic areas at night.

- Overwater structures and macrophyte beds appeared to influence movement patterns and depth selection. Actively migrating juvenile Chinook appeared to change course as they approached and moved around structures. Fish appeared less hesitant to pass beneath narrow structures. Fish also sometimes moved into deeper water to travel beneath or around structures.

- When macrophytes were present, juvenile Chinook appeared to use deeper water, moving above the macrophyte canopy rather than avoiding macrophytes altogether. Macrophytes appear to function as a false bottom.

- Smallmouth bass were generally close to shore in water that was less than four m deep. Bass were usually closely associated with overwater structure, steep sloping shoreline, and/or the offshore edge of aquatic macrophytes. Overlap in habitat between bass and juvenile Chinook appears to occur within each of these habitat types.

- Prickly sculpin were primarily active at night, especially in shallow water. Nighttime patterns of prickly sculpin behavior may help explain the distribution of juvenile Chinook (nighttime selection of offshore limnetic areas).

Celedonia et al. (2008, pp. ii-iv, 102) report findings from tracking studies performed in Lake Washington during May to August of 2007:

- Behaviors of juvenile Chinook were similar within release groups, but varied considerably between release groups. June 1 smolts exhibited an active migration pattern, rapidly migrating through the study site. June 14 and 28 smolts exhibited holding behaviors at or near the study site. Differences in migrational cues (moon apogee), physiological status, water temperature and clarity, and prey availability may have contributed to the observed differences in behavior between release groups.

- There was no evidence that the bridge at any time presented a complete barrier to juvenile Chinook migration. Common behaviors included: 1) fish passing beneath the bridge with no apparent delay; 2) fish passing beneath the bridge after delays of a few seconds up to 46 minutes; and 3) fish passing beneath the bridge on multiple occasions.

- Among actively migrating juvenile Chinook, slightly more than one-third were delayed 3 to 46 minutes (median 15 minutes). Slightly less than one-third were delayed for less than one minute, and one-third appeared completely unhindered by the presence of the bridge.

- Of the fish that delayed, time of delay and distance traveled varied widely. Nearly half (45 percent) took less than three minutes to pass beneath the bridge after initial encounter, travelling less than 33 m along the edge of the bridge. However, reluctance to pass beneath the bridge in this group appeared to trigger a holding behavior in some fish, whereby they appeared to cease searching for a favorable route to pass and instead moved away from the bridge and milled for prolonged periods.

- Juvenile Chinook passed beneath the bridge throughout the study area. The eastern portion appeared more favored particularly with the June 14 and June 28 smolts. This may have been partially due to increasing macrophyte density and height during the study period along the western portion.

- Behavior may have been influenced by water depth, height of the bridge above the water surface, location of the bridge shadow at time of encounter, degree of contrast at the light-shadow edge, light intensity at time of crossing, and presence and variation in macrophyte density. Many of these factors varied together, and thus could not be isolated for their individual influence on behavior.

- Holding juvenile Chinook often crossed beneath the bridge to the north and were later observed returning to and holding in areas around the bridge. Holding smolts selected for areas near the bridge (5-20 m from bridge edge), as well as areas of dense macrophytes away from the bridge. When near the bridge, smolts selected deeper water.

- Holding behaviors may be triggered by an inhibition to enter the Montlake Cut arising from one or more ecological barriers, such as high water clarity, lack of directional flow, and/or elevated water temperatures. Inhibitions may also arise from a decrease in migrational urge associated with desmoltification caused by prolonged exposure to elevated water temperatures.

- Northern pikeminnow selected moderately dense to dense vegetation during all times of day and night. It was difficult to ascertain any relationship between the bridge and pikeminnow foraging behaviors.

- Smallmouth bass previously captured in the Ship Canal were observed at the study site. Small bass overwhelmingly selected for nearshore overwater structures (i.e., boat docks), and made no notable use of the bridge. Larger bass selected for both nearshore overwater structures and the bridge. Some bass appeared to associate closely with bridge columns.

Celedonia et al. (Celedonia et al. 2009, Executive Summary pp. ii-iv) report findings from tracking studies performed in Lake Washington during May to August of 2008:

- Overarching patterns in juvenile Chinook behavior were similar to those observed in 2007, generally similar within release groups, but varied considerably between release groups. Three release groups primarily exhibited holding behaviors.

- As in 2007, response to the bridge was at least partially dependent upon whether fish were actively migrating or holding. Behaviors of actively migrating fish were similar in both years, although few independent observations were obtained in 2008. Combining both years, 35 percent of actively migrating smolts showed minimal or no response to the bridge, 42 percent paralleled the bridge before passing underneath, and 23 percent paralleled the bridge and milled near the bridge before passing underneath. Median delay was 63 seconds (range 6 seconds to 19 minutes) for paralleling fish, and 22 minutes (range 3 to 46 minutes) for milling fish.

- The bridge appeared to attract holding juvenile Chinook. Fish most commonly selected for areas near the bridge (within 20 m) or condominium on the south side of the site. During the day, fish selected for deeper water when near the bridge or condominium than when they were not near either structure. Similar observations were made in 2007.

- At night, juvenile Chinook were attracted to areas where street lamps cast light into the water. A reevaluation of 2007 data found a similar pattern. Bridge lighting may be partially responsible for nighttime selection of the bridge area by juvenile Chinook. However, neither smallmouth bass nor northern pikeminnow were attracted to the lights.

- Results for northern pikeminnow and smallmouth bass were similar to 2007, and therefore data from both years were combined to provide more robust analyses. Northern pikeminnow concentrated in moderately dense vegetation, with no strong affinity for the bridge. Smallmouth bass did show a strong affinity for overwater structures, including the bridge. Bass were also often closely associated with bridge columns.

- Juvenile salmonids made up 35 percent of the northern pikeminnow diet. Approximately half of the smallmouth bass diet was composed of juvenile salmonids.

- The authors suggest, with regard to holding behaviors and daytime attraction to the structure, that the proposed bridge should lessen attraction. Consequences could include shorter area residence times. The proposed new bridge would appear to reduce the quality of habitat for northern pikeminnow and smallmouth bass.

Together these reports and findings suggest 1) some outmigrating juvenile Chinook salmon experience a measurable delay in travel time in response to the existing bridge and conditions presented by the bridge; 2) juvenile salmon that behaviorally select the bridge for longer periods when holding or milling occupy habitat which is attractive to smallmouth bass; 3) some juvenile Chinook salmon use the bridge as cover during day and/or night, typically occupying deeper portions of the lake than they might otherwise; 4) nightime selection of the bridge may be a response to artificial light cast on to the adjacent waters, but may also reflect behavioral avoidance of littoral foraging sculpin (or other predators); and, 5) where holding or milling behaviors are exhibited, they may be in response to any number of factors (or combination of factors), and cannot be causally linked to the bridge's influence alone.

Temporary Habitat Effects, Stressors, and Response During Construction

Construction of the new bridges and ramps over Portage Bay, Union Bay, and Lake Washington will greatly increase the combined total over-water structure spanning these waters and wetlands for a period of several years. Whereas pile driving and temporary increases in turbidity are transient stressors, these extensive, over-water structures and supporting in-water piles and pile bents will result in persistent stressors. Temporary increases in over-water structure will result in stressors, including shade, artificial lighting, artificial light contrast and in-water complexity, with the potential to significantly disrupt normal bull trout behaviors (i.e., ability to successfully feed, move, and/or shelter).

This sub-section begins with a general discussion of stressors and response, then describes potential temporary effects to Ship Canal migratory conditions and function, and closes with a description of potential temporary effects to Union Bay and Lake Washington migratory and foraging functions.

Shading and Shade Effects Resulting from Over-Water Structure

For Portage Bay, Union Bay, and the west approach area east of Foster Island, the combined total over-water structure will increase from a baseline condition of approximately 14 acres (2011), to a peak value of approximately 47 acres (2015), before complete removal of the existing and temporary structures reduce over-water cover to its final, proposed condition (approximately 36.6 acres) in 2018 (Table 2, p. 14).

We expect that the most obvious and/or certain effect of this shading will be a temporary reduction of aquatic plant and algal growth below the extensive work bridges and trestles.

Throughout much of south Portage Bay and Union Bay, these waters support dense macrophyte growth, and since the project will typically place work bridge and trestle decks at approximately five ft above the surface water elevation, we expect that shading will limit and measurably reduce plant growth in some areas.

Shading will or may have a less certain, direct effect on the behavior of fish, including both juvenile salmonids and the predatory fish that feed on them. Kahler, Grassley, and Beauchamp (2000) have compiled a useful literature summary and discussion of the effects of artificial lake shoreline structures and development, with specific reference to salmonids and their predators. A short list of their observations with regard to shading and shade effects include:

- Artificial structures provide foraging habitat (shade and overhead cover) for structurally-oriented, littoral ambush predators (e.g., largemouth and smallmouth bass) (p. 29). However, it is less clear what advantages these structures may confer on predatory cutthroat trout (p. 30).

- In Lake Sammamish, smallmouth bass often select areas with overhead cover such as docks and piers (p. 16).

- Shoreline development provides concealment structures, and may allow predators to reduce their home range sizes (p. 21).

- Helfman (1981) experimented with attraction to shade-producing, floating objects, and found that bass were more likely to hover under large floats. Fish were generally not observed under floats consisting of wood frames only. Dimensions of the shaded area may be an important predictor of response (p. 35).

Helfman (1981) has assessed the attractiveness of shade-producing objects and the visual advantage that shading provides to freshwater fishes. Helfman found that fish were more abundant near floats, and that float size and the amount or depth of shade was a determinant of attractiveness (Helfman 1981, pp. 395-396). Helfman demonstrates photographically that a "…shaded observer (can) see a sunlit target at more than 2.5 times the distance at which a sunlit observer (can) see a shaded target", "…the combined result is that a shaded viewer will see an approaching sunlit viewer (earlier)." (Helfman 1981, pp. 392, 394)

We should not imply that shade only benefits piscivores, or ambush predators in particular. Planktivores may also benefit from the same visual advantage provided by shade, and small fish may use shade, even in the absence of complex cover, to detect and avoid predators with an active mode of foraging (i.e., cruising, as opposed to lying in ambush). However, Tabor and Piaskowski (2002, pp. 2, 3) found that outmigrating juvenile Chinook appeared to avoid overhead structure during both day and night. Kahler, Grassley, and Beauchamp (2000, p. 21) warn that this behavior could increase migration route length and exposure to predators.

In-Water Complexity Resulting from Over-Water Structure

Construction of the new bridges and ramps over Portage Bay, Union Bay, and Lake Washington will greatly increase the total number of piles, columns, and casings (artificial in-water

structures), until at completion of the project only the new, permanent columns and casings remain. In-water complexity will peak during construction year 2015, when a total of nearly 4,000 individual vertical structures will occupy large portions of south Portage and Union Bays, and the west approach area east of Foster Island.

Kahler, Grassley, and Beauchamp (2000) have compiled a useful literature summary and discussion of the effects of artificial lake shoreline structures and development, with specific reference to salmonids and their predators. A short list of their observations with regard to in-water complexity include:

- Juvenile salmonids modify their behavior in the presence of predators. This may include seeking out or orienting to complex refuge. Effective prey refuge includes shallow water, complex substrate, aquatic and emergent vegetation, overhanging terrestrial vegetation, undercut banks, and woody debris (p. 31).

- Docks, piers, and piles may provide shallow-water cover for juvenile salmon, but they also provide cover for bass. Docks, piers, and piles are relatively simple structural elements compared with rootwads and other forms of natural cover. Gotceitas and Colgan (1989) found that prey fish preferentially selected refuge habitat with greater complexity (p. 30).

- Docks and piers are structurally simple, lacking the complexity necessary to function as prey refuge habitat. Instead, they confer an advantage to predatory fish and birds over vulnerable juvenile salmonids (p. 47).

- Bass demonstrate an affinity for structural elements. Bass prefer natural cover, but utilize piers, piles, and other artificial structures for foraging and nesting in lieu of natural cover or structure (pp. 15, 35).

- Due to their life history strategies, largemouth and smallmouth bass are the predators most likely to benefit from shoreline development (p. 29). However, it is less clear what advantages these structures may confer on predatory cutthroat trout (p. 30).

- Because of their propensity for ambush foraging and shoreline orientation, smallmouth bass benefit from artificial structures placed in the littoral zone (p. 21).

- Smallmouth bass were the only species that Bryan and Scarnecchia (1992) consistently found in equal or greater abundance in developed sites (p. 16).

- Smallmouth bass were the only fish whose densities were highest in areas with (artificial) structures (Brown 1998) (p. 16).

- Shoreline development provides concealment structures, and may allow predators to reduce their home range sizes (p. 21).

- Unpublished results of a study by the Muckleshoot Indian Tribe in Lake Sammamish indicate smallmouth bass preferentially located nests around residential piers (Malcom, pers. comm. 2000) (p. 33).

We expect that the piles and pile bents that support work trestles and bridges will be attractive to bass and other predators. These structures lack the complexity of natural cover and therefore do not provide functional prey refuge habitat. We expect that the significant temporary increase in the number of artificial in-water structures will benefit juvenile salmonid predators for a duration measured in years.

Artificial Lighting and Light Contrast

The project's proposed lighting design will reduce, overall, the amount of artificial light cast onto adjacent waters. To the extent practicable, the project will limit incident light levels on adjacent waters to approximately 2.0 foot-candles. However, along the west approach, preliminary information suggests it should be possible to limit incident light to considerably lower levels (0.2 foot-candles or less) (WSDOT 2010a, pp. 6-152).

While the project includes design measures that will reduce permanent effects, we expect the project will have less flexibility to fully accommodate these concerns during construction. Worker and work zone safety dictate strict requirements for nighttime lighting, and while the nighttime lighting will be shielded and limited to the extent practicable, we expect a significant increase in artificial lighting during construction.

The behavioral responses of fish to natural and artificial lighting are complicated, exhibiting significant variation dependent on species, life history stage, feeding strategy, and any number of additional bio-behavioral and environmental factors. Fish may be attracted by, or may avoid artificial sources of light, dependent upon a complex set of feeding, foraging, concealment, and/or predator avoidance advantages and disadvantages.

Clark and Levy (1988, p. ab) describe the trade-off between foraging success and predation risk that influences sockeye salmon diel movements and migration. Sockeye sight feed on zooplankton at or near the lake surface during dawn and dusk "anti-predation windows", when light levels are intermediate and the ratio of mortality risk to feeding rate is minimized.

Investigating the feeding behaviors of northern pikeminnow and smallmouth bass in the John Day Reservoir (Columbia River), Vigg et al. (1991, pp. 430, 433, 434) found that both species of sight feeder exhibited greater feeding activity during periods of low ambient light (dawn and dusk, including a nocturnal peak for pikeminnow). The authors suggest that the pikeminnow's nocturnal feeding mode may be in response to extended twilight conditions produced by artificial lighting.

Investigating the effect of light intensity on sockeye fry predation by sculpin, Tabor, Brown, and Luiting (1998, p. ii) found that increased light levels enabled fry to better avoid predation. However, they also found that sockeye fry movements were reduced or inhibited at above-natural light levels.

Investigating patterns of habitat use by outmigrating juvenile Chinook, Tabor and Piaskowski (2002, pp. 2, 42) found that fish were inactive at night, residing at the bottom of shallow waters, even where shoreline light levels were influenced by sources of artificial light. Fish became active, moved off the bottom, and began schooling as light intensity increased around dawn.

Mazur and Beauchamp (2003, p. 397) investigated prey detection and reaction distance in piscivorous salmonids, including trout and char. Reaction distances for cutthroat and rainbow trout increased rapidly as light levels increased, reaching relatively constant reaction distances at higher levels. By comparison, reaction distances for lake char continued to increase with increasing light intensity "…to asymptote at distances 65 percent higher than those for both cutthroat and rainbow trout." At higher light levels, piscivorous char react to prey at greater distances than do cutthroat and rainbow trout.

Kahler, Grassley, and Beauchamp (2000, pp. 21, 32, 37) warn that artificial lighting may allow visual predators to forage more effectively at night, perhaps even allowing for "…around-the-clock foraging." The authors also report that piscivorous birds, including grebes and herons, have been observed foraging along shorelines in south Lake Washington around sources of artificial light.

We expect that artificial lighting during construction will influence fish behaviors in the immediate surroundings. Lighting will have the effect of extending the duration of twilight incident light conditions around dawn and dusk. These conditions are likely to benefit both sight feeding planktivores (juvenile Chinook and sockeye) and piscivores (northern pikeminnow and smallmouth bass). Avian piscivores may also exploit favorable conditions produced by nighttime lighting.

Temporary Effects to Ship Canal Migratory Conditions and Function

The Ship Canal is important bull trout FMO habitat, since it provides access to the greater Lake Washington watershed and its abundant prey base. However, the Ship Canal is also very heavily degraded, and available information would suggest that bull trout are unlikely to make extended use of the habitats along its length.

Replacement of the bridges and approaches over south Portage Bay will temporarily increase combined, total over-water structure, creating shade effects, in-water complexity, and artificial lighting during construction, for a duration of approximately six years. These stressors have the potential to significantly disrupt normal bull trout behaviors (i.e., ability to successfully feed, move, and/or shelter). These conditions are also likely to benefit smallmouth bass, which are known to occupy habitat along the Ship Canal in significant numbers.

However, the shallow littoral zone along south Portage Bay provides little migratory or foraging function of significance to bull trout. Available information suggests that most adult salmonids pass through the Ship Canal without delay, and the existing and proposed bridge alignments across south Portage Bay are far removed from the primary migration route. At this location, temporary increases in over-water structure and artificial lighting should not have a measurable effect on bull trout movements and migration.

Construction activities over and adjacent to the Montlake Cut are also unlikely to affect bull trout movements and migration. On a few brief occasions, the project will employ the use of barges for delivering materials and/or completing work (e.g., launching and setting new bridge girders), but any resulting stressors will be transient and are unlikely to affect bull trout behaviors.

It is possible that during cooler months (November to April), when water quality conditions are improved, bull trout may make limited use of degraded foraging habitats along the Ship Canal. If this is the case, then artificial lighting might possibly serve as an attractant, and might even confer a limited advantage for piscivorous bull trout by extending the duration of twilight incident light conditions around dawn and dusk.

During construction, temporary conditions will benefit smallmouth bass and could, at least hypothetically, lead to increased predator numbers or density. However, subadult and adult bull trout documented around the Ship Canal locks, or elsewhere throughout the Lake Washington watershed, have all been mature individuals ranging in size between 330 and 604 mm (12 - 24 inches) (USFWS 2006). We expect that bull trout in this size range are not a focus for foraging nonnative fish predators. We expect that any incremental increase in bull trout predation or mortality resulting from temporary structures and construction will not be measurable and is therefore insignificant.

We conclude that the proposed action's temporary effects to Ship Canal migratory conditions and function will not significantly disrupt normal bull trout behaviors. Effects to bull trout movements and migration, foraging, and predation, resulting from temporary structures and associated stressors will not be measurable and are therefore insignificant.

Temporary Effects to Union Bay and Lake Washington (Migratory and Foraging Functions)

Union Bay and Lake Washington provide important bull trout FMO habitat. In particular, available bull trout capture data would suggest that south Lake Washington and the Cedar River delta provide important foraging areas for bull trout (USFWS 2006).

However, we expect that bull trout make fairly limited use of the Lake Washington littoral zone, due to seasonally unsuitable conditions (high temperatures and low DO), competitive exclusion by dominant native cutthroat trout, and a preference for limnetic zones and open-water or benthic foraging. While the expansive, shallow littoral zone along south Union Bay provides little migratory or foraging function of significance to bull trout, the deeper waters along the west approach east of Foster Island function as important migratory habitat. It is completely unknown to what extent bull trout may forage in the open waters close to the existing or proposed bridge alignments.

Replacement of the bridges and approaches over south Union Bay and Lake Washington will temporarily increase combined, total over-water structure, creating shade effects, in-water complexity, and artificial lighting during construction for approximately six years. These stressors have potential to significantly disrupt normal bull trout behaviors (i.e., ability to successfully feed, move, and/or shelter). These conditions are also likely to benefit smallmouth bass.

We expect that bull trout make very infrequent use of the shallow littoral zone along south Union Bay. Beginning as early as May, and frequently extending through November, Lake Washington's littoral zones present conditions stressful to salmonids (especially near dense macrophyte beds). The area provides little migratory or foraging function of significance to bull trout, and therefore we conclude that temporary increases in over-water structure and artificial lighting should not, in this area, have a measurable effect on bull trout behaviors.

Along the west approach east of Foster Island we expect that temporary increases in over-water structure and artificial lighting may measurably affect bull trout migratory behaviors. Bull trout might be expected to avoid and navigate around these temporary structures.

It is possible, though we think unlikely, that bull trout may be attracted to artificial lighting during construction. If so, this might confer a limited advantage for piscivorous bull trout by extending the duration of twilight incident light conditions around dawn and dusk. This same effect might also be evident during construction along the proposed east approach, which lies in close proximity to know sockeye salmon spawning areas.

During construction, temporary conditions will advantage smallmouth bass and could, at least hypothetically, lead to increased predator numbers or density. However, subadult and adult bull trout documented throughout the Lake Washington watershed, have all been mature individuals ranging in size between 330 and 604 mm (12 - 24 inches) (USFWS 2006). We expect that bull trout in this size range are not a focus for foraging nonnative fish predators. We expect that any incremental increase in bull trout predation or mortality resulting from temporary structures and construction will not be measurable and is therefore insignificant.

We conclude that the proposed action's temporary effects to Union Bay and Lake Washington migratory and foraging functions will not significantly disrupt normal bull trout behaviors. Effects to bull trout movements and migration, foraging, and predation, resulting incrementally from temporary structures and associated stressors will not be measurable and are therefore insignificant.

<u>Permanent Habitat Effects, Stressors, and Response</u>

The proposed action includes design measures which we expect will reduce permanent impacts to aquatic resources and maintain or restore important habitat functions over time. The new, permanent bridges and ramps over Portage Bay, Union Bay, and Lake Washington will have fewer in-water columns, will restore conditions that better approximate ambient incident light, and reduce the amount of artificial light cast onto adjacent waters and wetlands.

Permanent Effects to Ship Canal Migratory Conditions and Function

The Ship Canal is important bull trout FMO habitat, since it provides access to the greater Lake Washington watershed and its abundant prey base. However, the Ship Canal is also very heavily degraded, and available information would suggest that bull trout are unlikely to make extended use of the habitats along its length.

The shallow littoral zone along south Portage Bay provides little migratory or foraging function of significance to bull trout. Available information suggests that most adult salmonids pass through the Ship Canal without delay, and the proposed bridge alignment across south Portage Bay is far removed from the primary migration route. At this location, permanent increases in over-water structure should not have a measurable effect on bull trout movements and migration.

The new, permanent bascule bridge over the Montlake Cut will double the combined total over-water area, and will also increase the amount of artificial light cast onto adjacent waters. However, it appears that stressors associated with the existing structure, including shade, artificial lighting and light contrast, have an insignificant effect on adult migration. We have no information that would indicate a foreseeable change in response based on the location and scale of these permanent impacts. Accordingly, we conclude that increases in over-water structure and artificial lighting will not have a measurable effect on bull trout movements and migration.

It is possible that during cooler months (November to April), when water quality conditions are improved, bull trout may make limited use of degraded foraging habitats along the Ship Canal. If this is the case, then artificial lighting might possibly serve as an attractant, and might even confer a limited advantage for piscivorous bull trout by extending the duration of twilight incident light conditions around dawn and dusk.

For the same reasons outlined in preceding sub-sections, we expect that any incremental increase in bull trout predation or mortality resulting from permanent over-water structure and artificial lighting will not be measurable, and is therefore insignificant.

We conclude that the proposed action's permanent effects to Ship Canal migratory conditions and function will not significantly disrupt normal bull trout behaviors. Effects to bull trout movements and migration, foraging, and predation, resulting from new, permanent structures and associated stressors will not be measurable and are therefore insignificant.

Permanent Effects to Union Bay and Lake Washington (Migratory and Foraging Functions)

Union Bay and Lake Washington provide important bull trout FMO habitat. However, we expect that bull trout make fairly limited use of the Lake Washington littoral zone, due to seasonally unsuitable conditions (high temperatures and low DO), in response to competitive exclusion by dominant native cutthroat trout, and in preference for limnetic zones and open-water or benthic foraging strategies. While the expansive, shallow littoral zone along south Union Bay provides little migratory or foraging function of significance to bull trout, the deeper waters along the west approach east of Foster Island function as important migratory habitat. It is completely unknown to what extent bull trout may forage in the open waters close to the existing or proposed bridge alignments.

We expect that bull trout make very infrequent use of the shallow littoral zone along south Union Bay. Beginning as early as May, and frequently extending through November, Lake Washington's littoral zones present conditions stressful to salmonids, especially near dense macrophyte beds. The area provides little migratory or foraging function of significance to bull

trout, and therefore we conclude that permanent increases in over-water structure and artificial lighting in this area should not have a measurable effect on bull trout behaviors.

Along the west approach east of Foster Island and east approach, we expect that the project's design measures will maintain or restore important habitat functions over time. The new, permanent bridges and approaches will have fewer in-water columns, will restore conditions that better approximate ambient incident light, and reduce, overall, the amount of artificial light cast onto adjacent waters and wetlands. We expect that throughout these portions of Lake Washington, the project will maintain or improve habitats functions that support bull trout foraging and migration.

The proposed, new floating bridge span is substantially larger and floats with a deeper draft than does the existing floating span. The overall significance of these changes and potential effects are at least partially offset by location; the floating bridge span is located over some of Lake Washington's deepest contours (60 to 180 ft). The new floating bridge span will permanently affect shading and incident light levels in the immediate vicinity of the bridge. However, it is extremely unlikely that the proposed action will alter conditions on anything more than a very localized scale, or that the measurable localized effects will translate to anything of greater significance for system-wide physical, chemical, or biotic processes (Bloch, pers. comm. 2011a). We conclude that measurable, incremental effects to lake circulation patterns, thermal stratification, or primary production are extremely unlikely, and therefore discountable.

It is possible, though we think unlikely, that bull trout may be attracted to artificial lighting along the bridges and approaches. If so, this might confer a limited advantage for piscivorous bull trout by extending the duration of twilight incident light conditions around dawn and dusk. Any permanent effect will probably be most evident along the east approach, since continuous lighting is not proposed along the floating bridge span or west approach east of Foster Island.

For the same reasons outlined in preceding sub-sections, we expect that any incremental increase in bull trout predation or mortality resulting from permanent over-water structure and artificial lighting will not be measurable, and is therefore insignificant.

We conclude that the proposed action's permanent effects to Union Bay and Lake Washington migratory and foraging functions will not significantly disrupt normal bull trout behaviors. Effects to bull trout movements and migration, foraging, and predation, resulting from new, permanent structures and associated stressors will not be measurable and are therefore insignificant.

Effects to the Bull Trout Prey Base

The Lake Washington FMO, including the Cedar River, Sammamish River, and their tributaries, provide significant foraging habitat and a large prey base. While recent decades have seen development on a large scale, with an attendant decline in the quality and productivity of aquatic environments, observations suggest that bull trout continue to find some locations both attractive and productive (e.g., below the Ship Canal locks, and around south Lake Washington and the Cedar River delta).

During construction, we expect that the proposed action will create conditions which benefit large and smallmouth bass and could, at least hypothetically, lead to increased predator numbers or density. It is less clear how temporary conditions may advantage or disadvantage native predatory cutthroat trout.

Cutthroat trout are the dominant predator in the Lake Washington system (Kahler et al. 2000, p. 17; Nowak et al. 2004, p. 633). Even in the Ship Canal, where bass concentrations are greatest and take their apparent greatest toll on outmigrating juvenile salmonids, bass predation is "…not considerable relative to the numbers of juvenile salmonids migrating from the system…" (Tabor et al. 2007, p. 1183), and "…has had little impact on the observed decrease in sockeye salmon abundance." (Fayram and Sibley 2000, p. 88)

In the long term, we do not expect that the proposed action will create markedly different conditions for native or nonnative piscivores that feed on bull trout prey. The proposed action includes design measures which we expect will reduce permanent impacts to aquatic resources and maintain or restore important habitat functions over time. The new, permanent bridges and ramps over Portage Bay, Union Bay, and Lake Washington will have fewer in-water columns, will restore conditions that better approximate ambient incident light, and reduce the amount of artificial light cast onto adjacent waters and wetlands.

We have concluded that pollutant loadings resulting from the post-project condition are unlikely to further degrade surface water and sediment quality in the action area. In the long term, we do not expect that the proposed action will worsen surface water or sediment quality trajectories at the scale of the action area or Lake Washington watershed. Furthermore, we do not expect that the project's long term, operational stormwater effects will cause or contribute to a measurable, incremental decline in the bull trout prey base.

Throughout portions of the action area, including the Ship Canal and south Union Bay, conditions will continue to advantage large and smallmouth bass, and other predators. However, we do not expect that the project will measurably increase nonnative predator numbers or density in the long term, or measurably increase sources of bull trout predation or mortality.

We expect that the proposed action will do little to measurably change predator-prey dynamics, or prey productivity, at the scale of the action area. Furthermore, we expect that any measurable temporary effects to nonnative predator numbers or density will not change the primary role that native cutthroat trout play as the system's dominant piscivore.

We conclude that the proposed action will have only temporary impacts to the bull trout prey base. We do not expect that these temporary impacts will measurably reduce or impair bull trout foraging success or efficiency, and therefore we regard these effects as insignificant. We expect that the action will do little to measurably change predator-prey dynamics or prey productivity at the scale of the action area, in the short or long term.

Effects of the Action – Synthesis

The proposed action includes design measures and mitigation components which we expect will reduce permanent impacts to aquatic resources and maintain or restore important habitat functions over time. The new, permanent bridges and ramps over Portage Bay, Union Bay, and Lake Washington will have fewer in-water columns, will restore conditions that better approximate ambient incident light, and reduce the amount of artificial light cast onto adjacent waters and wetlands.

The proposed stormwater treatment design will provide basic or enhanced treatment for runoff originating from approximately 500 percent of the net-new PGIS by area, and is expected to achieve measurable reductions in post-project annual stormwater loadings of TSS, total and dissolved Cu, and total and dissolved Zn. In each of the largest, most significant TDAs, the project will reduce stormwater pollutant concentrations at the point of discharge. The proposed stormwater design will reduce CSS contributions, will avoid increasing the frequency or size of future CSO events, and dramatically reduce the size of annual direct discharges to the project's receiving waters.

Despite these important environmental enhancements, we expect that the proposed action will result in measurable adverse effects to bull trout, their prey base, and habitat. Some exposures and adverse effects will be temporary (i.e., construction-related), while others will last in perpetuity (e.g., adverse stormwater effects).

When constructing pontoons at the Port of Tacoma, we expect that adverse effects to individual bull trout will result from fish entrainment and handling within the CTC casting basin. With consideration for the amount and quality of adjacent habitat, the duration of direct contact with adjacent waters, variability in the risk of entrainment at different times of the year, and because we expect that bull trout occur in the Blair Waterway in only very low numbers, we expect that bull trout will not be entrained within the CTC casting basin during most of the planned cycles. We expect that no more than one subadult or adult bull trout will suffer physical injury or mortality, and no more than two subadult or adult bull trout will experience stress not reaching the level of physical injury. We do not expect that fish entrainment, capture, and handling at the CTC casting basin will have a measurable effect on the bull trout's available prey base.

While completing work below the OHWM in Portage Bay, Union Bay, and Lake Washington, we expect the proposed action will result in temporary stressors with potential adverse effects to bull trout and their habitat. These stressors include effects to water quality and temporary increases in underwater sound resulting from impact pile driving. Temporary stressors resulting from work completed in Portage Bay, Union Bay, and Lake Washington have the potential to kill or injure a limited number of subadult and adult bull trout. However, the project includes conservation measures which we expect will dramatically reduce the physical extent of any injurious effects (e.g., a noise attenuation system implemented during impact pile driving and proofing).

These same temporary stressors and exposures resulting from work below the OHWM in Portage Bay, Union Bay, and Lake Washington will also significantly disrupt normal bull trout behaviors (i.e., ability to successfully feed, move, and/or shelter). These exposures may temporarily cause bull trout to avoid the action area, may impede or discourage free movement through the action area, prevent individuals from exploiting preferred habitats, and/or expose individuals to less favorable conditions. Construction of the project will require approximately seven years of work below the OHWM, so temporary stressors and potential adverse exposures will persist for several years. At individual locations these stressors and potential adverse exposures will be episodic.

For a duration measured in years, most bull trout entering the Ship Canal and Lake Washington will be exposed to on-going construction activities. However, we expect that the vast majority of these exposures will be sub-lethal, and many are likely to elicit only mild behavioral responses (e.g., avoidance of the immediate work area). Construction activities will not prevent bull trout from using Lake Washington FMO, and we expect bull trout will continue to forage and migrate through the area during construction.

Many of the other included project elements, and associated items of work, will have no measurable adverse effects on bull trout individuals, their prey base, or habitat. These elements include pontoon construction at the Port of Olympia; anchor construction and pontoon outfitting at existing port and industrial facilities located in Grays Harbor, Olympia, Tacoma, Seattle, Everett, and Bellingham; pontoon storage, transport, and delivery; upland construction activities; and, all activities associated with the proposed mitigation components.

We expect that the proposed action will result in potential adverse effects to bull trout and their habitat resulting from the discharge of treated and untreated highway stormwater runoff. The resulting effects to surface water and sediment quality will last in perpetuity, but will create only infrequent, episodic conditions with the potential to significantly disrupt normal bull trout behaviors (i.e., ability to successfully feed, move, and/or shelter).

The proposed stormwater treatment facilities and outfalls will discharge, for the most part, to low quality habitats along heavily developed and disturbed portions of Lake Union, and Portage, Union, and Fairweather Bays. These facilities and outfalls discharge to locations which we expect are not very attractive to bull trout. However, these facilities and outfalls will discharge intermittently during most months for the full operational life of the project. Considering the amount and quality of affected habitat, the frequency of discharge events and full operational life of the project, we expect that relatively few subadult and adult bull trout will be exposed to stormwater discharges and experience measurable adverse effects. Again, we expect that most of these exposures will be sub-lethal, and many are likely to elicit only mild behavioral responses.

In the long term, we do not expect that the proposed action will worsen surface water or sediment quality trajectories at the scale of the action area or Lake Washington watershed. Furthermore, we do not expect that the project's long term, operational stormwater effects will cause or contribute to a measurable, incremental decline in the bull trout prey base.

The proposed action will have both temporary and permanent impacts to bull trout FMO habitat. However, we conclude that potential effects to bull trout movements and migration, foraging, and predation risk resulting from temporary structures and associated stressors will not be measurable and are therefore insignificant. We also conclude that potential effects to bull trout movements and migration, foraging, and predation risk resulting from new, permanent structures and associated stressors will not be measurable and are therefore insignificant. Finally, with regard to permanent features of the proposed action, we conclude that the proposed, new floating bridge span will affect shading and incident light levels in the immediate vicinity of the bridge, but will only measurably alter conditions on a localized scale. We conclude that measurable, incremental effects to lake circulation patterns, thermal stratification, or primary production are extremely unlikely, and therefore discountable.

In the short term (i.e., during construction), we expect that the proposed action will create conditions which benefit large and smallmouth bass and could, at least hypothetically, lead to increased predator numbers or density. However, we do not expect that the project will measurably increase nonnative predator numbers or density in the long term, or measurably increase sources of bull trout predation or mortality. The proposed action will do little to measurably change predator-prey dynamics, or prey productivity, at the scale of the action area, and will not change the primary role that native cutthroat trout play as the system's dominant piscivore.

Based on location and proximity to bull trout core areas and local populations, it is reasonable to conclude that relatively few individuals will be exposed to the action's short or long term effects. Suitable bull trout rearing and spawning habitats are not present in the action area, and therefore the proposed action will have no effect on bull trout rearing or spawning habitat, or these essential behaviors.

While we cannot entirely discount the risk of physical injury or mortality as a result of temporary exposures, we expect that the number of killed or injured bull trout will be very low (i.e., a few individuals at most). These subadult and adult bull trout may originate from any of three bull trout core areas (Puyallup, Snohomish-Skykomish, and Skagit River core areas), and fifteen (or more) local populations. Because these few individuals originate from any of the fifteen (or more) local populations, we expect that no measurable effect to numbers (abundance) will be evident at the scale of the local populations or core areas.

Temporary exposures resulting in sublethal physiological stress, and/or a significant disruption of normal behaviors, could potentially have consequences for individual growth or long term survival. However, we expect that for most exposed bull trout these potential incremental effects to growth and long term survival will not be measurable. These subadult and adult bull trout may originate from any of three bull trout core areas (Puyallup, Snohomish-Skykomish, and Skagit River core areas), and we expect that no measurable effect to numbers (abundance) or reproduction (productivity) will be evident at the scale of the local populations or core areas.

Temporary exposures may impede or discourage free movement through the action area, prevent individuals from exploiting preferred habitats, and/or expose individuals to less favorable conditions. However, the proposed action will not create or contribute to any permanent

impediments of the migratory corridor. Any measurable effects to migratory habitat (or migrating individuals) will be temporary, and we expect that no measurable short or long term effects to distribution will be evident at the scale of the local populations or core areas.

Effects to Bull Trout Critical Habitat

An earlier section identified the PCEs of bull trout critical habitat and described their baseline condition in the action area (*Status of Critical Habitat in the Action Area*). The following sub-sections discuss the effects of the action with reference to the six PCEs which are present and may be affected.

Lake Washington FMO

The action area includes portions of Lake Washington, Union Bay, Portage Bay, and major tributaries (Cedar River, tributary to Lake Washington; Bear Creek, tributary to Sammamish River; etc.), including nearshore freshwater environments less than 10 m in depth. These habitats provide six of the nine PCEs:

(2) *Migration habitats with minimal physical, biological, or water quality impediments between spawning, rearing, overwintering, and freshwater and marine foraging habitats, including but not limited to permanent, partial, intermittent, or seasonal barriers.*

The proposed action will result in temporary adverse effects to this PCE. Construction activities will impair function of the migratory corridor in Portage Bay, Union Bay, and Lake Washington, intermittently, but for a term of approximately seven years (2012 through 2018).

In addition, the proposed action will also have persistent effects to surface water quality resulting from treated and untreated stormwater discharges. Discharge events will be episodic and are more likely to occur during winter months. Discharge events will result in measurable mixing or dilution zones, where dissolved metal concentrations are sufficient to result in adverse sub-lethal effects, including avoidance response and reduced olfactory sensory responsiveness. Discharge events will create temporary conditions that may impair free movement through the action area and/or temporarily displace bull trout from refugia or preferred habitats.

All other project elements and activities will result in no measurable effects to short or long term function of this PCE. Given the nature, size, and duration of these adverse effects, we expect that within the action area this PCE will retain its current level of function (moderately to severely impaired).

(3) *An abundant food base, including terrestrial organisms of riparian origin, aquatic macroinvertebrates, and forage fish.*

The proposed action will result in temporary adverse effects to this PCE. Construction activities will create conditions which benefit large and smallmouth bass and could, at least hypothetically, lead to increased predator numbers or density in the short term. Outmigrating juvenile Chinook

and sockeye salmon are preferred prey species, and might experience measurable short term declines in numbers.

In the long term, we do not expect that the proposed action will create markedly different conditions for native or nonnative piscivores that feed on bull trout prey. The proposed action will do little to measurably change predator-prey dynamics, or prey productivity, at the scale of the action area. Furthermore, we expect that any measurable temporary effects to nonnative predator numbers or density will not change the primary role that native cutthroat trout play as the system's dominant piscivore. We expect that any measurable declines in juvenile salmon numbers will be temporary, and the project will have no permanent adverse effects to the bull trout prey base.

All other project elements and activities will result in no measurable effects to short or long term function of this PCE. Given the nature, size, and duration of these adverse effects, we expect that within the action area this PCE will retain its current level of function (moderately impaired).

(4) *Complex river, stream, lake, reservoir, and marine shoreline aquatic environments, and processes that establish and maintain these aquatic environments, with features such as large wood, side channels, pools, undercut banks and unembedded substrates, to provide a variety of depths, gradients, velocities, and structure.*

The proposed action will result in both temporary and permanent adverse effects to this PCE. However, the project also includes design measures and mitigation components which we expect will reduce permanent or long term impacts to aquatic resources, and maintain or restore important habitat functions over time. The new, permanent bridges and ramps over Portage Bay, Union Bay, and Lake Washington will have fewer in-water columns, will restore conditions that better approximate ambient incident light, and reduce the amount of artificial light cast onto adjacent waters and wetlands.

Construction of the new bridges and ramps over Portage Bay, Union Bay, and Lake Washington will require that the project install large, temporary work bridges and trestles. These temporary structures will greatly increase the combined total over-water structure spanning portions of Portage Bay, Union Bay, and Lake Washington for a period of several years. For Portage Bay, Union Bay, and the west approach area east of Foster Island, the combined total over-water area will increase from a baseline condition of approximately 14 acres (2011), to a peak value of approximately 47 acres (2015), before complete removal of the existing and temporary structures reduce over-water cover to its final, proposed condition (approximately 36.6 acres) in 2018.

Excluding the new floating bridge anchors, which the project will install at depths of 60 to 180 ft, the combined, total in-water footprint of the proposed structures (approximately 42,500 ft^2) is only modestly larger than the existing in-water footprint (approximately 8,500 ft^2); much of this difference is attributable to the new mudline footings required in Portage Bay and along the east approach.

Measurable permanent adverse effects will persist for the functional life of the constructed features. However, given the nature, size, and duration of these adverse effects, we expect that within the action area this PCE will retain its current level of function (moderately to severely impaired).

(5) *Water temperatures ranging from 2 to 15 °C (36 to 59 °F), with adequate thermal refugia available for temperatures that exceed the upper end of this range. Specific temperatures within this range will depend on bull trout life-history stage and form; geography; elevation; diurnal and seasonal variation; shading, such as that provided by riparian habitat; stream flow; and local groundwater influence*.

The proposed action will have no measurable effects to short or long term function of this PCE. Within the action area this PCE will retain its current level of function (moderately to severely impaired).

(8) *Sufficient water quality and quantity such that normal reproduction, growth, and survival are not inhibited*.

The proposed action will result in temporary adverse effects to this PCE. Construction activities will impair water quality, intermittently but for a term of approximately seven years (2012 through 2018).

In addition, the proposed action will also have persistent effects to surface water quality resulting from treated and untreated stormwater discharges. Discharge events will be episodic and are more likely to occur during winter months. Discharge events will result in measurable mixing- or dilution-zones, wherein dissolved metal concentrations are sufficient to result in adverse sub-lethal effects, including avoidance response and reduced olfactory sensory responsiveness. Discharge events will create temporary conditions that may impair free movement through the action area and/or temporarily displace bull trout from refugia or preferred habitats.

All other project elements and activities will result in no measurable effects to short or long term function of this PCE. Given the nature, size, and duration of these adverse effects, we expect that within the action area this PCE will retain its current level of function (moderately impaired).

(9) *Sufficiently low levels of occurrence of nonnnative predatory (e.g., lake trout, walleye, northern pike, smallmouth bass); interbreeding (e.g., brook trout); or competing (e.g., brown trout) species that, if present, are adequately temporally and spatially isolated from bull trout*.

The proposed action will result in temporary adverse effects to this PCE. Construction activities will create conditions which advantage large and smallmouth bass and could, at least hypothetically, lead to increased predator numbers or density in the short term.

The subadult and adult bull trout documented throughout the Lake Washington watershed have all been mature individuals ranging in size between 330 and 604 mm (12 - 24 inches) (USFWS

2006). We expect that bull trout in this size range are not a focus for foraging nonnative fish predators.

In the long term, we do not expect that the proposed action will create markedly different conditions for native or nonnative piscivores that feed on bull trout prey. The proposed action will do little to measurably change predator-prey dynamics at the scale of the action area. Furthermore, we expect that any measurable temporary effects to nonnative predator numbers or density will not change the primary role that native cutthroat trout play as the system's dominant piscivore. We expect no measurable, permanent adverse effects to this PCE.

All other project elements and activities will result in no measurable effects to short or long term function of this PCE. Given the nature, size, and duration of these adverse effects, we expect that within the action area this PCE will retain its current level of function (moderately impaired).

In summary, we expect that the action will result in adverse effects to critical habitat resulting from temporary adverse effects to PCEs #3 (food base) and #9 (competitive or predatory nonnative species), and resulting from both temporary and limited, permanent adverse effects to PCEs #2 (migration habitats with minimal impediments), #4 (complex lake shoreline environments), and #8 (water quantity and quality).

Nearshore Marine Waters

The Ports of Grays Harbor, Olympia, Tacoma, Seattle, Everett, and Bellingham are located in developed nearshore marine waters. Nearshore marine waters less than 10 m in depth provide four of the nine PCEs of bull trout critical habitat (50 FR 63898 [October 18, 2010]):

(2) *Migration habitats with minimal physical, biological, or water quality impediments between spawning, rearing, overwintering, and freshwater and marine foraging habitats, including but not limited to permanent, partial, intermittent, or seasonal barriers.*

The proposed action will have no measurable effects to short or long term function of this PCE. Within the action area this PCE will retain its current level of function (moderately to severely impaired).

(3) *An abundant food base, including terrestrial organisms of riparian origin, aquatic macroinvertebrates, and forage fish.*

The proposed action will have no measurable effects to short or long term function of this PCE. Within the action area this PCE will retain its current level of function (moderately to severely impaired).

(5) *Water temperatures ranging from 2 to 15 °C (36 to 59 °F), with adequate thermal refugia available for temperatures that exceed the upper end of this range. Specific temperatures within this range will depend on bull trout life-history stage and form; geography; elevation; diurnal and seasonal variation; shading, such as that provided by riparian habitat; stream flow; and local groundwater influence.*

The proposed action will have no measurable effects to short or long term function of this PCE. Within the action area this PCE will retain its current level of function (little or no significant impairment).

(8) *Sufficient water quality and quantity such that normal reproduction, growth, and survival are not inhibited.*

The proposed action will have no measurable effects to short or long term function of this PCE. Within the action area this PCE will retain its current level of function (moderately to severely impaired).

In summary, we conclude that use of existing port and industrial facilities, and use of established open-water shipping routes, will have no measurable, incremental effects on short or long term function of the nearshore marine PCEs.

Our rationale for this conclusion is the following. When performed at existing port and industrial facilities, floating bridge pontoon and anchor construction, pontoon outfitting and storage, and other off-site activities (e.g., waste material recycling, processing, and reuse) represent activities consistent with current, established uses. No temporary effects to the aquatic environment will extend from these facilities more than a few hundred feet. Also, with implementation of the proposed measures (i.e., pontoon inspection and cleaning), we conclude that the risk of introducing or furthering the spread of any invasive species as a result of pontoon transport is extremely unlikely and therefore discountable. With implementation of the proposed conservation measures and permanent design elements, including the identified site selection criteria, we conclude that these activities will have no measurable, adverse effects on the PCEs of designated bull trout critical habitat. We expect that the proposed action will result in no measurable effects to short or long term function of the nearshore marine PCEs.

Indirect Effects (Bull Trout and Critical Habitat)

Indirect effects are caused by or result from the proposed action, are later in time, and are reasonably certain to occur. Indirect effects may occur outside of the area directly affected by the action (USFWS and NMFS 1998).

The FHWA has assessed potential indirect effects to land use development pattern, rate, or intensity. The BA finds that the action will alter traffic circulation patterns along a zone of influence extending from the I-5/SR 520 interchange in Seattle, to the SR 520/SR 202 interchange in Redmond. However, the BA also finds that no development is contingent or dependent on the proposed action, and no discernible changes in development pattern, rate, or intensity are likely to result (WSDOT 2010a, p. 6-182 and Appendix H).

The proposed action will reduce congestion and improve mobility for vehicles traveling SR 520. The action will establish a six thru-lane configuration (four west- and east-bound general purpose lanes; two west- and east-bound HOV/transit lanes) between the I-5/SR 520 interchange in Seattle, and the SR 520/92nd Avenue NE interchange in Yarrow Point. The action will

improve transit, HOV, and multi-modal access, improve levels of service, and reduce current and projected traffic congestion and travel times. The project will not construct new general purpose points of access along the corridor, but will make limited improvements to surrounding local arterials (mostly in the vicinity of the existing Montlake Interchange).

While the project's zone of influence, or service area, is large, it is also already extensively built-out, and serviced by a number of high-capacity general purpose, transit, and multi-modal transportation systems. Combined with the other, concurrent transit and mobility improvements along SR 520, we expect that the most likely result will be modest rates of localized redevelopment in some already developed portions of the service area.

We expect that only very modest changes to land use development pattern, rate, or intensity may result in part from the proposed action. We expect that any resulting incremental effects to watershed functions will not be measurable, and are therefore insignificant. We expect no significant, measurable effects to bull trout, their habitat, or prey base at the scale of action area or Lake Washington watershed as a result of indirect effects.

Effects of Interrelated & Interdependent Actions (Bull Trout and Critical Habitat)

Interrelated actions are defined as actions "that are part of a larger action and depend on the larger action for their justification"; interdependent actions are defined as actions "that have no independent utility apart from the action under consideration" (50 CFR section 402.02).

The proposed action is part of the WSDOT's larger program of transit, safety, and mobility improvements along SR 520, between the I-5/SR 520 interchange in Seattle, and the SR 520/SR 202 interchange in Redmond (WSDOT 2010a, p. 1-1). The program includes two additional projects that the FHWA has determined have independent utility. Corridor improvements extending between Evergreen Point Road and the SR 520/SR 202 interchange were the subject of an independent section 7 consultation completed during 2009 (SR 520, Medina to SR 202 Eastside Transit and HOV Project; FWS Ref. No. 13410-2008-I-0601). Construction and operation of a pontoon casting basin located in Grays Harbor, Washington, and production, moorage/storage, outfitting, and delivery of finished pontoons to Lake Washington, were the subject of an independent section 7 consultation completed during 2010 (SR 520, Pontoon Construction Project; FWS Ref. No. 13410-2010-F-0497).

No measurable effects to bull trout individuals, their prey base, or habitat are expected to result from interrelated or interdependent actions.

CUMULATIVE EFFECTS (Bull Trout and Critical Habitat)

Cumulative effects include the effects of future State, tribal, local, or private actions that are reasonably certain to occur in the action area. 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 Act.

A wide variety of government, public non-governmental, local, tribal, and private partners are taking coordinated actions to monitor and improve water quality conditions in the greater Lake Washington watershed. The WDOE and its partners are implementing several Total Maximum Daily Loads (TMDLs) aimed at controlling point and non-point sources of fecal coliform, nutrients, and biological oxygen demand. Additional TMDLs target improved dissolved oxygen and temperature conditions throughout the basin, and monitoring and control or remediation of pesticide, dioxin, PCB, PAH, and metals contamination in the basin's lakes.

Future State and local actions which may affect Lake Washington FMO habitat include implementation of TMDLs. Planning and implementation has begun for fecal coliform, dissolved oxygen, and temperature TMDLs in the Bear, Evans, and Cottage Creek sub-watersheds, and for fecal coliform in the Swamp Creek and North Creek sub-watersheds of the Sammamish River basin (WDOE 2011). State, local, tribal, and private partners are also taking actions aimed at directly improving floodplain functions and instream habitat conditions, for the benefit of native resident and anadromous fish.

Future local actions that may affect bull trout and designated bull trout critical habitat include planned growth consistent with the land use and growth management plans of King County and the City of Seattle, and of surrounding cities including Bellevue, Kirkland, Redmond, Renton, and Issaquah. Additional residential, commercial, and industrial development (or redevelopment) is certain to occur in the action area. Planned growth consistent with the land use and growth management plans of these municipalities will, over the long term, result in additional effects to watershed functions, surface water quality, and instream habitat. However, with full implementation of the Comprehensive Plans, Shoreline Management Programs, and Critical Area Ordinances administered by these municipalities, and in conjunction with State and County environmental permit requirements, including those requirements established for the protection of wetlands and for the regulation of private and municipal stormwater discharges, effects to habitats supporting bull trout and their prey may be reduced.

Climate change and its potential effects should also be considered when describing possible future actions and conditions within the action area. In particular, potential effects to seasonal patterns of precipitation, surface water temperatures, and stream hydrology could present dramatically altered conditions for bull trout and other cold-water fish of the Pacific Northwest. A recent, wide-ranging assessment of these potential effects has identified the following trends (Littell et al. 2009 in USFWS 2010a):

- Wetter autumns and winters, drier summers, and reductions in permanent snowpack.

- Higher winter stream flows, earlier spring snowmelt and peak spring stream flow, and lower summer stream flows in rivers that depend on snowmelt.

- Rising stream temperatures and a corresponding reduction in the quality and extent of cold-water habitats.

Littell et al. (2009) have concluded that the combined effects of warming stream temperatures and altered stream flows will very likely reduce the reproductive success of many salmon populations. As much as one-third of the current habitat in the Pacific Northwest may no longer be suitable by the end of the century. Rising stream temperatures and temporal shifts in stream hydrology will have more pronounced effects on the systems, populations, and life-history types that are most sensitive.

Lake Washington and the Lake Washington Ship Canal exhibit a significant trend toward increasing average temperatures in the months of August, September, October, and November (Quinn et al. 2002, pp. 592, 594). These temperatures already present a thermal barrier to salmonid movements and migration along the Ship Canal (City of Seattle and USACE 2008, pp. 83-84; Fresh et al. 1999, pp. 3, 12-13; NMFS 2008, p. 27; WSDOT 2010a, pp. 5-20, 5-26, F-1, G-3), and present conditions stressful to salmonids throughout the lake's shallow littoral zones (Nowak et al. 2004, p. 631).

The Climate Impacts Group, an interdisciplinary research group studying the impacts of natural climate variability and global climate change, has published findings from recent work throughout the Pacific Northwest. This work includes an examination of year-to-year and decadal trends in projected future surface water temperatures, and their significance for salmonid habitat function. Mantua, Tohver, and Hamlet (2009) have reported model projections for the Lake Washington Ship Canal, which is "…among the most thermally stressed freshwater salmon habitats in western Washington." Temperatures exceeding thermal tolerances of migrating salmon persist today for between 5 and 10 weeks, each year. By the end of the century, these conditions may persist for as long as 15 to 17 weeks during most years (Mantua et al. 2009, p. 14).

More than one author has warned that if the observed trend toward increasing surface water temperatures continues, and especially if this warming is exacerbated by climatic shifts resulting from global greenhouse production, predator-prey dynamics and prey productivity could be substantially altered. Warming temperatures would expand the spatial and temporal overlap of native salmonids and nonnative predators, and increase metabolic rates and consumption of prey (Mantua et al. 2009, p. 14; Tabor et al. 2007, p. 1185). The threats that warming temperatures would present to cold water fishes are numerous, and in the Lake Washington watershed these are likely to include additional thermal stress while migrating, additional delay while migrating, increased susceptibility to disease, increased incidence of pre-spawn mortality, and reduced spawning success (Newell and Quinn 2005, p. 1237).

Taken as a whole, the foreseeable future State, tribal, local, and private actions may have both beneficial effects and adverse effects to bull trout and designated bull trout critical habitat. Some of these actions (e.g., implementation of the TMDL clean-up plans) are likely to improve

conditions in the action area for bull trout. Over time, other actions may further degrade conditions for bull trout and the function of designated bull trout critical habitat. However, at the scale of the action area, we expect that foreseeable future actions may be less important than the consequences of climate change and its potential effects to watershed functions.

CONCLUSION

We have reviewed the current status of the bull trout in its coterminous range, the current status of designated bull trout critical habitat in its coterminous range, the environmental baseline for the action area, the direct and indirect effects of the proposed action, the effects of interrelated and interdependent actions, and the cumulative effects that are reasonably certain to occur in the action area.

It is our Biological Opinion that the action, as proposed, is not likely to jeopardize the continued existence of the bull trout in its coterminous range. This determination is based on the following:

- The action area contains non-core FMO habitat supporting low numbers of subadult and adult bull trout. Suitable bull trout rearing and spawning habitats are not present in the action area, and therefore the proposed action will have no effect on bull trout rearing or spawning habitat, or these essential behaviors.

- The proposed action incorporates both permanent design elements and conservation measures which will reduce effects to habitat and avoid and minimize impacts during construction. The action's temporary adverse effects are limited in both physical extent and duration. The action’s temporary adverse effects will not preclude bull trout from foraging, migrating, and overwintering in the action area.

- The action’s permanent adverse effects to bull trout habitat (i.e., persistent effects to surface water quality resulting from stormwater discharges, in-water and over-water structures) may result in episodic conditions sufficient to significantly disrupt normal bull trout behaviors, but will not preclude bull trout from foraging, migrating, and overwintering in the action area.

- With full implementation of the proposed conservation measures, we expect that low numbers of subadult and adult bull trout will be adversely affected by construction activities. Exposure to construction activities may kill or injure a limited number of bull trout, may result in sublethal physiological stress with potential consequences for individual growth and/or long term survival, and will significantly disrupt normal bull trout behaviors (feeding, moving, and sheltering). As many as three individual subadult and adult bull trout may become entrained within the CTC casting basin and suffer adverse effects as a result of capture and handling prior to release. However, we expect that the vast majority of temporary, construction-related bull trout exposures will be sub-lethal, and many are likely to elicit only mild behavioral responses (e.g., avoidance of the immediate work area). Because these subadult and adult bull trout may originate from

any of three bull trout core areas (Puyallup, Snohomish-Skykomish, and Skagit River core areas), and fifteen (or more) local populations, we expect that any resulting temporary or long term effects to bull trout numbers (abundance) or reproduction (productivity) will not be measurable at the scale of the local populations or core areas.

- We expect that relatively few subadult and adult bull trout will be exposed to operational stormwater discharges and experience measurable adverse effects. In the long term, we do not expect that the proposed action will worsen surface water or sediment quality trajectories at the scale of the action area or Lake Washington watershed. Furthermore, we do not expect that the project's long term, operational stormwater effects will cause or contribute to a measurable, incremental decline in the bull trout prey base.

- The proposed action will result in temporary adverse effects to the bull trout prey base. Construction activities will create conditions which benefit nonnative fish predators and could, at least hypothetically, lead to increased predator numbers or density in the short term. Outmigrating juvenile salmon are preferred prey species, and might experience measurable short term declines in numbers. In the long term, we do not expect that the proposed action will create markedly different conditions for native or nonnative piscivores that feed on bull trout prey. We expect that any measurable declines in juvenile salmon numbers will be temporary, and the project will have no permanent adverse effects to the bull trout prey base.

- The proposed action will have no measurable short or long term effects on bull trout distribution at the scale of the local populations or core areas (Puyallup, Snohomish-Skykomish, and Skagit River core areas).

- The proposed mitigation components will restore habitat and habitat functions, with potential benefits for bull trout and their prey.

- The anticipated direct and indirect effects of the action, combined with the effects of interrelated and interdependent actions, and the cumulative effects associated with future State, tribal, local, and private actions will not appreciably reduce the likelihood of survival and recovery of the species. The anticipated direct and indirect effects of the action (permanent and temporary) will not measurably reduce bull trout numbers, reproduction, or distribution at the scale of the core areas or Puget Sound interim recovery unit. The anticipated direct and indirect effects of the action will not alter the status of bull trout at the scale of the Puget Sound interim recovery unit or coterminous range.

It is our Biological Opinion that the action, as proposed, will not destroy or adversely modify bull trout critical habitat. This determination is based on the following:

- The action area includes Lake Washington, the Lake Washington Ship Canal, and nearshore marine waters in Puget Sound and Grays Harbor. Lake Washington and the Ship Canal provide six of the nine PCEs of designated bull trout critical habitat. Nearshore marine waters provide four of the nine PCEs. The action area includes the

geographic extent of the open-water shipping routes along which the project will transport pontoons and materials. However, no incremental effects to the physical, biotic, or chemical environment are reasonably foreseeable as a result of transport along established open-water shipping routes.

- The action area provides non-core FMO habitat and supports low numbers of subadult and adult bull trout. Suitable bull trout rearing and spawning habitats are not present in the action area, and therefore the proposed action will have no effect on bull trout rearing or spawning habitat, including PCE #6 (substrates to ensure spawning success and juvenile survival).

- The proposed action incorporates both permanent design elements and conservation measures which will reduce effects to critical habitat and avoid and minimize impacts during construction. The action's temporary, construction-related adverse effects are limited in both physical extent and duration.

- The action will result in temporary adverse effects to function of the migratory corridor in Lake Washington and the Ship Canal (PCE #2), intermittently but for a term of approximately seven years (2012 through 2018).

- The action will result in temporary adverse effects to the bull trout prey base (PCE #3). Construction activities will create conditions which benefit nonnative fish predators and could, at least hypothetically, lead to increased predator numbers or density in the short term. Outmigrating juvenile salmon are preferred prey species, and might experience measurable short term declines in numbers.

- The action will result in both temporary and permanent adverse effects to water quality (PCE # 8). Construction activities in Lake Washington and the Ship Canal will produce intermittent turbidity, for a term of approximately seven years (2012 through 2018). In addition, the proposed action will also have persistent effects to surface water quality resulting from operational stormwater discharges. Discharge events will create temporary conditions that impair free movement and/or temporarily displace bull trout from refugia or preferred habitats. However, in the long term, we do not expect that the proposed action will worsen surface water or sediment quality trajectories at the scale of the action area or Lake Washington watershed. Furthermore, we do not expect that the project’s long term, operational stormwater effects will cause or contribute to a measurable, incremental decline in the bull trout prey base.

- The action will result in limited, temporary and permanent adverse effects to complex lake and shoreline aquatic habitats and processes (PCE #4). Construction activities will greatly increase the amount of artificial, over-water and in-water structure for a term of approximately seven years (2012 through 2018). However, the action also includes design measures and mitigation components which we expect will reduce permanent or long term impacts to aquatic habitats, and maintain or restore important habitat functions over time. The action’s permanent adverse effects to lake and shoreline habitats (i.e., persistent effects to surface water quality resulting from stormwater discharges, in-water

and over-water structures) are limited in physical extent, will not further degrade current function, prevent future establishment of full, proper function, or preclude bull trout from foraging, migrating, and overwintering in the action area.

- The action will result in temporary adverse effects to PCE #9. Construction activities will create conditions which benefit nonnative fish predators and could, at least hypothetically, lead to increased predator numbers or density in the short term. However, we do not expect any measurable increase in bull trout predation or mortality, or measurably different long term conditions for native and nonnative piscivores.

- Within the action area, bull trout critical habitat will retain its current ability to establish functioning PCEs. The anticipated direct and indirect effects of the action, combined with the effects of interrelated and interdependent actions, and the cumulative effects associated with future State, tribal, local, and private actions will not prevent the PCEs of critical habitat from being maintained, and will not degrade the current ability to establish functioning PCEs at the scale of the action area. Critical habitat within the action area will continue to serve the intended conservation role for the species at the scale of the core areas (Puyallup, Snohomish-Skykomish, and Skagit River core areas), Puget Sound interim recovery unit, and coterminous range.

INCIDENTAL TAKE STATEMENT

Section 9 of the Act and Federal regulation pursuant to section 4(d) of the Act prohibit the take of endangered and threatened species, respectively, without 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 defined by the Service as an act which actually kills or injures wildlife. Such act may include significant habitat modification or degradation where it actually kills or injures wildlife by significantly impairing essential behavior patterns, including breeding, feeding, or sheltering (50 CFR 17.3). Harass is defined by the Service as an intentional or negligent act or omission which creates the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavioral patterns which include, but are not limited to, breeding, feeding, or sheltering (50 CFR 17.3). Incidental take is defined as take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity. Under the terms of section 7(b)(4) and section 7(o)(2), taking that is incidental to and not intended as part of the agency action is not considered to be prohibited taking under the Act provided that such taking is in compliance with the terms and conditions of this Incidental Take Statement.

The measures described below are non-discretionary, and must be undertaken by the FHWA so that they become binding conditions of any grant or permit issued, as appropriate, for the exemption in section 7(o)(2) to apply. The FHWA has a continuing duty to regulate the activity covered by this incidental take statement. If the FHWA (1) fails to assume and implement the terms and conditions or (2) fails to require the contractor or applicant to adhere to the terms and conditions of the incidental take statement through enforceable terms that are added to the permit or grant document, the protective coverage of section 7(o)(2) may lapse. In order to monitor the

impact of incidental take, the FHWA must report the progress of the action and its impact on the species to the Service as specified in the incidental take statement [50 CFR section 402.14(i)(3)].

AMOUNT OR EXTENT OF TAKE

We anticipate that take in the form of harm and harassment of subadult and adult bull trout from the Puyallup, Snohomish-Skykomish, and/or Skagit River core areas will result from the proposed action.

1. Incidental take of bull trout in the form of ***harm*** (physical injury or mortality) resulting from fish entrainment, capture, and handling at the Port of Tacoma CTC casting basin.

    - One adult or subadult bull trout will be harmed during ten casting basin gate openings scheduled between August 2012 and June 2014.

2. Incidental take of bull trout in the form of ***harassment*** (stress not reaching the level of physical injury) resulting from fish entrainment, capture, and handling at the Port of Tacoma CTC casting basin.

    - Two adult or subadult bull trout will be harassed during ten casting basin gate openings scheduled between August 2012 and June 2014.

The following forms of incidental take will be difficult to detect or quantify for the following reasons: 1) the low likelihood of finding dead or injured adults, subadults, or juveniles; 2) delayed mortality; and, 3) the relationship between habitat conditions and the distribution and abundance of individuals is imprecise such that a specific number of affected individuals cannot be practically obtained. Where this is the case, we use post-project habitat conditions as a surrogate indicator of take.

3. Incidental take of bull trout in the form of ***harassment*** resulting from degraded surface water quality and exposure to elevated turbidity and sedimentation during construction. Water quality will be degraded intermittently while construction activities are being completed below the OHWM of Portage Bay, Union Bay, and Lake Washington. Take will result when levels of turbidity reach or exceed the following:

    i) 84 NTUs above background at any time; or

    ii) 40 NTUs above background for more than 1 hour, continuously; or

    iii) 18 NTUs above background for more than 3 hours, cumulatively, over a 18-hour workday; or

    iv) 9 NTUs above background for durations approaching two 24-hour days, continuously.

- All adult and subadult bull trout within 300 ft of sediment-generating activities will be harassed during construction within stated in-water work windows, for a period of approximately 1,500 working days (Portage Bay; August 16 - April 30, 2013-2018), 2,000 working days (Union Bay; 2013-2018), 1,600 working days (Lake Washington – West Approach; August 1 - April 30, 2013-2018), and 1,200 working days (Lake Washington – East Approach; July 1 - May 15, 2012-2015), respectively.

- All adult and subadult bull trout within 300 ft of sediment-generating activities will be harassed during demolition and removal of existing bridge and approach columns outside stated in-water work windows, for a period of approximately 50 working days (Portage Bay; 2013-2018), and 10 working days (Lake Washington - West; 2013-2018), respectively.

4. Incidental take of bull trout in the form of ***harm*** as a direct effect of exposure to elevated underwater SPLs resulting from impact pile driving and proofing of approximately 165 steel piles along the east approach to Lake Washington, between August 16, 2012, and March 15, 2014 (approximately 200 working days in total).

    - All adult or subadult bull trout within approximately 1,800 ft of piling installation operations in Lake Washington (150 acres during 2012-13; 134 acres during 2013-14) will be harmed.

5. Incidental take of bull trout in the form of ***harm*** as a direct effect of exposure to elevated underwater SPLs resulting from impact pile driving and proofing of approximately 950 steel piles along the west approach to Lake Washington (east of Foster Island), between October 1, 2013, and April 15, 2014, and between October 1, 2015, and April 15, 2016 (approximately 400 working days in total).

    - All adult or subadult bull trout within approximately 62 ft of piling installation operations in Lake Washington (4.0 acres during 2013-14; 3.8 acres during 2015-16) will be harmed.

6. Incidental take of bull trout in the form of ***harassment*** as a direct effect of exposure to elevated underwater SPLs resulting from impact pile driving and proofing of approximately 165 steel piles along the east approach to Lake Washington, between August 16, 2012, and March 15, 2014 (approximately 200 working days in total).

    - All adult or subadult bull trout within approximately 7,100 ft of piling installation operations in Lake Washington (1,810 acres during 2012-13; 1,760 acres during 2013-14) will be harassed.

7. Incidental take of bull trout in the form of ***harassment*** as a direct effect of exposure to elevated underwater SPLs resulting from impact pile driving and proofing of approximately 950 steel piles along the west approach to Lake Washington (east of Foster Island), between October 1, 2013, and April 15, 2014, and between October 1, 2015, and April 15, 2016 (approximately 400 working days in total).

- All adult or subadult bull trout within approximately 450 ft of piling installation operations in Lake Washington (42.8 acres during 2013-14; 41.7 acres during 2015-16) will be harassed.

8. Incidental take of bull trout in the form of ***harassment*** as a direct effect of exposure to elevated underwater SPLs resulting from impact pile driving and proofing of approximately 1,100 steel piles in Union Bay, between September 1, 2013, and April 30, 2014, and between September 1, 2015, and April 30, 2016 (approximately 500 working days in total).

    - All adult or subadult bull trout within approximately 72 ft of piling installation operations in Union Bay (9.7 acres during 2013-14; 10.0 acres during 2015-16) will be harassed.

9. Incidental take of bull trout in the form of ***harassment*** as a direct effect of exposure to elevated underwater SPLs resulting from impact pile driving and proofing of approximately 1,300 steel piles in Portage Bay, between September 1, 2013, and April 30, 2014, between September 1, 2015, and April 30, 2016, and between September 1, 2017, and April 30, 2018 (approximately 700 working days in total).

    - All adult or subadult bull trout within approximately 72 ft of piling installation operations in Portage Bay (10.2 acres during 2013-14; 6.6 acres during 2015-16; and, 6.6 acres during 2017-18) will be harassed.

10. Incidental take of bull trout in the form of ***harassment*** as a direct effect of exposure to elevated stormwater pollutant concentrations. Effects to surface water quality will last in perpetuity, but exposure and effects to bull trout will be episodic. Harassment will result when dissolved Cu concentrations exceed the sub-lethal neurotoxic threshold of an increase of 2 µg/L over background, or when dissolved Zn concentrations exceed 5.6 µg/L over background.

    - All adult or subadult bull trout within 20 ft of points of stormwater discharge to Lake Union, Portage Bay, Union Bay, and Fairweather Bay (approximately 10 locations in total); and within 70 ft of points of stormwater discharge to Lake Washington (approximately 44 locations in total, along the floating bridge span); in perpetuity, and for the life of the proposed project.

EFFECT OF THE TAKE

In the accompanying Opinion, we determined that the level of anticipated take is not likely to result in jeopardy to the bull trout.

REASONABLE AND PRUDENT MEASURES

The proposed action incorporates design elements and conservation measures which we expect will reduce permanent effects to habitat and avoid and minimize impacts during construction. We expect that the FHWA will fully implement these measures, and therefore they have not been specifically identified as Reasonable and Prudent Measures or Terms and Conditions.

The following reasonable and prudent measures (RPMs) are necessary and appropriate to minimize the impact of incidental take to bull trout:

1. Minimize and monitor incidental take caused by fish entrainment, capture, and handling at the Port of Tacoma CTC casting basin during each of ten casting basin gate openings.

2. Minimize and monitor incidental take caused by elevated turbidity and sedimentation during construction.

3. Minimize and monitor incidental take caused by elevated underwater SPLs from impact driving and proofing of steel piles.

4. Minimize and monitor incidental take caused by elevated stormwater pollutant concentrations.

TERMS AND CONDITIONS

In order to be exempt from the prohibitions of section 9 of the Act, the FHWA must comply with the following terms and conditions, which implement the RPMs described above. These terms and conditions are non-discretionary.

The following terms and conditions are required for the implementation of RPM 1:

1. The FHWA shall ensure that casting basin pump inlets are screened according to criteria outlined by the NMFS (NMFS 1997).

2. The FHWA shall ensure that water quality conditions within the partially dewatered casting basin are adequate to support any entrained bull trout. The operations shall use aerators or air stones, as necessary, to provide for the circulation of clean, cold, well-oxygenated water.

3. The FHWA shall ensure that a qualified biologist oversees implementation of fish capture and handling procedures.

4. In the event that fish capture requires the use of electrofishing equipment, the FHWA shall use the minimum voltage, pulse width, and rate settings necessary to immobilize fish. Use of electrofishing equipment shall conform to WSDOT *Fish Exclusion Protocols and Standards* (WSDOT 2009), and guidelines outlined by the NMFS (NMFS 2000b).

5. The FHWA shall document and report all bull trout encountered during fish capture and handling operations. The FHWA shall submit a monitoring report to the Washington Fish and Wildlife Office in Lacey, Washington (Attn: Transportation Planning Branch), within 30 days of the fish capture and handling operations associated with each casting basin gate opening.

The following terms and conditions are required for the implementation of RPM 2:

1. The FHWA shall monitor turbidity levels in Portage Bay, Union Bay, and Lake Washington during sediment-generating activities. Monitoring shall be conducted at a distance of 150 ft from sediment-generating activities.

2. Monitoring shall be conducted at 30-minute intervals from the start of sediment-generating activities. If turbidities measured over the course of three consecutive 30-minute sample intervals do not exceed 9 NTUs over background, then monitoring of sediment-generating activities will be conducted for the remainder of the workday at a frequency of once every 6 hours, or if there is a visually appreciable increase in turbidity.

3. If, at any time, monitoring conducted 150 ft from sediment-generating activities indicates turbidity in excess of 9 NTUs over background, then monitoring shall instead be conducted at 300 ft from sediment-generating activities. Monitoring shall be conducted at 30-minute intervals until turbidity falls below 9 NTUs over background.

4. If turbidity levels measured at 300 ft from the sediment-generating activity exceed 84 NTUs above background at any time, 40 NTUs above background for more than 1 hour continuously, or 18 NTUs above background for more than 3 hours, cumulatively, over a 18-hour workday, then the amount of take authorized by the Incidental Take Statement will have been exceeded. Sediment-generating activities shall cease, and the FHWA shall contact a consulting biologist with the Transportation Planning Branch at the Washington Fish and Wildlife Office in Lacey, Washington (360-753-9440) within 24 hours.

5. Monitoring shall be conducted to establish background turbidity levels away from the influence of sediment-generating activities. Background turbidity shall be monitored at least twice daily during sediment-generating activities. In the event of a visually appreciable change in background turbidity, an additional sample shall be taken.

6. If, in cooperation with other permit authorities, the FHWA develops a functionally equivalent monitoring strategy (e.g., intensive monitoring, by project area or activity, followed by validation and routine monitoring), they may submit this plan to the Service for review and approval in lieu of the above monitoring requirements. The strategy must be submitted to the Service a minimum of 60 days prior to construction. In order to be approved for use in lieu of the above requirements, the plan must meet each of the same objectives.

7. The FHWA shall submit a monitoring report to the Washington Fish and Wildlife Office in Lacey, Washington (Attn: Transportation Planning Branch), by April 15 following each construction season. The report shall include, at a minimum, the following: (a) dates, times, and locations of construction activities, (b) monitoring results, sample times, locations, and measured turbidities (in NTUs), (c) summary of construction activities and measured turbidities associated with those activities, and (d) summary of corrective actions taken to reduce turbidity.

8. The FHWA shall also copy the Service with any water or sediment quality monitoring data or reports submitted to the Washington State Department of Ecology in satisfaction of related permits. This shall include any water or sediment quality monitoring data collected when constructing mitigation components elsewhere in the Lake Washington watershed (e.g., Cedar River, tributary to Lake Washington; Bear Creek, tributary to Sammamish River; etc.).

The following terms and conditions are required for the implementation of RPM 3:

1. The FHWA shall use a vibratory pile hammer to the fullest extent practicable when installing steel piles below the OHWM.

2. The FHWA shall monitor in-water sound generation and attenuation while installing steel piles with an impact pile hammer.

3. The FHWA shall conduct a performance test of the noise attenuation device, prior to any impact pile driving or proofing. The performance test shall confirm calculated pressures and flow rates at each manifold ring.

4. The FHWA shall ensure that a qualified individual is present during all impact pile driving and proofing operations to observe and report any indications of dead, injured, or distressed fish.

5. The FHWA shall document the effectiveness of the noise attenuation device with hydroacoustic monitoring in Portage Bay and Union Bay (west of Foster island), in Union Bay (east of Foster Island), and, along the east approach. In each of these three areas, the FHWA will perform both routine monitoring and, as necessary, contingency monitoring.

    a. Routine monitoring will document effectiveness of the noise attenuation device and resulting peak sound levels for:

        i. A minimum of five steel piling installed during the initial pile driving activity in each of the three areas; and,

        ii. A minimum of five additional steel piling installed at the mid-point of the piling installation schedule for Portage Bay and Union Bay (west of Foster island); and,

iii. A minimum of five additional steel piling installed at both the mid-point and near completion of the piling installation schedule (10 piles in total) for Union Bay (east of Foster Island); and,

iv. A minimum of five additional steel piling installed at both the mid-point and near completion of the piling installation schedule (10 piles in total) for the east approach.

b. If the pile strike count for four consecutive piles exceeds by 50 percent or more the maximum single pile strike count observed when performing routine monitoring in that area, this shall be indicative of changed pile driving characteristics. The FHWA shall cease pile driving and not restart except with implementation of contingency hydroacoustic monitoring.

c. In each instance of changed pile driving characteristics, contingency hydroacoustic monitoring will document effectiveness of the noise attenuation device and resulting peak sound levels for the next five steel piling.

d. Factors to consider in identifying the piles to be monitored include, but are not limited to bathymetry of the project site, total number of piles to be impact driven and proofed, depth of water, and distance from shore. This monitoring shall document recorded SPLs, and single strike and cumulative SELs, monitored at a distance of 10 meters from the pile at mid-water depth.

6. The FHWA shall contact the Service within 24 hours if the hydroacoustic monitoring indicates that the sound levels will exceed the extent of take exempted in the Biological Opinion. The FHWA shall also contact the Service within 24 hours if they determine that unattenuated pile strikes are necessary to determine baseline sound levels or evaluate effectiveness of the noise attenuation device at locations other than the east approach. The FHWA shall consult with the Service regarding modifications to the proposed action in an effort to reduce the sound levels below the limits of take and continue hydroacoustic monitoring.

7. The FHWA shall submit a monitoring report to the Washington Fish and Wildlife Office in Lacey, Washington (Attn: Transportation Planning Branch), by April 15 following each construction season. The report shall include the following information:

a. Size and type of piles driven and proofed;

b. The impact hammer force used to drive and proof piles;

c. A description of the monitoring equipment;

d. The distance between hydrophone and pile;

e. The depth of the hydrophone;

f. The distance from the pile to the wetted perimeter;

g. The depth of water;

h. The depth into the substrate the pile was driven and proofed;

i. The physical characteristics of the bottom substrate into which the piles were driven and proofed; and

j. The results of the hydroacoustic monitoring, including the frequency spectrum, SPLs, and single-strike and cumulative SEL. The report must also include the ranges and means for peak, rms, and SELs.

The following terms and conditions are required for the implementation of RPM 4:

1. The FHWA shall implement the programmatic approach to stormwater quality monitoring (Programmatic Monitoring Approach for Highway Stormwater Runoff in Support of the Act Section 7 Consultation, dated June 2009). The WSDOT shall accurately characterize stormwater BMP effectiveness and end-of-pipe effluent discharge concentrations for treated and untreated stormwater runoff (total and dissolved Cu; total and dissolved Zn; total suspended solids). Sampling, data collection, analysis, and reporting (including quality control/quality assurance procedures) shall follow requirements from the WSDOT's Municipal Stormwater NPDES (National Pollutant Discharge Elimination System) and State Waste Discharge General Permit. Data and conclusions derived through this programmatic monitoring approach are broadly representative of conditions within the action area, including average daily traffic and temporal variations in stormwater runoff quantity and quality.

2. If the programmatic monitoring results suggest that the analyses included in this Opinion may have underestimated end-of-pipe effluent discharge concentrations or the size of resulting dilution zones, then the FHWA and the Service shall consider jointly any potential change(s) to exposure and effects in listed species and/or their critical habitat, and the need for reinitiation of consultation.

3. If the final, approved stormwater design(s) differ from the design described in this Opinion, then the FHWA shall evaluate potential changes in stormwater pollutant loadings and concentrations. The FHWA shall provide to the Service a description of the design change(s) and a corrected version of the stormwater model analyses. If predicted pollutant loadings, concentrations, or resulting dilution zones exceed those described in this Opinion, the FHWA and the Service shall consider jointly any potential change(s) to exposure and effects, and the need for reinitiation of consultation.

4. The FHWA shall design and build the MOHAI enhanced stormwater treatment facility with a well-integrated stormwater quality monitoring capability. The MOHAI facility shall incorporate design features that facilitate accurate characterization of stormwater BMP effectiveness and end-of-pipe effluent discharge concentrations for treated

stormwater runoff (total and dissolved copper, total and dissolved zinc, and total suspended solids).

5. The FHWA shall provide to the Service a copy of the approved site-specific monitoring and reporting plan for the conditionally-approved AKART enhanced treatment method on the floating bridge span. The FHWA shall also provide a courtesy copy of any required monitoring reports or other documentation submitted to the Washington State Department of Ecology in support and validation of the AKART treatment method. The FHWA shall provide notice to the Service in advance of any plan to deviate from specific elements of the conditionally-approved AKART method (i.e., monthly high-efficiency sweeping and twice-annual catch basin cleaning).

6. The FHWA shall provide to the Service a courtesy copy of any permit application(s), monitoring data, or other documentation provided to the City of Seattle in support of compliance with applicable combined sewer overflow discharge requirements.

7. The FHWA shall submit all documentation in writing to the Washington Fish and Wildlife Office in Lacey, Washington (Attn: Transportation Planning Branch).

We expect that the amount or extent of incidental take described above will not be exceeded as a result of the proposed action. The RPMs, with their implementing terms and conditions, are designed to minimize the impact of incidental take that might otherwise result from the proposed action. If, during the course of the action, this level of incidental take is exceeded, such incidental take represents new information requiring reinitiation of consultation and review of the reasonable and prudent measures provided. FHWA must provide an explanation of the causes of the taking and review with the Service the need for possible modification of the reasonable and prudent measures.

The Service is to be notified within three working days upon locating a dead, injured or sick endangered or threatened species specimen. Initial notification must be made to the nearest U.S. Fish and Wildlife Service Law Enforcement Office. Notification must include the date, time, precise location of the injured animal or carcass, and any other pertinent information. Care should be taken in handling sick or injured specimens to preserve biological materials in the best possible state for later analysis of cause of death, if that occurs. In conjunction with the care of sick or injured endangered or threatened species or preservation of biological materials from a dead animal, the finder has the responsibility to ensure that evidence associated with the specimen is not unnecessarily disturbed. Contact the U.S. Fish and Wildlife Service Law Enforcement Office at (425) 883-8122, or the Service's Washington Fish and Wildlife Office at (360) 753-9440.

CONSERVATION RECOMMENDATIONS

Section 7(a)(1) of the Act directs Federal agencies to utilize their authorities to further the purposes of the Act by carrying out conservation programs for the benefit of endangered and threatened species. Conservation recommendations are discretionary agency activities to minimize or avoid adverse effects of a proposed action on listed species or critical habitat, to help implement recovery plans, or to develop information.

The Service recommends the following to the FHWA:

1. The FHWA should further evaluate the potential stormwater quality benefits of a program of high-efficiency sweeping performed between the west approach high-rise and Montlake Interchange. Long stretches of the Portage and Union Bay bridges and approaches have been designed to convey surface runoff to land-based stormwater treatment facilities for treatment and discharge. However, under conditions exceeding the storm design event, stormwater runoff originating from the Portage and Union Bay bridges and approaches will release through scuppers and direct discharge to the adjacent waters without treatment. High-efficiency sweeping performed at strategic times of year (i.e., after prolonged periods without precipitation, and before the next significant storm event) may provide measurable stormwater quality benefits.

In order for the Service to be kept informed of actions minimizing or avoiding adverse effects or benefiting listed species or their habitats, the Service requests notification of the implementation of any conservation recommendations.

REINITIATION NOTICE

This concludes formal consultation on the action outlined in the request. As provided in 50 CFR section 402.16, reinitiation of formal consultation is required 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 take 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 agency action is subsequently modified in a manner that causes an effect to the listed species or critical habitat not considered in this opinion; or (4) a new species is listed or critical habitat designated that may be affected by the action. In instances where the amount or extent of incidental take is exceeded, any operations causing such take must cease pending reinitiation.

LITERATURE CITED

Abbott, R.R., E. Bing-Sawyer, and R. Blizard. 2002. Assessment of pile driving impacts on the Sacramento blackfish (*Orthodon microlepidotus*). Caltrans, Administrative draft, Oakland, California, October 10, 2002. 16 pp.

Abbott, R.R., J.A. Reyff, and G. Marty. 2005. Monitoring the effects of conventional pile driving on three species of fish. Strategic Environmental Consulting for Manson Construction Company, Final Report, Richmond, California, April 8, 2005. 131 pp.

Aitkin, J.K. 1998. The importance of estuarine habitats to andradromous salmonids of the Pacific Northwest: a literature review. U.S. Fish and Wildlife Service Western Washington Office Aquatic Resources Division Puget Sound Program, Lacey, Washington, August 1998. 25 pp.

Anderson, B.C., W.E. Watt, and J. Marsalek. 2002. Critical issues for stormwater ponds: learning from a decade of research. Water Science and Technology 45(9):277-283.

Armstrong, R.H. 1965. Some feeding habits of the anadromous Dolly Varden Salvelinus malma (Walbaum) in southeastern Alaska. Dept. of Fish and Game, Juneau. 27 pp.

Bailey, A., H. Berry, and B. Bookheim. 1988. Probability-based estimation of nearshore habitat characteristics. *In* Proceedings of Puget Sound Research '98 Conference, Seattle, WA, Washington State Department of Natural Resources, Olympia, WA. 13 pp.

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.

Ballinger, D. 2000. Quan, J. Lummi Indian fisheries beach seine data for Dolly Varden / bull trout. 12/10/2000.

Barton, B.A., and G.K. Iwama. 1991. Physiological changes in fish from stress in aquaculture with emphasis on the response and effects of corticosteroids. Annual Review of Fish Diseases 1:3-26.

Bash, J., C.H. Berman, and S. Bolton. 2001. Effects of turbidity and suspended solids on salmonids. Center for Streamside Studies, University of Washington, Seattle, WA, November 2001. 72 pp.

Baun, A., A.M. Christensen, and F. Nakajima. 2003. Ecotoxic effects of wet weather discharges in an urban stream. Pages 4-1; 4-5 *In* Diffuse Pollution Conference, .

Bennie, D.T. 1999. Review of the environmental occurrence of alkylphenols and alkylphenols ethoxylates. Water Quality Resources Journal of Canada 34(1):79-122.

Berg, L., and T.G. Northcote. 1985. Changes in territorial, gill-flaring, and feeding behavior in juvenile coho salmon (*Oncorhynchus kisutch*) following short-term pulses of suspended sediment. Canadian Journal of Fisheries and Aquatic Sciences 42:1410-1417.

Berge, H.B. 2003. 5/13/2003 record of telephone conversation with Hans Berge, fisheries biologist, King County DNR, regarding native char captured during beach seining efforts in 2001 and 2002.

Berge, H.B., and B.V. Mavros. 2001. King County Bull Trout Program: 2000 Bull trout surveys. King County Department of Natural Resources, Seattle, Washington, June 2001. 42 pp.

Bloch, P. 2011a. McReynolds, R. Communication between Phil Bloch and Ryan McReynolds re: findings from the 520 bridge replacement limnological investigation. 04/15/2011.

Bloch, P. 2011b. McReynolds, R. Communication from Phil Bloch to Ryan McReynolds re: column demolition and unattenuated pile strikes. 04/07/2011.

Bloch, P. 2011c. McReynolds, R., and M. Lisitza. Email from Phil Block to Ryan McReynolds and Mike Lisitza concerning the aquatic mitigation Taylor Creek mitigation site. 02/25/2011.

Bloch, P. 2011d. McReynolds, R., and M. Lisitza. Email from Phil Block to Ryan McReynolds and Mike Lisitza concerning the test pile bubble curtain specification. 02/25/2011.

BMSL, Pentec Environmental, Striplin Environmental Associates Inc, I. Shapiro and Associates, and King County Department of Natural Resources. 2001. Reconnaissance assessment of the state of the nearshore ecosystem: eastern shore of central Puget Sound, including Vashon and Maury Islands (WRIA 8 and 9). Prepared for King County Department of Natural Resources, Seattle, Washington.

Booth, D.B. 2000. Forest cover, impervious-surface area, and the mitigation of urbanization impacts in King County, Washington. Journal of the American Water Resources Association 38(3):835-845.

Booth, D.B., D. Hartley, and R. Jackson. 2002. Forest cover, impervious-surface area, and the mitigation of stormwater impacts. Journal of the American Water Resources Association 38(3):835-845.

Booth, D.B., J.R. Karr, S. Schauman, C.P. Konrad, S.A. Morely, M.G. Larson, P.C. Henshaw, E.J. Nelson, and S.J. Burges. 2001. Urban stream rehabilitation in the Pacific Northwest. The Washington Water Resource 12(1):11.

Bostick, B.C., A.J. Hansen, M.J. La Guardia, and S.E. Fendorf. 1998. Zinc local structure and partitioning within a contaminated wetland.1998 SSRL Activity Report. Dept of Geological and Environmental Science, Stanford University, Proposal 2519M, Stanford, CA. 8 pp.

Brown, A.M. 1998. Shoreline residential development and physical habitat influences on fish density at the lake edge of Lake Joseph, Ontario. Master's thesis. University of Toronto, Ottawa, ON. 74 pp.

Bryan, M.D., and D.L. Scarnecchia. 1992. Species richness, composition, and abundance of fish larvae and juveniles inhabiting natural and developed shorelines of a glacial Iowa lake. Environmental Biology of Fishes 35:329-341.

Burton, G.A., R. Pitt, and S. Clark. 2000. The role of traditional and novel toxicity test methods in assessing stormwater and sediment contamination. Critical Reviews in Environmental Science and Toxicology 30(4):413-447.

CALTRANS. 2007. Update on Recommendations for Revised Interim Sound Exposure Criteria for Fish during Pile Driving Activities. CALTRANS, CALTRANS-Arlington Memo Update 12-21-07, Arlington, VA, December 21, 2007. 8 pp.

Carlson, T.J., G. Ploskey, R.L. Johnson, R.P. Mueller, M.A. Weiland, and P.N. Johnson. 2001. Observations of the behavior and distribution of fish in relation to the Columbia River navigation channel and channel maintenance activities. U.S. Army Corps of Engineers, PNNL-13595, Portland, Oregon, October 2001. 38 pp.

Carr, R.S., P.A. Montagna, J.M. Biedenbach, R. Kalke, M.C. Kennicutt, R. Hooten, and G. Cripe. 2000. Impact of storm-water outfalls on sediment quality in Corpus Christi Bay, Texas, USA. Environmental Toxicology and Chemistry 19(3):561-574.

Castle, P. 2003. Chan, J. Phone record 06/12/03 regarding bull trout observations in marine areas. 06/12/2003.

CDPR, and J. Schuette. 1998. Environmental fate of glyphosate. Environmental Monitoring & Pest Management, Sacramento, CA, November 1998. 13 pp.

Cederholm, C.J., and L.M. Reid. 1987. Impact of forest management on coho salmon (*Oncorhynchus kisutch*) populations of the Clearwater River, Washington: A project summary. Pages 373-398 *In* E.O. Salo, and T.W. Cundy, eds. Streamside management: Forestry and fishery interactions. University of Washington Institute of Forest Resource Contribution 57.

Celedonia, M.T., R.A. Tabor, S. Sanders, S. Damm, T.M. Lee, D.W. Lantz, Z. Li, J. Pratt, B. Price, and L. Seyda. 2008. Movement and habitat use of Chinook salmon smolts, northern pikeminnow, and smallmouth bass near the SR 520 Bridge - 2007 acoustic tracking study. U.S. Fish and Wildlife Service, Lacey, Washington, October, 2008. 139 pp.

Celedonia, M.T., R.A. Tabor, S. Sanders, S. Damm, T.M. Lee, D.W. Lantz, Z. Li, J. Pratt, B. Price, and L. Seyda. 2009. Movement and habitat use of Chinook salmon smolts, northern pikeminnow, and smallmouth bass near the SR 520 Bridge - 2008 acoustic tracking study. U.S. Fish and Wildlife Service, Lacey, Washington, October, 2009. 139 pp.

Celedonia, M.T., R.A. Tabor, S. Sanders, D.W. Lantz, and J. Grettenberger. 2008. Movement and habitat use of Chinook salmon smolts and two predatory fishes in Lake Washington and the Lake Washington Ship Canal - 2004-2005 acoustic tracking study. U.S. Fish and Wildlife Service, Lacey, Washington. 129 pp.

Chalmers, A.T., P.C. Van Metre, and E. Callender. 2007. The chemical response of particle-associated contaminants in aquatic sediments to urbanization in New England, U.S.A. Journal of contaminant hydrology 91(1-2):4-25.

Chen, W., S.K. Tan, and J.H. Tay. 1996. Distribution, fractional composition and release of sediment-bound heavy metals in tropical reservoirs. Water, Air, & Soil Pollution 92(3-4):273-287.

City of Seattle, and USACE. 2008. Synthesis of salmon research and monitoring, investigation conducted in the Western Lake Washington Basin. Seattle Public Utilities and US Army Corps of Engineers, Seattle Division, Seattle, Washington.

Clark, C.W., and D.A. Levy. 1988. Diel vertical migrations by juvenile sockeye salmon and the antipredation window. The American Naturalist 131(2):271-290.

Cook, P.M., Fredenberg, W., Lawsonn, M., Loeffler, I.K., Andreasen, E., andPeterson, R.E. 1999. Early life stage toxicity of 2,3,7,8-Tetrachlorodibenzodioxin (TCDD) and PCB 126 to bull trout. Abstract of draft manuscript.

Crum, L.A., and Y. Mao. 1996. Acoustically enhanced bubble growth at low frequencies and its implications for human diver and marine mammal safety. Journal of the Acoustical Society of America 99(5):2898-2907.

CSTEE. 1999. CSTEE Opinion on human and wildlife health effects on endocrine disrupting chemicals, with emphasis on wildlife and on ecotoxicology test methods. Consumer Policy and Consumer Health Protection. 96 pp.

Currence, N. 2003. Chan, J. Whatcom and Squalicum Creek char and descriptions for review, floy tag in lower Fraser. 01/22; 2003/01.

Daughton, C.G., and T. Ternes. 1999. Pharmaceuticals and personal care products in the environment: agents of subtle change? Environmental health perspectives 107(6):907-938.

Davidson, M. 2004. Transmission loss, 8. Available: http://freespace.virgin.net/mark.davidson3/TL/TL.html. (2005).

Eisler, R. 1993. Zinc hazards to fish, wildlife, and invertebrates: a synoptic review. United States Fish and Wildlife Service, Patuxent Wildlfe Research Center, Biological Report 10, Laurel, Maryland, April 1993. 106 pp.

Eisler, R. 1998. Copper hazards to fish, wildlife, and invertebrates: a synoptic review. Biological Resources Division, U.S. Geological Survey, Biological Science Report USGS/BRD/BSR--1997-0002, Laurel, MD, January 1998. 120 pp.

Ellis, J.B. 2000. Risk assessment approaches for ecosystem responses to transient pollution events in urban receiving waters. Chemosphere 41(1-2):85-91.

EVS Environment Consultants, I. 1999. Cherry Point screening level ecological risk assessment, EVS porject no. 2/868-01.1, July 1999.

Fan, C., R. Field, W.C. Pisano, J. Barsanti, J.J. Joyce, and H. Sorenson. 2001. Sewer and tank flushing for sediment, corrosion, and pollution control; Mini-symposium on urban drainage. Journal of Water Resources Planning and Management 127(3):194-201.

Fayram, A., and T.H. Sibley. 2000. Impact of predation by smallmouth bass on sockeye salmon in Lake Washington, Washington. North American Journal of Fisheries Management 20:81-89.

Feist, B.E., J.J. Anderson, and R. Miyamoto. 1992. Potential impacts of pile driving on juvenile pink (*Onchorhynchus gorbuscha*) and chum (*O. keta*) salmon behavior and distribution. University of Washington, Seattle, WA, May 1992. 58 pp.

Fewtrell, J.L. 2003. The response of marine finfish and invertebrates to seismic survey noise. Doctoral dissertation. Curtin University of Technology, Perth, Australia.

FHWA, Mathis, D.M., andEverett, R. 2011. USFWS, and K. Berg. Communication from Daniel M. Mathis to Ken Berg answering his questions regarding the State Route 520, Interstate-5 to Medina Bridge replacement and HOV project biological assessment (BA).

FHWG. 2008. Agreement in principle for interim criteria for injury to fish from pile driving activities. Fisheries Hydroacoustic Working Group, June 12, 2008. 3 pp.

Fitzpatrick, K.C. 2010. White, J. Memo from Kevin C. Fitzpatrick to John White concerning WDOE's conditional approval of WSDOT's AKART and water quality studies report.

Folmar, L.C. 1976. Overt avoidance reaction of rainbow trout fry to nine herbicides. Bulletin of Environmental Contamination and Toxicology 15(5):509-514.

Footen, B. 2000. Preliminary results of an investigation into the impacts of piscivorous predation on juvenile Chinook (*Oncorynchus tshawytscha*) and other salmonids in Salmon and Shilshole Bays, King County, Washington. King County Department of Natural Resources, 2000 Lake Washington Chinook Salmon Workshop, Auburn, WA. 10 pp.

Footen, B. 2003. Piscivorous impacts on Chinook (*Oncorhynchus tshawytscha*) and other salmonids in Salmon and Shilshole Bay, King County, Washington. 2003 Greater Lake Washington Chinook Workshop, 2003. 19 pp.

Foster, I.D.L., and S.M. Charlesworth. 1996. Heavy metals in the hydrological cycle: Trends and explanation. Hydrological Processes 10(2):227-261.

Fresh, K.L., D. Rabin, C.A. Simenstad, E.O. Salo, K. Garrison, and L. Matheson. 1979. Fish ecology studies in the Nisqually Reach Area of Southern Puget Sound, Washington. University of Washington, FRI-UW-7904, Seattle, WA, February 1979. 246 pp.

Fresh, K.L., E. Warner, R.A. Tabor, and D. Houck. 1999. Migratory behavior of adult Chinook salmon spawning in the Lake Washington Watershed in 1988 and 1999 as determined with ultrasonic telemetry. King County Wastewater Treatment Division, Draft Progress Report, Seattle, Washington, October, 1999. 35 pp.

Frisch, A.J., and T.A. Anderson. 2000. The response of coral trout (*Plectropomus leopardus*) to capture, handling and transport and shallow water stress. Fish Physiology and Biochemistry 23(1):23-24.

Ghanmi, Z., M. Rouabhia, O. Othmane, and P.A. Deschaux. 1989. Effects of metal ions on cyprinid fish immune response: invitro effects of Zn2+ and Mn2+ on the mitogenic response of carp pronephros lymphocytes. Ecotoxicology and Environmental Safety 17(2):183-189.

Gisiner, R.C., E. Cudahy, G.V. Frisk, R. Gentry, R. Hofman, A.N. Popper, and J.W. Richardson. 1998. Effects of anthropogenic noise in the marine environment. Pages 1-141 *In* Gisiner, R.C. ed. Workshop on the effects of anthropogenic noise in the marine environment, February 10-12, 1998, Marine Mammal Science Program, Office of Naval Research, Arlington, VA. 141 pp.

Glenn, D., L. Dingfang, and J. Sansalone. 2002. Influence of chemistry, hydrology and suspended solids on partitioning of heavy metals to particles - considerations for in-situ control of urban stormwater quality, Louisiana State University.

Goetz, F. 2003. Chan, J. Re: Ballard ladder observation. 08/18; 2003/08.

Goetz, F. 2003. Example of a couple of fish migrating from Port Susan/Everett to Skagit, .

Gotceitas, V., and P. Colgan. 1989. Predator Foraging Success and Habitat Complexity: Quantitative Test of the Threshold Hypothesis. Oecologia 80(2):pp. 158-166.

Grant, S.B., N.V. Rekhi, N.R. Pise, R.L. Reeves, M. Matsumoto, A. Wistrom, L. Moussa, and S. Bay. 2003. A review of the contaminants and toxicity associated with particles in stormwater runoff. CALTRANS (California Department of Transportation), CTSW-RT-03-059.73.15, Sacramento, CA 95826. 172 pp.

Guiney, P.D., P.M. Cook, J.D. Fitzsimmons, H.A. Simonin, E.W. Zabel, and R.E. Peterson. 1996. Assessment of 2,3,7,8-tetracholorodibenzo-p-dioxin induced sac fry mortality in lake trout (*Salvelinus namavcush*) from different regions in the Great Lakes. Canadian Journal of Fisheries and Aquatic Sciences 53(9):2080-2092.

Hallberg, M., G. Renman, and T. Lundbom. 2007. Seasonal variations of ten metals in highway runoff and their partition between dissolved and particulate matter. Water, Air, and Soil Pollution 181:183-191.

Hansen, J.A., P.G. Welsh, J. Lipton, D. Cacela, and A.D. Dailey. 2002. Relative sensitivity of bull trout (*Salvelinus confluentus*) and rainbow trout (*Oncorhynchus mykiss*) to acute exposures of cadmium and zinc. Environmental Toxicology and Chemistry 21(1):67-75.

Hastings, M.C. 2002. Clarification of the meaning of sound pressure levels and the known effects of sound on fish. Ohio State University, Columbus, Ohio, August 26, 2002. 6 pp.

Hastings, M.C., and A.N. Popper. 2005. Effects of sound on fish. California Department of Transportation, Contract No. 43A0139, Task Order, 1, Sacramento, CA, January 28, 2005. 82 pp.

Hawkins, A.D., and A.D.F. Johnstone. 1978. The hearing of the Atlantic Salmon, *Salmo salar*. Journal of Fish Biology 13(6):655-673.

Heintz, R.A., S.D. Rice, A.C. Wertheimer, R.F. Bradshaw, F.P. Thrower, J.E. Joyce, and J.W. Short. 2000. Delayed effects on growth and marine survival of pink salmon *Oncorhynchus gorbuscha* after exposure to crude oil during embryonic development. US National Marine Fisheries Service, Auke Bay Laboratory, 205-216, Juneau, Alaska, December 08, 2000. 12 pp.

Helfman, G.S. 1981. The advantage to fish of hovering in shade. Copeia 1981(2):392-400.

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.

Herngren, L., A. Goonetilleke, and G.A. Ayoko. 2005. Understanding heavy metal and suspended solids relationships in urban stormwater using simulated rainfall. Journal of Environmental Management 76(2):149-158.

Herrera Environmental Consultants. 2007. Untreated highway runoff in Western Washington, May 16, 2007. 66 pp.

Hilmy, A.M., N.A. Eldomiaty, A.Y. Daabees, and H.A.A. Latife. 1987a. Some physiological and biochemical indices of zinc toxicity in 2 fresh-water fishes, Clarias lazera and Tilapia zilli. Comparative Biochemistry and Physiology, C. 87C(2):297-301.

Hilmy, A.M., N.A. Eldomiaty, A.Y. Daabees, and H.A.A. Latife. 1987b. Toxicity in *Tilapia zilli* and *Clarias lazera* (*Pisces*) induced by zinc, seasonally. Comparative Biochemistry and Physiology, C. 86C(2):263-265.

Hodgson, S., T.P. Quinn, R. Hilborn, R.C. Francis, and D.E. Rogers. 2006. Marine and freshwater climatic factors affecting interannual variation in the timing of return migration to fresh water of sockeye salmon (*Oncorhynchus nerka*). Fisheries Oceanography 15(1):1-24.

Hodson, P.V. 1988. Effect of metal metabolism on uptake, disposition, and toxicity in fish. Aquatic Toxicology 11(1-2):3-18.

Hutchinson, I. 1988. Estuarine marsh dynamics in the Puget trough-implications for habitat management. Pages 455-462 *In* Proceedings first annual meeting on Puget Sound research, .

Illingworth & Rodkin. 2010. Underwater sound levels associated with driving steel piles for the State Route 520 bridge replacement and HOV project installation test program. Illingworth & Rodkin, Inc., Final, Petaluma, CA, March 2010. 143 pp.

John, D.A., and J.S. Leventhal. 1995. Bioavailability of metals; Preliminary compilation of descriptive geoenvironmental mineral deposit models. U. S. Geological Survey, Reston, VA, United States (USA), OF 95-0831, United States (USA).

Jonsson, B., N. Jonsson, K. Hindar, T.G. Northcote, and S. Engen. 2008. Asymmetric competition drives lake use of coexisting salmonids. Oecologia 157(4):553-560.

Kahler, T., M. Grassley, and D.A. Beauchamp. 2000. A summary of the effects of bulkheads, piers, and other artificial structures and shorezone development on ESA-listed salmonids in lakes. The Watershed Company, Final Report, Kirkland, WA, July 13, 2000. 78 pp.

Karr, J.R., and E.W. Chu. 2000. Sustaining living rivers. Hydrobiologia 422/423:1-14.

Kayhanian, M., A. Singh, C. Suverkropp, and S. Borroum. 2003. Impact of annual average daily traffic on highway runoff pollutant concentrations. Journal of Environmental Engineering-Asce 129(11):975-990.

KCDNRP. 2000. Literature review and recommended sampling protocol for bull trout in King County, Final Draft, Seattle, Washington, May 2000.

KCDNRP. 2002. King County bull trout program: 2001 bull trout surveys, freshwater and marine nearshore. Prepared by Talylor Associates, Inc, Seattle, Washington, October 2002. 32 pp.

KCDNRP, and WSCC. 2000. Habitat limiting factors and reconnaissance assessment report: Green/Duwamish and central Puget Sound watersheds (water resource inventory area 9 and Vashon Island) executive summary, Olympia and Seattle, Washington.

Kerwin, J. 2001. Salmon and steelhead habitat limiting factors report for the Cedar-Sammamish Basin (water resource inventory area 8). Washington Conservation Commission, Olympia, Washington, September 2001. 31 pp.

King County. 1995. Cedar River draft basin and nonpoint pollution action plan. King County Dept. of Public Works, Surface Water Management Division.

King County. 2010. Sediment monitoring for streams and rivers, Available: http://green.kingcounty.gov/wlr/waterres/streamsdata/sedimentguidelines.aspx. (03/31/2011).

Klein, R.D. 1979. Urbanization and stream quality impairment. Water Resources Bulletin 15:948-963.

Knudsen, F.R., P.S. Enger, and O. Sand. 1992. Awareness reactions and avoidance responses to sound in juvenile Atlantic salmon, *Salmo salar* L. Journal of Fish Biology 40(4):523-534.

Knudsen, F.R., C.B. Schreck, S.M. Knapp, P.S. Enger, and O. Sand. 1997. Infrasound produces flight and avoidance responses in Pacific juvenile salmonids. Journal of Fish Biology 51(4):824-829.

Kraemer, C. 1994. Some observations on the life history and behavior of the native char, dolly varden (*Salvelinus malma*) and bull trout (*Salvelinus confluentus*) of the north Puget Sound region. Washington Department of Fish and Wildlife, Olympia, WA.

Kraemer, C. 2003. Management brief: Lower Skagit bull trout, age and growth information developed from scales collected from anadromous and fluvial char. Washington Department of Fish and Wildlife, Olympia, WA, January 1, 2003. 16 pp.

Kubena, K. 1998. Rounding up the facts about rodeo: an evaluation of non-target effects on estuarine invertebrates and juvenile salmonids. Master's Thesis. University of Washington, Seattle,WA.

Lester, D.C., and D. Wilson. 2002. Sediment quality evaluation in an urban lake - Lake Sammamish, Washington. *In* Droscher, T. ed. Proceedings of the 2001 Puget Sound Research Conference, February 12-14, 2001, Puget Sound Action Team, Olympia, WA.

Levings, C.D., and R.M. Thom. 1994. Habitat changes in Georgia Basin: implications for resource management and restoration. Pages 330-349 *In* Wilson, R.C.H., R.J. Beamish, F. Aitkens and J. Bell eds. BC/Washington symposium on the marine environment, January 13-14, 1994, Minister of Supply and Services Canada.

Littel, J.S., M. McGuire Elsner, L.W. Binder, and A.K. Snover. 2009. The Washington climate change impacts assessment: evaluating Washington's future in a changing climate. Climate Impacts Group, University of Washington, Seattle, Washington.

Lloyd, R. 1987. Special tests in aquatic toxicity for chemical mixtures: Interactions and modifications of response by variation of physicochemical conditions. Pages 491-507 *In* V.B. Vouk, G.C. Butler, A.C. Upton, D.V. Parke, and S.C. Asher, eds. Methods for assessing the effects of mixtures of chemicals, John Wiley & Sons, New York.

MacDonald, D.D., and C.G. Ingersoll. 2002. A guidance manual to support the assessment of contaminated sediments in freshwater ecosystems. Volume I - An Ecosystem-Based Framework for Assessing and Managing Contaminated Sediments. USEPA, EPA-905-B02-001-A, Chicago, Illinois, December 2002. 149 pp.

MacDonald, D.D., C.G. Ingersoll, and T.A. Berger. 2000. Development and evaluation of consensus-based sediment quality guidelines for freshwater ecosystems. Archives of Environmental Contamination and Toxicology 39(1):20-31.

Malcom, R. 2000. Muckleshoot Indian Tribe Fisheries Division. Personal communication, telephone conversation with Tom Kahler (The Watershed Company), 22 November 1999, and 13 April 2000.

Maltby, L., D.M. Forrow, A.B.A. Boxall, P. Calow, and C.I. Betton. 1995. The effects of motorway runoff on freshwater ecosystems: 1. Field study. Environmental Toxicology and Chemistry 14(6):1079-1092.

Mantua, N., I. Tohver, and A. Hamlet. 2009. Impacts of climate change on key aspects of freshwater salmon habitat in Washington State, Final (3.3.09). 56 pp.

Marsalek, J., B.C. Anderson, and W.E. Watt. 2002. Suspended particulate in urban stormwater ponds: physical, chemical and toxicological characteristics. ASCE, September 8, 2002. 12 pp.

Marsalek, J., B. Brownlee, T. Mayer, S. Lawal, and G.A. Larkin. 1997. Heavy metals and PAHs in stormwater runoff from the Skyway Bridge, Burlington, Ontario. Water Quality Research Journal of Canada 32(4):815-827.

Marsalek, J., Q. Rochfort, B. Brownlee, T. Mayer, and M.R. Servos. 1999. An exploratory study of urban runoff toxicity. Water Science and Technology 39(12):33-39.

Marsalek, J., W.E. Watt, and B.C. Anderson. 2006. Trace metal levels in sediments deposited in urban stormwater management facilities. Water Science & Technology 53(2):175-183.

May, C.W., R.R. Horner, J.R. Karr, B.W. Mar, and E.B. Welch. 1997. Effects of urbanization on small streams in the Puget Sound lowland ecoregion. Watershed Protection Techniques 2(4):483-494.

Mazur, M.M., and D.A. Beauchamp. 2003. A comparison of visual prey detection among species of piscivorous salmonids: effects of light and low turbidities. Environmental Biology of Fishes 67(4):397-405.

MBTSG. 1998. The relationship between land management activities and habitat requirements of bull trout. Montana Fish, Wildlife, and Parks, Helena, MT, May 1998. 77 pp.

McCarthy, S.G., J.P. Incardona, and N.L. Scholz. 2008. Coastal storms, toxic runoff, and the sustainable conservation of fish and fisheries. Pages 7-27 *In* Proceedings of the American Fisheries Society/Sea Grant Symposium, 2008, American Fisheries Society, Bethesda, MD. 21 pp.

McPhail, J.D., and J.S. Baxter. 1996. A review of bull trout (*Salvelinus confluentus*) life-history and habitat use in relation to compensation and improvement opportunities. Department of Zoology, University of British Columbia, Fisheries Management Report Number 104, Vancouver, BC. 31 pp.

Mesa, M.G. 1994. Effects of multiple acute stressors on the predator avoidance ability and physiology of juvenile Chinook salmon. Transactions of the American Fisheries Society 123(5):786-793.

Morely, S.A., and J.R. Karr. 2002. Assessing and restoring the health of urban streams in the Puget Sound Basin. Conservation Biology 16(6):1498-1509.

Moshenberg, K.L. 2004. A sediment triad analysis of Lake Sammamish, Washington. King County Department of Natural Resources and Parks, Seattle, WA, 2004. 29 pp.

Mueller, R.P., D.A. Neitzel, and W.V. Mavros. 1998. Evaluation of low and high frequency sound for enhancing fish screening facilities to protect outmigrating salmonids. U.S. Department of Energy, Bonneville Power Administration, BPA Report DOE/BP-62611-13, Portland, Oregon, February 1998. 26 pp.

Muthukrishnan, S., and A. Selvakumar. 2006. Evaluation of retention pond and constructed wetland BMPs for treating particulate-bound heavy metals in urban stormwater runoff. *In* Muthukrishnan, S. and A. Selvakumar eds. 2006 World Environmental and Water Resources Congress 2006: Examining the Confluence of Environmental and Water Concerns, May 21 -25, 2006, World Environmental and Water Resources Congress, Omaha, Nebraska. 13 pp.pp.

Nedwell, J., and B. Edwards. 2002. Measurements of underwater noise in the Arun River during piling at County Wharf, Littlehampton. Subacoustech Ltd, Report No. 513 R 0108, Hampshire, UK, August 01, 2002. 25 pp.

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.

Newcombe, C.P., and D.D. MacDonald. 1991. Effects of suspended sediments on aquatic ecosystems. North American Journal of Fisheries Management 11(1):72-82.

Newell, J.C., and T.P. Quinn. 2005. Behavioral thermoregulation by maturing adult sockeye salmon (Oncorhynchus nerka) in a stratified lake prior to spawning. Canadian journal of zoology 83(9):1232-1239.

Niyogi, S., P. Couture, G. Pyle, D.G. McDonald, and C.M. Wood. 2004. Acute cadmium biotic ligand model characteristics of laboratory-reared and wild yellow perch (*Perca flavescens*) relative to rainbow trout (*Oncorhynchus mykiss*). Canadian Journal of Fisheries and Aquatic Sciences 61:942-953.

NMFS. 1997. Fish screening criteria for anadromous salmonids, Available: http://swr.nmfs.noaa.gov/hcd/fishscrn.htm. (11/18/2010).

NMFS. 2000a. Biological opinion on the reinitiation of consultation on operation of the Federal Columbia River Power System, including the juvenile fish transportation program, and 19 Bureau of Reclamation projects in the Columbia Basin. Northwest Region, National Marine Fisheries Service, 1990/01902, Seattle, WA, December 21, 2000. 648 pp.

NMFS. 2000b. Guidelines for electrofishing waters containing salmonids listed under the Endangered Species Act. National Marine Fisheries Service, Portland, Oregon, June 2000. 5 pp.

NMFS. 2000c. Status review of Pacific hake, Pacific cod, and walleye pollock from Puget Sound Washington.

NMFS. 2008. Endangered Species Act – Section 7 Consultation Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Consultation - Operation and Maintenance of the Lake Washington Ship Canal Lower Sammamish River 171100120301, Cedar River 171100120302 and Shell Creek 171100190401. NMFS, 2001-01298, Seattle, WA, March 31, 2008. 75 pp.

Northcote, T.G. 1995. Confessions from a four decade affair with dolly varden: a synthesis and critique of experimental tests for interactive segregation between dolly varden char (Salvelinus malma) and cutthroat trout (Oncorhynchus clarki) in British Columbia. Nordic Journal of Freshwater Resources 71:49-67.

Nowak, G.M., R.A. Tabor, E.J. Warner, K.L. Fresh, and T.P. Quinn. 2004. Ontogenetic shifts in habitat and diet of cutthroat trout in Lake Washington, Washington. North American Journal of Fisheries Management 24(2):624-635.

Packman, J.J., K.J. Comings, and D.B. Booth. 1999. Using turbidity to determine total suspended solids in urbanizing streams in the Puget lowlands. University of Washington, Seattle, Washington. 11 pp.

Pettersson, T.J.R. 2002. Characteristics of suspended particles in a small stormwater pond. Urban Drainage 2002, ASCE Publications 2004. 12 pp.

Pickering, A.D., T.G. Pottinger, and P. Christie. 1982. Recovery of the brown trout, *Salmo trutta* L., from acute handling stress: a time-course study. Journal of Fish Biology 20:229-244.

PIE (Pacific International Engineering). 1999. Catch summary of anadromous trout in Commencement Bay, Tacoma, Washington. Summary of four beach seine and three townet studies and one trammel net study from 1980-1999.

Playle, R.C. 2004. Using multiple metal-gill binding models and the toxic unit concept to help reconcile multiple-metal toxicity results. Aquatic Toxicology 67(4):359-370.

Popper, A.N. 2003. Effects of anthropogenic sounds of fishes. Fisheries 28(10):24-31.

Popper, A.N., T.J. Carlson, A.D. Hawkins, B.L. Southall, and R. Gentry. 2006. Interim criteria for injury of fish exposed to pile driving operations: A white paper, pile driving Interim Criteria 5-13-06, May 13, 2006. 15 pp.

PSWQAT. 2000. 2000 Puget Sound update: seventh report of the Puget Sound ambient monitoring program, Olympia, Washington.

Puget Sound Water Quality Authority. 1987. 1987 Puget Sound water quality management plan. Puget Sound Water Quality Authority, Seattle, WA.

Quinn, T.P., J.A. Peterson, V.F. Gallucci, W.K. Hershberger, and E.L. Brannon. 2002. Artificial selection and environmental change: countervailing factors affecting the timing of spawning by coho and chinook salmon. Transactions of the American Fisheries Society 131(4):591-598.

Rhoads, B.L., and R.A. Cahill. 1999. Geomorphological assessment of sediment contamination in an urban stream system. Applied Geochemistry 14(4):459-483.

Roos, J.F. 1959. Feeding Habits of the Dolly Varden, Salvelinus malma (Walbaum), at Chignik, Alaska. Transactions of the American Fisheries Society 88(4):253-260.

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 & Technology 41(8):2998-3004.

Santulli, A., A. Modica, C. Messina, L. Ceffa, A. Curatolo, G. Rivas, G. Fabi, and V. D'Amelio. 1999. Biochemical responses of European sea bass (*Dicentrarchus labrax* L.) to the stress induced by off shore experimental seismic prospecting. Marine Pollution Bulletin 38(12):1105-1114.

Schmitt, C., J. Schweigert, and T.P. Quinn. 1994. Anthropogenic influences on fish populations of the Georgia Basin. Pages 218-255 *In* Wilson, R.C.H., R.J. Beamish, F. Aitkens and J. Bell eds. BC/Washington symposium on the marine environment, January 13-14, 1994, Minister of Supply and Services Canada.

Schueler, T.R. 1987. Controlling urban runoff: A practical manual for planning and design of urban BMPs. Metropolitan Washington Council of Governments, Washington, D.C. 275 pp.

Scoggins, M., N.L. McClintock, L. Gosselink, and P. Bryer. 2007. Occurrence of polycyclic aromatic hydrocarbons below coal-tar-sealed parking lots and effects on stream benthic macroinvertebrate communities. Journal of the North American Benthological Society 26(4):694-707.

Servos, M.R. 1999. Review of the aquatic toxicity, estrogenic responses and bioaccumulation of Alkylphenol and Alklyphenol Polyethoxylates. Water Quality Resources Journal of Canada 34(1):123-177.

Shaffer, A.J. 1998. Kelp bed habitats of the inland waters of Western Washington. Pages 353-362 *In* Puget Sound Research '98 proceedings, March 12 & 13, 1998, Puget Sound Water Quality Action Team, Olympia, WA.

Shepard, M.F., and R.G. Dykeman. 1977. A study of the aquatic biota and some physical parameters of Lake Washington in the vicinity of the Shuffleton Power Plant, Renton, Washington 1975-1976. Washington Cooperative Fishery Research Unit, College of Fisheries, University of Washington, Seattle, WA.

Shin, H.O. 1995. Effect of the piling work noise on the behavior of snakehead (*Channa argus*) in the aquafarm. Journal of the Korean Fisheries Society 28(4):492-502.

Simenstad, C.A., and B.E. Feist. 1996. Restoration potential of diked estuarine wetlands: inferring fate and recovery rate of historically-breached sites. U.S. Environmental Protection Agency, 910/R-96-005, Seattle, Washington, July 1996. 14 pp.

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. Pages 343-364 *In* V.S. Kennedy, ed. Estuarine comparisons, Academic Press.

Smith, S.L., D.D. MacDonald, K.A. Keenleyside, C.G. Ingersoll, and L.J. Field. 1996. A preliminary evaluation of sediment quality assessment values for freshwater ecosystems. Journal of Great Lakes Research 22(3):624-638.

Sprague, J.B. 1964. Avoidance of copper-zinc solutions by young salmon in the laboratory. Journal - Water Pollution Control Federation 36:990-1004.

Sprague, J.B. 1968. Avoidance reactions of rainbow trout to zinc sulfate solutions. Water Research 2:367-372.

Sprague, J.B., and J.A. Ramsay. 1965. Lethal levels of mixed copper-zinc solutions for juvenile salmon. Journal of the Fisheries Research Board of Canada 22(2):425-432.

Stadler, J.H. 2002. Notes from site visit, Winslow Ferry Terminal, to observe pile driving and monitoring of noise levels and effects to fishes. 10/07/2002.

Stadler, J.H. 2009. Guidance on applying SEL interim criteria spreadsheet for pile driving projects.

Starzec, P., B.B. Lind, A. Lanngren, A. Lindgren, and T. Svenson. 2005. Technical and environmental functioning of the tension ponds for the treatment of highway and road runoff. Water, Air, and Soil Pollution 163(1-4):153-167.

Staubitz, W.W., G.C. Bortleson, S.D. Semans, A.J. Tesoriero, and R.W. Black. 1997. Water-quality assessment of the Puget Sound Basin, Washington, environmental setting and its implications for water quality and aquatic biota. USGS, Water-Resources Investigations Report 97-4013, Tacoma, WA, 1997. 86 pp.

Stotz, T., and J. Colby. 2001. January 2001 Dive report for Mukilteo wingwall replacement project. Washington State Ferries, Memorandum, Seattle, WA, April 30, 2001. 19 pp.

Stroetz, R.W., N.E. Vlahakis, B.J. Walters, M.A. Schroeder, and R.D. Hubmayr. 2001. Validation of a new live cell strain system: Characterization of plasma membrane stress failure. Journal of Applied Physiology 90(6):2361-2370.

Tabor, R.A., G. Brown, and V.T. Luiting. 1998. The effect of light intensity on predation of sockeye salmon fry by prickly sculpin and torrent sculpin. USFWS, Lacey, WA, May 1998. 16 pp.

Tabor, R.A., B.A. Footen, K.L. Fresh, M.T. Celedonia, F. Mejia, D.L. Low, and L. Park. 2007. Smallmouth bass and largemouth bass predation on juvenile chinook salmon and other salmonids in the Lake Washington Basin. North American Journal of Fisheries Management 27(4):1174-1188.

Tabor, R.A., and R.M. Piaskowski. 2002. Nearshore habitat use by juvenile Chinook salmon in lentic systems of the Lake Washington basin, Annual Report 2001. U.S. Fish and Wildlife Service, Western Washington Office, Division of Fisheries and Watershed Assessment, Lacey, WA, February, 2002. 56 pp.

Thorpe, J.E. 1994. Salmonid Fishes and the Estuarine Environment. Estuaries 17(1).

Turnpenny, A.W.H., and J. Nedwell. 1994. The effects on marine fish, diving mammals and birds of underwater sound generated by seismic surveys. Fawley Aquatic Research Laboratories Limited, Marine and Freshwater Biology Unit, FCR 089/94, Southampton, Hampshire, UK, October 1994. 40 pp.

Turnpenny, A.W.H., K.P. Thatcher, R. Wood, and J. Nedwell. 1994. The effects on fish and other marine animals of high-level underwater sound. Fawley Aquatic Research Laboratory, Ltd., Marine and Freshwater Biology Unit, Report FRR 127/94, Southampton, United Kingdom, October 1994. 35 pp.

USACOE, USACE, USFWS, and NOAA. 1993. Commencement Bay cumulative impact study - Vol 1 :assessment of impacts. US COE, Seattle;WA.

USEPA. 1980a. Ambient water quality criteria for copper. Criteria and Standards Division, Office of Water Regulations and Standards, Publication 440/5-80-036, Washington, D.C. 162 pp.

USEPA. 1980b. Ambient water quality criteria for zinc. The Division; Available to the public through the National Technical Information Service, Washington, D.C; Springfield, Va.

USEPA. 1987. Ambient aquatic life water quality criteria document for zinc. U.S. Environmental Protection Agency, Office of Research and Development, Environmental Research Laboratories; Available from the National Technical Information Service, Washington, D.C; Springfield, Va.

USEPA. 1993. EPA reregistration eligibility decision (R.E.D): Glyphosate. US EPA, Office of Prevention, Pesticides, and Toxic Substances, EPA 738-R-93-014, September, 1993. 290 pp.

USEPA. 2002. Consumer factsheet on: Glycosphate. EPA website.

USEPA. 2011. Contaminated sediments: technical resources-techniques and procedures. Available: http://water.epa.gov/polwaste/sediments/cs/techniques.cfm. (3/31/2011).

USFWS. 1998. A framework to assist in making Endangered Species Act determinations of effect for individual or grouped actions at the bull trout subpopulation watershed scale. Western Washington Fish and Wildlife Office, Lacey, WA. 45 pp.

USFWS. 2004. Draft Recovery Plan for the Coastal-Puget Sound distinct population segment of bull trout (*Salvelinus confluentus*). Volume I: Puget Sound Management Unit, 389+xvii pp and Volume II: Olympic Peninsula Management Unit, 277+xvi pp, Portland, Oregon.

USFWS. 2006. Compendium of bull trout occurrence data (Lake Washington/Lake Union/Lake Sammamish). USFWS, Lacey, WA, 10/12/06. 2 pp.

USFWS. 2010a. Climate change in the Pacific Northwest, Available: http://www.fws.gov/pacific/Climatechange/changepnw.html. (03/31/2011).

USFWS. 2010b. Sediment analysis framework: determining effects for Section 7 consultations. USFWS, Lacey, WA, 2010. 21 pp.

USFWS, and NMFS. 1998. Final endangered species consultation handbook: Procedures for conducting consultation and conference activities under section 7 of the Endangered Species Act. U. S. Fish and Wildlife Service and National Marine Fisheries Service, U.S. GPO: 2004-690-278, Washington, D.C., March 1998. 189 pp.

Van Metre, P.C., B.L. Mahler, and E.T. Furlong. 2000. Urban sprawl leaves its PAH signature. Environmental Science & Technology 34:4064-4070.

Vigg, S., T.P. Poe, L.A. Prendergast, and H.C. Hansel. 1991. Rates of consumption of juvenile salmonids and alternative prey fish by northern squawfish, walleyes, smallmouth bass, and channel catfish in John Day Reservoir, Columbia River. Transaction of American Fisheries Society 120:421-438.

Vlahakis, N.E., and R.D. Hubmayr. 2000. Plasma membrane stress failure in alveolar epithelial cells. Journal of applied physiology 89:2490-2496.

Waters, T.F. 1995. Sediment in streams: Sources, biological effects, and control. American Fisheries Society, Monograph 7, Bethesda, Maryland.

WDFW. 1997. Final environmental impact statement for the Wild Salmon Policy. Washington Department of Fish and Wildlife, Olympia, WA, September 18, 1997. 215 pp.

WDFW. 1998. Washington state salmonid stock inventory: bull trout/dolly varden. Washington Department of Fish and Wildlife, Olympia, WA, July 1998. 437 pp.

WDFW. 2000. Critical spawning habitat for herring, surf smelt, sand lance, and rock sole in Puget Sound, Washington. Washington Department of Fish and Wildlife, Olympia, WA. 162 pp.

WDNR. 1998. Smoke management plan. Washington Department of Natural Resources, Olympia, WA. 146 pp.

WDOE. 2008. Information presented on: Washington state's water quality assessment [303(d)], .

WDOE. 2010a. Fact sheet for the draft national pollutant discharge elimination system (NPDES) and State Waste Discharge General Permit for Washington State Department of Transportation's municipal separate storm sewers, 2010. 60 pp.

WDOE. 2010b. Washington State Department of Transportation Municipal Stormwater Permit. Olympia, Final Report, WA, 2010. 142 pp.

WDOE. 2011. WRIA 08, Cedar-Sammamish, Available: http://www.ecy.wa.gov/biblio/wria08.html. (3/31/2011).

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 13:141-164.

Wong, T., P. Breen, and S. Lloyd. 2000. Water sensitive road design - design options for improving stormwater quality of road runoff. Cooperative research centre for catchment hydrology, 00/1. 83 pp.

WSCC. 1999a. Salmon and steelhead habitat limiting factors water resource inventory area 11 Washington state conservation commission final report. Washington State Conservation Commission.

WSCC. 1999b. Salmon habitat limiting factors final report water resource inventory area 5 Stillaguamish watershed. Washington State Conservation Commission, Olympia, WA, July, 1999. 80 + appendices pp.

WSDOT. 2006. 2006 stormwater report. Washington State Department of Transportation. 107 pp.

WSDOT. 2008. Highway runoff manual. WSDOT, Environmental and Engineering Programs Design Office, Technical Manual M31-16.01. 603 pp.

WSDOT. 2009. WSDOT fish exclusion protocols and standards. WSDOT, Olympia, WA, June 25, 2009. 14 pp.

WSDOT. 2010a. Biological assessment - SR 520, I-5 to Medina: bridge replacement and HOV project, November 2010. 785 pp.

WSDOT. 2010b. SR 520 bridge replacement and HOV program I-5 to Medina: bridge replacement and HOV project - AKART and water quality studies for SR 520 replacement floating bridge, April 2010. 216 pp.

Wydoski, R.S., G.A. Wedemeyer, and N.C. Nelson. 1976. Physiological response to hooking stress in hatchery and wild rainbow trout (Salmo gairdneri). Transactions of the American Fisheries Society 105(5):601-606.

Yelverton, J.T., and D.R. Richmond. 1981. Underwater explosion damage risk criteria for fish, birds, and mammals. Pages 1-17 *In* 102nd Meeting of the Acoustical Society of America, November 30 - December 04, 1981, Department of Biodynamics, Lovelace Biomedical and Environmental Research Institute, Albuquerque, New Mexico.

Yelverton, J.T., D.R. Richmond, R.E. Fletcher, and R.K. Jones. 1973. Safe distances from underwater explosions for mammals and birds. Lovelace Foundation for Medical Education and Research, DNA 3114 T, Albuquerque, NM, July 13, 1973. 64 pp.

Yelverton, J.T., D.R. Richmond, W. Hicks, K. Saunders, and R.E. Fletcher. 1975. The relationship between fish size and their response to underwater blast. Report prepared for the Defense Nuclear Agency, AD-A015-970, Albuquerque, New Mexico. 39 pp.

Ylitalo, G.M., J. Buzitis, M.M. Krahn, N. Scholz, T.K. Collier, and Puget Sound Action Team, Olympia, WA (USA). 2004. Is PAH exposure of adult coho salmon related to abnormal pre-spawn mortality?. Puget Sound Action Team, Olympia, WA.

Young, G.K., S. Stein, P. Cole, T. Krammer, F. Graziano, and F. Bank. 1996. Evaluation and management of highway runoff water quality. Federal Highway Administration, Publication No. FHWA-PD-96-032, Washington, D.C. 457 pp.

APPENDICES

Appendix A: Bubble Curtain Specification
Appendix B: Status of the Species (Bull Trout; Coterminous Range)
Appendix C: Status of Designated Critical Habitat (Bull Trout; Coterminous Range)
Appendix D: Core Area Summaries – Puyallup, Snohomish-Skykomish, and Skagit River Core Areas (Bull Trout)
Appendix E: Sediment Analysis Framework (2010)

APPENDIX A: Bubble Curtain Specification

Bubble Curtain Systems

The bubble curtain air supply system shall be designed by (or under the direct supervision of) a Professional Engineer qualified to design compressed air systems, licensed under Title 18 RCW, State of Washington, in the branch of Mechanical Engineering. The drawings and calculations shall bear the stamp or seal, original signature, date of signature, and registration number of the Professional Engineer.

The bubble curtain systems shall conform to the following:

1. Piling shall be completely engulfed in bubbles over the full depth of the water column at all times when an impact pile driver is in use.

2. Air shall be delivered from bubbler ring assemblies ("bubblers") at intervals shown on the Plans.

3. The lowest bubble ring shall be in contact with the mudline for the full circumference of the ring. No portion of the bubbler shall be below the mudline.

4. Bubblers shall completely surround the pile. Bubbler minimum dimensions shall be as shown on the Plans.

5. Bubblers shall be constructed of 2.5 inches (minimum) nominal diameter aluminum pipe with 1/16-inch diameter bubble release holes in five rows in the axial direction and staggered spacing in the radial direction as

indicated on the Plans. Bubblers shall be durable enough to withstand repeated deployment during pile driving and shall be constructed to facilitate underwater setup, knockdown, and reuse on the next pile. Material shall be as specified on the Plans.

6. One or more compressors shall be provided to supply air in sufficient volume and pressure to self-purge water from bubblers and maintain the required bubble flux for the duration of pile driving. Compressors shall be of a type that prevents the introduction of oil or fine oil mist by the compressed air into the water. The presence of oil film or sheen on the water surface in the vicinity of the operating bubbler will indicate that the Contractor has failed to meet this requirement. The Contractor shall immediately stop work until the source of oil film or sheen is identified and corrected.

7. Bubbler feed lines (secondary feed lines) shall be sized taking into account backpressure at the exit point, in-line friction losses and losses through fittings.

8. The system shall provide a bubble flux of 32.91 cubic feet per minute per linear foot of pipe in each layer. The total volume of air per layer is the product of the bubble flux and the circumference of the ring:

$$V_t = 32.91\ ft^3/min/ft * \text{Circum of the aeration ring in ft}$$

9. Total air volume shall be 350 SCFM at 90 psi per bubbler ring.

10. The bubbler ring manifold shall incorporate a shut-off valve, flow meter, a throttling globe valve with a pressure gauge for each bubble ring supply as shown and detailed on the Plans.

11. Prior to first use of the bubble curtain during pile driving, the fully assembled system shall be test-operated to demonstrate proper function and to train personnel in the proper balancing of the air flow to the bubblers. The test shall also confirm the calculated pressures and flow rates at each bubble ring. The Contractor shall submit an inspection/performance report to WSDOT, NMFS and/or USFWS within 72 hours following the performance test.

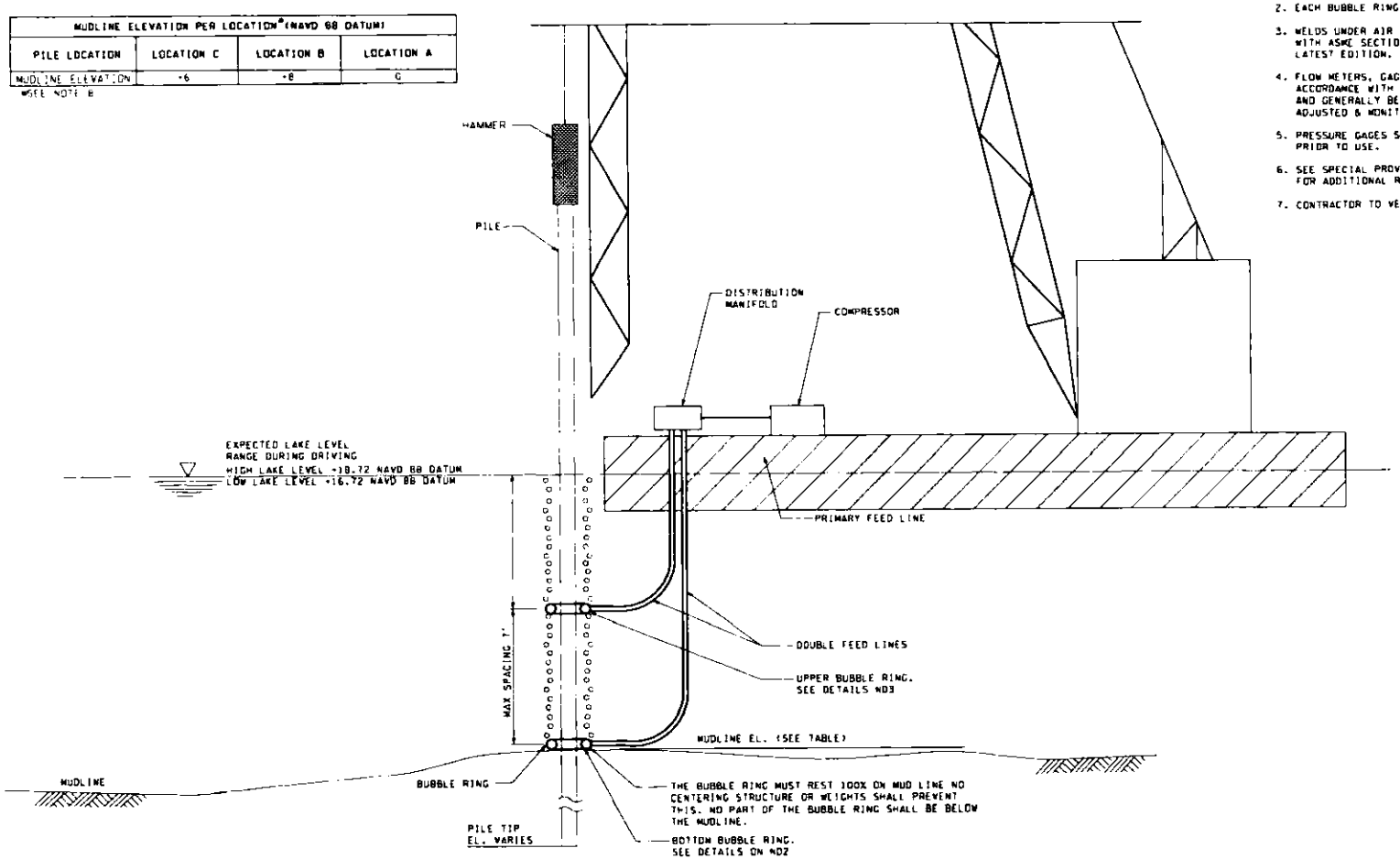
12. Resilient pile guides shall be used to prevent contact between pile and bubble system. The pile guide shall be constructed of material that does not transmit vibration.

13. A qualified biologist may be present during all impact pile driving operations to observe and report any indication of dead, injured or distressed fish, including direct observation of these fish or increases in bird foraging activity.

14. If a barge is used to house the pile-driver, it shall be isolated from the noise-producing operations. This isolation shall be such that noise from the pile driving operation is not transmitted through the barge to the water column.

MUDLINE ELEVATION PER LOCATION* (NAVD 88 DATUM)			
PILE LOCATION	LOCATION C	LOCATION B	LOCATION A
MUDLINE ELEVATION	+6	+8	0

*SEE NOTE 8



ELEVATION

NTS

NOTES:

1. EXISTING STRUCTURES NOT SHOWN FOR CLARITY.
2. EACH BUBBLE RING REQUIRES 570 CFM OF AIR.
3. WELDS UNDER AIR PRESSURE SHALL BE IN ACCORDANCE WITH ASME SECTION 8 BOILER AND PRESSURE VESSEL CODE, LATEST EDITION.
4. FLOW METERS, GAGES AND VALVES SHALL BE MOUNTED IN ACCORDANCE WITH THE MANUFACTURER'S RECOMMENDATIONS AND GENERALLY BE WAIST HIGH SO EQUIPMENT CAN BE ADJUSTED & MONITORED EASILY.
5. PRESSURE GAGES SHALL BE CALIBRATED AND CERTIFIED PRIOR TO USE.
6. SEE SPECIAL PROVISION "Bubble Curtain Systems" FOR ADDITIONAL REQUIREMENTS.
7. CONTRACTOR TO VERIFY MUDLINE ELEVATION.

UNCONFINED BUBBLE CURTAIN ARRANGEMENT

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DESIGNED BY	WSF
ENTERED BY	BL BORON
CHECKED BY	J. SCHUFREIDER
PROJ. ENGR.	D. YANKAUSKAS
REGIONAL ADM.	C. STORE

REVISION | DATE | BY

REGION NO. 10 | STATE WASH | FED.AID PROJ.NO.

JOB NUMBER 08A808

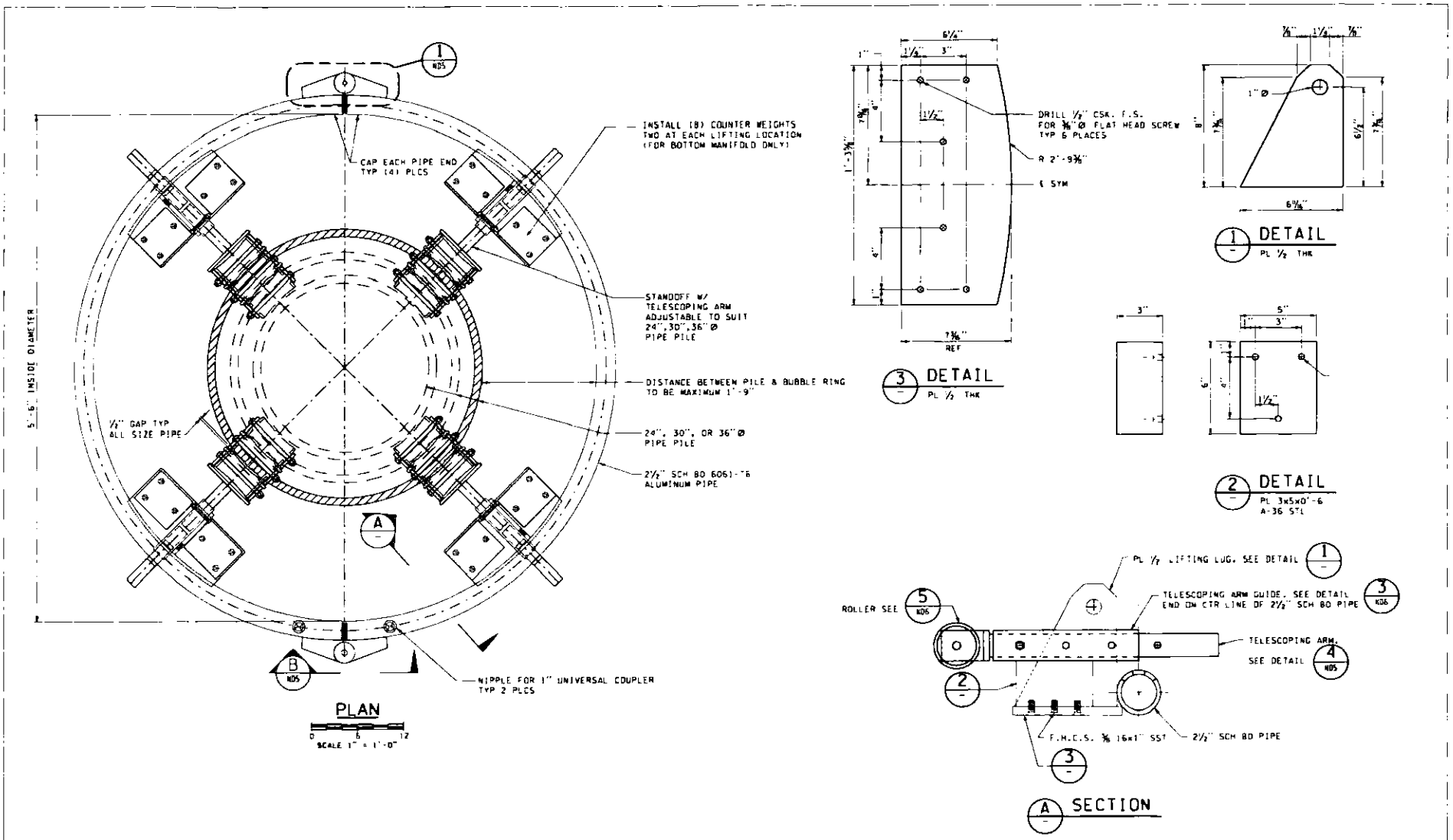
Washington State Department of Transportation

SR 520
EVERGREEN POINT BRIDGE VICINITY
PILE DRIVING

NOISE ATTENUATION DETAIL

ND1

SHEET 10 OF 19



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CHECKED BY	J. SCHUFREIDER
PROJ. ENGR.	D. YANKAUSKAS
REGIONAL ADM.	C. STONE

REVISION	DATE	BY

REVISION NO. 10 STATE WASH

JOB NUMBER 09A803

CONTRACT NO.

FED.AID PROJ.NO.

LOCATION NO.

P.E. STAMP NO. DATE

P.E. STAMP NO. DATE

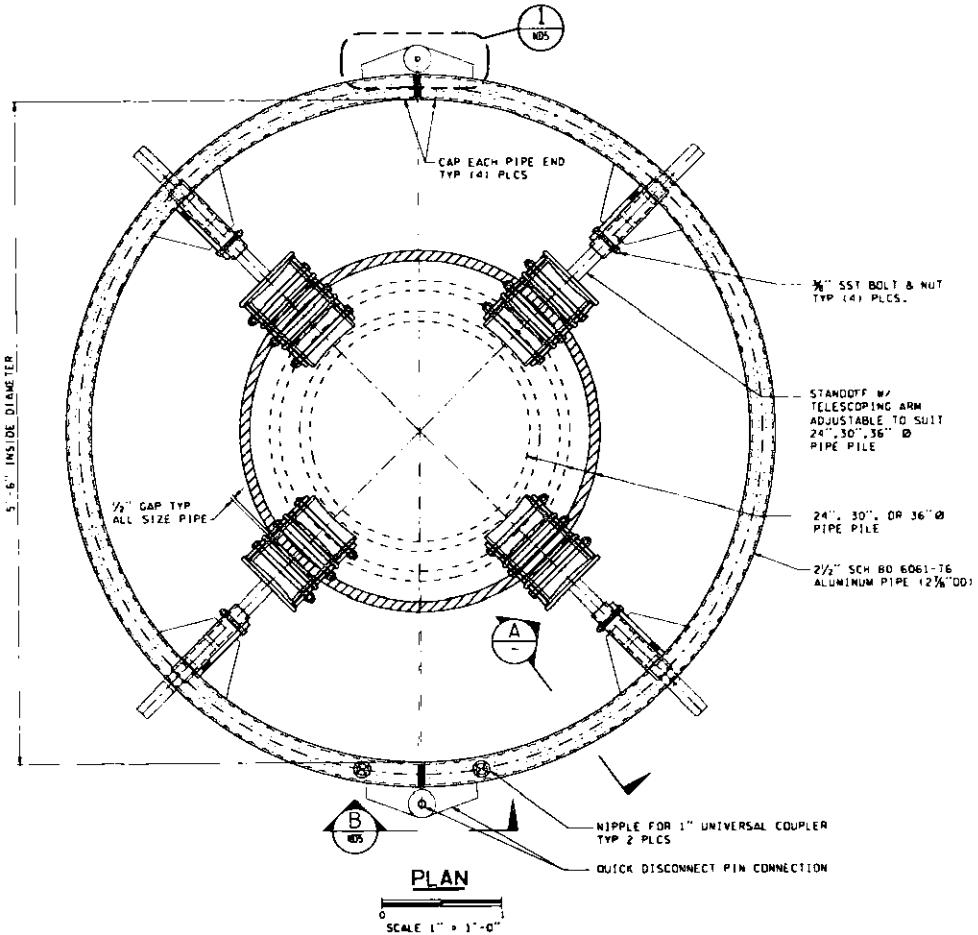
Washington State Department of Transportation

SR 520
EVERGREEN POINT BRIDGE VICINITY
PILE DRIVING

BOTTOM RING NOISE ATTENUATION DETAIL

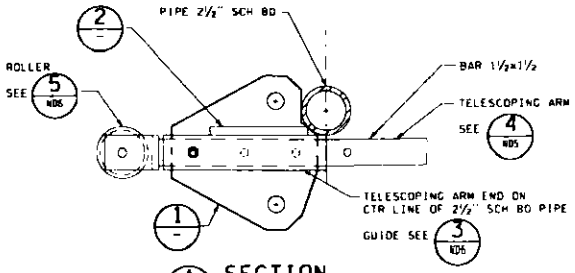
ND2

SHEET 11 OF 19 SHEETS

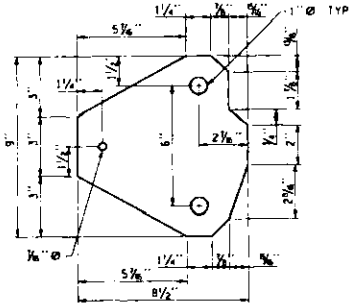


PLAN

SCALE 1" = 1'-0"



A SECTION



1 DETAIL

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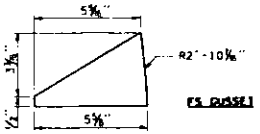

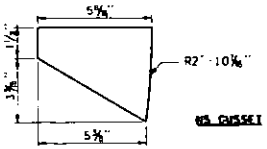

2 DETAIL

PL ½ GUSSET PL

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DESIGNED BY	WSF
ENTERED BY	M. WORDN
CHECKED BY	J. SCHUFREIDER
PROJ. ENGR.	D. YANKAUSKAS
REGIONAL ADM.	C. STONE

REVISION	DATE	BY

REGION NO.	STATE	FED.AID PROJ.NO.
10	WASH	
JOB NUMBER 09A888		

Washington State Department of Transportation

SR 520
EVERGREEN POINT BRIDGE VICINITY
PILE DRIVING

TOP BUBBLE RING

ND3

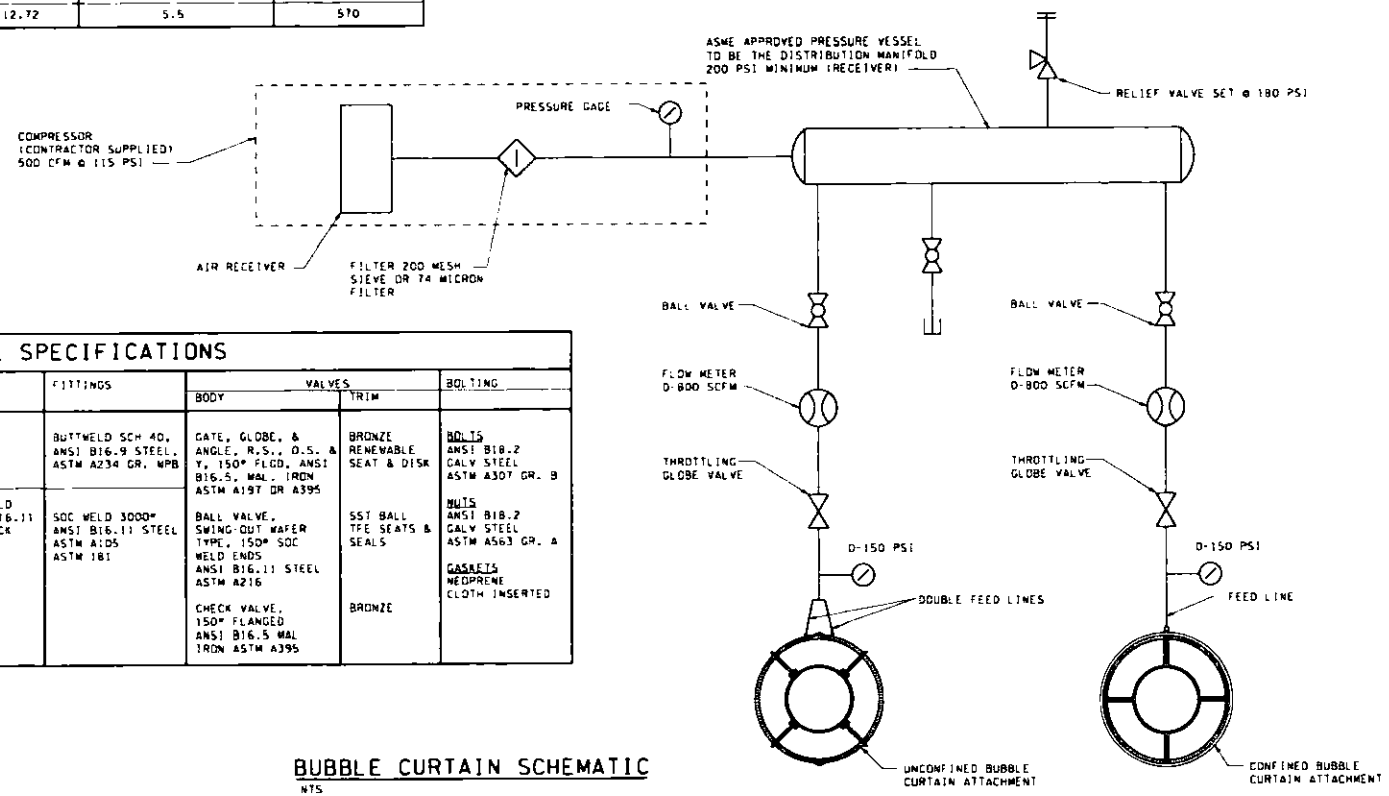
SHEET 12 OF 19 SHEETS

UNCONFINED BUBBLE CURTAIN DESIGN ASSUMPTIONS

	BUBBLE RING	ELEVATION	APPROX WATER DEPTH (FT)	APPROX HYDROSTATIC PRESSURE (PSI)	REQD MIN FLOW VOLUME (CFM)
LOCATION A	N/A	+18.72 (HIGH LAKE LEVEL)	0	0	-
	2	+10	8.72	3.8	570
	1	0	18.72	8.1	570
LOCATION B	N/A	+18.72 (HIGH LAKE LEVEL)	0	0	-
	1	+18	0.72	0.3	570
	2	+8	10.72	4.6	570
LOCATION C	N/A	+18.72 (HIGH LAKE LEVEL)	0	0	-
	1	+16	2.72	1.2	570
	2	+6	12.72	5.5	570

CONFINED BUBBLE CURTAIN DESIGN ASSUMPTIONS

	BUBBLE RING	ELEVATION	APPROX. WATER DEPTH (FT)	APPROX HYDROSTATIC PRESSURE (PSI)	REQD MIN FLOW VOLUME (CFM)
LOCATION B	N/A	+18.72 (HIGH LAKE LEVEL)	0	0	-
	1	+8	10.72	4.6	570



MATERIAL SPECIFICATIONS

SYSTEM	SIZE	PIPE	TAKEDOWN JOINTS	FITTINGS	VALVES BODY	VALVES TRIM	BOLTING
COMPRESSED AIR 200 PSI, 100°F	2" AND ABOVE	CARBON STEEL SEAMLESSS ASTM A106 GR B SCH 40	FLANGE, WELDNECK OR SLIP-ON, 150# ANSI B16.5, STEEL ASTM A105	BUTTWELD SCH 40, ANSI B16.9 STEEL, ASTM A234 GR. WPB	GATE, GLOBE, & ANGLE, R.S., O.S. & Y, 150# FLGD. ANSI B16.5, MAL. IRON ASTM A197 OR A395	BRONZE RENEWABLE SEAT & DISK	BOLTS ANSI B18.2 CALV STEEL ASTM A307 GR. B
	1½" AND BELOW		UNION 300# SOC WELD GRD JOINT, ANSI B16.11 OR FLANGE, WELDNECK OR SLIP-ON, 150# ANSI B16.5, STEEL ASTM A105 OR A181	SOC WELD 3000# ANSI B16.11 STEEL ASTM A105 ASTM 181	BALL VALVE, SWING-OUT WAFER TYPE, 150# SOC WELD ENDS ANSI B16.11 STEEL ASTM A216	SST BALL TFE SEATS & SEALS	NUTS ANSI B18.2 CALV STEEL ASTM A563 GR. A
					CHECK VALVE, 150# FLANGED ANSI B16.5 MAL IRON ASTM A395	BRONZE	GASKETS NEOPRENE CLOTH INSERTED

BUBBLE CURTAIN SCHEMATIC

NTS

FILE NAME	G:\Proj\Outside WSF proj\SR520\CADD\Marked_up 7-23-09\PE2344_TP_ND4.dgn
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DESIGNED BY	WSF
ENTERED BY	M. MORON
CHECKED BY	J. SCHUFREIDER
PROJ. ENGR.	D. YANKAUSKAS
REGIONAL ADM.	C. STONE

REVISION	DATE	BY

REGION NO. 10 | STATE WASH | FED.AID PROJ.NO.

JOB NUMBER 09A888

CONTRACT NO. | LOCATION NO.

P.E. STAMP REQ. | DATE

P.E. STAMP REQ. | DATE

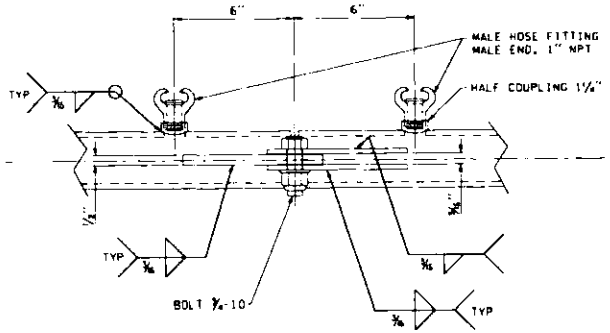
Washington State Department of Transportation

SR 520
EVERGREEN POINT BRIDGE VICINITY
PILE DRIVING

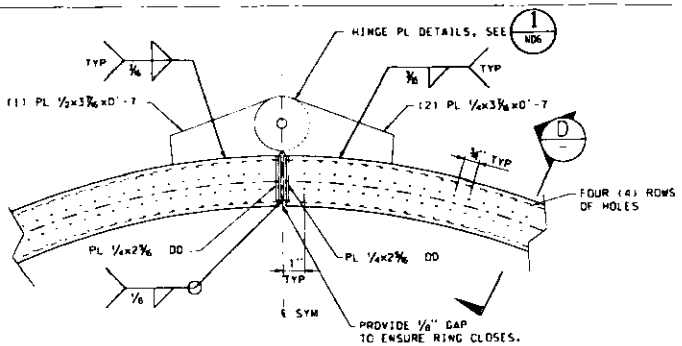
PNEUMATIC SCHEMATIC

ND4

SHEET 13 OF 19 SHEETS



B/ND2 B/ND3 SECTION



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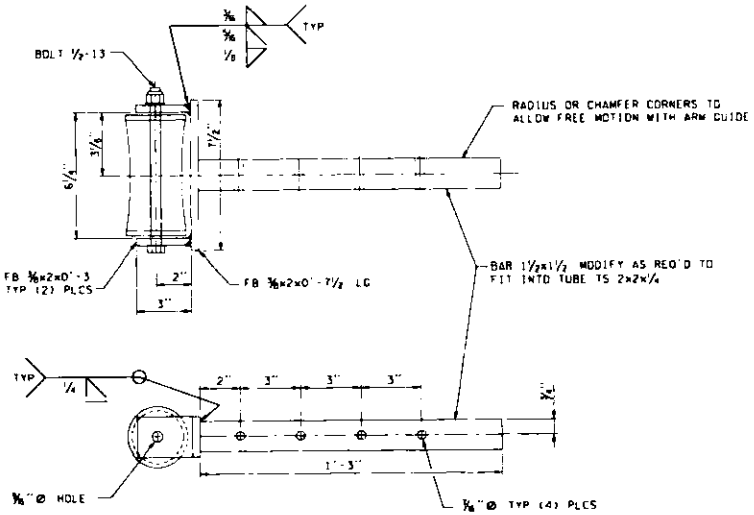
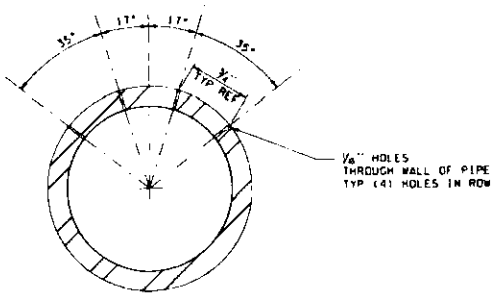


4/ND2 4/ND3 DETAIL

TYP TELESCOPING ARM
MATERIAL: AL 6061-T6



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CHECKED BY	J. SCHUFREIDER				
PROJ. ENGR.	D. YANKAUSKAS				
REGIONAL ADM.	C. STORK	REVISION	DATE	BY	

REVISION NO.	DATE	FED.AID PROJ.NO.
10	WASH	
JOB NUMBER 09A808		
CONTRACT NO.		LOCATION NO.

DATE

P.E. STAMP BOX

DATE

P.E. STAMP BOX

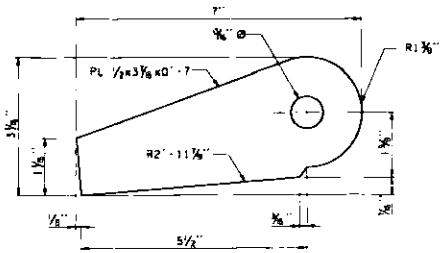
Washington State Department of Transportation

SR 520
EVERGREEN POINT BRIDGE VICINITY
PILE DRIVING

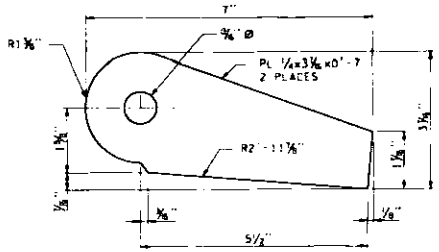
NOISE ATTENUATION DETAIL

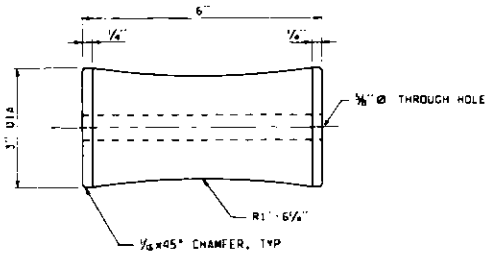
ND5

SHEET 14 OF 19 SHEETS

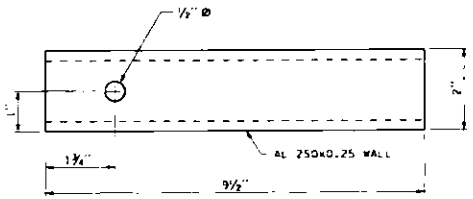


1 ND5 DETAIL
TYP HINGE PLS
MATERIAL: AL 6061-T6





5 ND3 5 ND2 DETAIL
TYP ROLLER
MATERIAL: UHMW OR EQUAL



3 ND3 3 ND2 DETAIL
TYP ARM GUIDE

FILE NAME	G:\Proj\Outside_WSF_proj\SR520\CADD\Marked up 7-22-09\PE2344_TP_ND6.dgn
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DATE	$$$$DATE$$$
PLOTTED BY	janssent
DESIGNED BY	WSF
ENTERED BY	M. MORIN
CHECKED BY	J. SCHUFREIDER
PROJ. ENGR.	D. YANKAUSKAS
REGIONAL ADM.	C. STONE

REVISION	DATE	BY

REVISION NO. 10 STATE WASH
JOB NUMBER 09A803
CONTRACT NO.
FED.AID PROJ.NO.
LOCATION NO.

P.E. STAMP NO. DATE

P.E. STAMP NO. DATE

Washington State Department of Transportation

SR 520
EVERGREEN POINT BRIDGE VICINITY
PILE DRIVING

NOISE ATTENUATION DETAIL

ND6

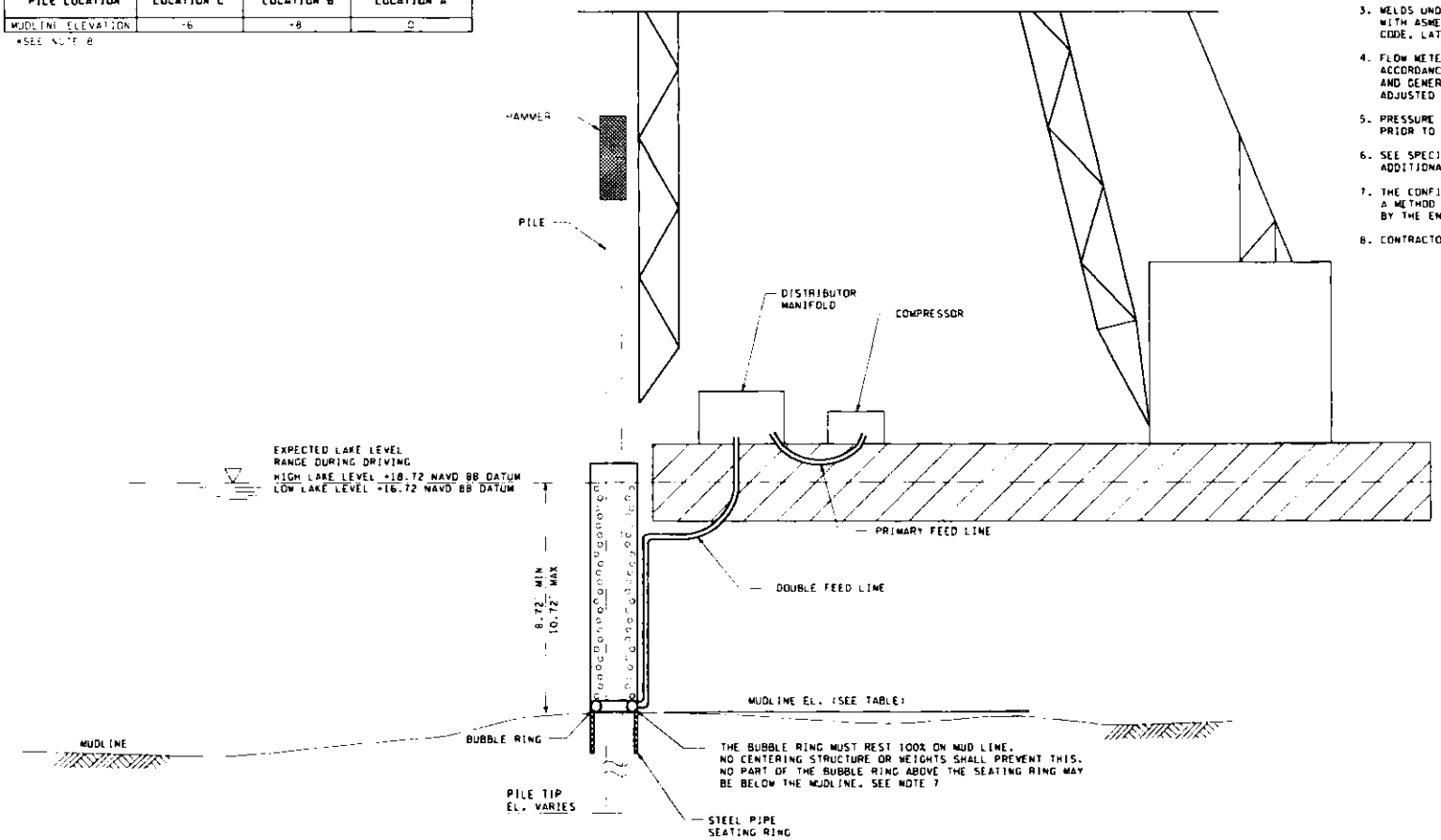
SHEET 15 OF 19 SHEETS

MUDLINE ELEVATION PER LOCATION* (NAVD 88 DATUM)			
PILE LOCATION	LOCATION C	LOCATION B	LOCATION A
MUDLINE ELEVATION	-6	-8	0

*SEE NOTE 8

NOTES:

1. EXISTING STRUCTURES NOT SHOWN FOR CLARITY.
2. BUBBLE RING REQUIRES 350 SCFM @ 90 PSIG MINIMUM.
3. WELDS UNDER AIR PRESSURE SHALL BE IN ACCORDANCE WITH ASME SECTION 8 BOILER AND PRESSURE VESSEL CODE, LATEST EDITION.
4. FLOW METERS, GAGES AND VALVES SHALL BE MOUNTED IN ACCORDANCE WITH THE MANUFACTURER'S RECOMMENDATIONS AND GENERALLY BE WAIST HIGH SO EQUIPMENT CAN BE ADJUSTED & MONITORED EASILY.
5. PRESSURE GAGES SHALL BE CALIBRATED AND CERTIFIED PRIOR TO USE.
6. SEE SPECIAL PROVISION Bubble Curtain Systems FOR ADDITIONAL REQUIREMENTS.
7. THE CONFINED BUBBLE CURTAIN SHALL BE SUPPORTED BY A METHOD OF THE CONTRACTOR'S CHOOSING WITH APPROVAL BY THE ENGINEER.
8. CONTRACTOR TO VERIFY MUDLINE ELEVATION.



ELEVATION

NTS

CONFINED BUBBLE CURTAIN ARRANGEMENT

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DESIGNED BY	A. WARNER
ENTERED BY	A. WARNER
CHECKED BY	G. GOLPKENEE
PROJ. ENGR.	D. YANKAUSKAS
REGIONAL ADM.	C. STONE

REVISION | DATE | BY

REGION NO. 10 | STATE WASH | FED.AID PROJ.NO.

JOB NUMBER 09A809

CONTRACT NO. | LOCATION NO.

P.E. STAMP DATE | P.E. STAMP DATE

Washington State Department of Transportation

SR 520
EVERGREEN POINT BRIDGE VICINITY
PILE DRIVING

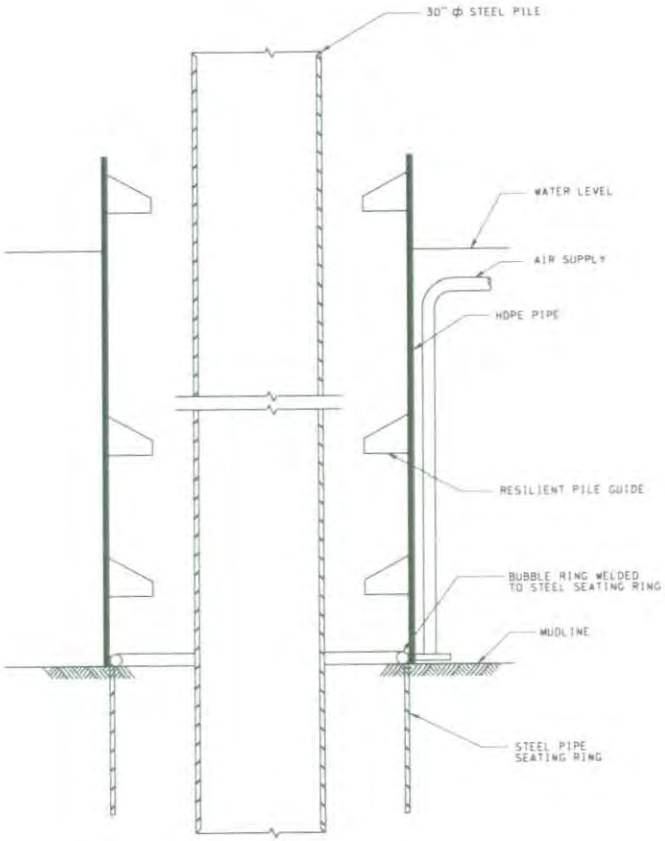
NOISE ATTENUATION DETAIL

ND7

SHEET 18 OF 19 SHEETS

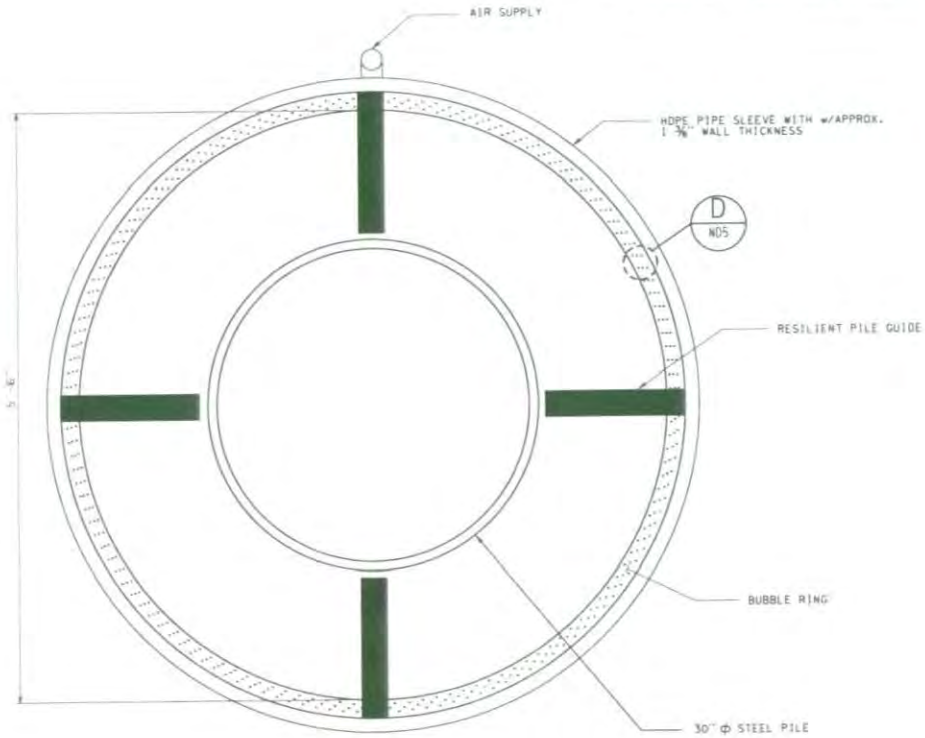
NOTES:

1. SEE SHEET P5 FOR DETERMINING WHEN CONFINED BUBBLE CURTAIN IS REQUIRED.
2. WELDS UNDER PRESSURE SHALL BE IN ACCORDANCE WITH ASME SECTION 8 BOILER AND PRESSURE VESSEL CODE, LATEST EDITION.
3. THE CONTRACTOR SHALL DESIGN AND PROVIDE A COUNTERWEIGHT OR EQUIVALENT METHOD TO COUNTERACT THE BUOYANCY OF THE BUBBLE CURTAIN SYSTEM.



ELEVATION

NTS



PLAN

NTS

CONFINED BUBBLE CURTAIN ASSEMBLY

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DESIGNED BY	A. WARNER					
ENTERED BY	A. WARNER					
CHECKED BY	G. GOLPHENEE					
PROJ. ENGR.	D. YANKAUSKAS					
REGIONAL ADM.	C. STONE	REVISION	DATE	BY		

REGION NO. 10 | STATE WASH | FED.AID PROJ.NO.

JOB NUMBER 09A808

CONTRACT NO.

LOCATION NO.

P.E. STAMP NO. DATE

P.E. STAMP NO. DATE

Washington State Department of Transportation

SR 520
EVERGREEN POINT BRIDGE VICINITY
PILE DRIVING

NOISE ATTENUATION DETAIL

ND8

SHEET 17 OF 19 SHEETS

APPENDIX B: Status of the Species (Bull Trout; Coterminous Range)

Appendix B: STATUS OF THE SPECIES (Bull Trout)

Listing Status

The coterminous United States population of the bull trout (*Salvelinus confluentus*) was listed as threatened on November 1, 1999 (64 FR 58910). The threatened bull trout generally occurs in the Klamath River Basin of south-central Oregon; the Jarbidge River in Nevada; the Willamette River Basin in Oregon; Pacific Coast drainages of Washington, including Puget Sound; major rivers in Idaho, Oregon, Washington, and Montana, within the Columbia River Basin; and the St. Mary-Belly River, east of the Continental Divide in northwestern Montana (Bond 1992, p. 2; Brewin and Brewin 1997, p. 215; Cavender 1978, pp. 165-166; Leary and Allendorf 1997, pp. 716-719).

Throughout its range, the bull trout are threatened by the combined effects of habitat degradation, fragmentation, and alterations associated with dewatering, road construction and maintenance, mining, grazing, the blockage of migratory corridors by dams or other diversion structures, poor water quality, entrainment (a process by which aquatic organisms are pulled through a diversion or other device) into diversion channels, and introduced non-native species (64 FR 58910). Although all salmonids are likely to be affected by climate change, bull trout are especially vulnerable given that spawning and rearing are constrained by their location in upper watersheds and the requirement for cold water temperatures (Battin et al. 2007, pp. 6672-6673; Rieman et al. 2007, p. 1552). Poaching and incidental mortality of bull trout during other targeted fisheries are additional threats.

The bull trout was initially listed as three separate Distinct Population Segments (DPSs) (63 FR 31647; 64 FR 17110). The preamble to the final listing rule for the United States coterminous population of the bull trout discusses the consolidation of these DPSs with the Columbia and Klamath population segments into one listed taxon and the application of the jeopardy standard under section 7 of the Act relative to this species (64 FR 58910):

> Although this rule consolidates the five bull trout DPSs into one listed taxon, based on conformance with the DPS policy for purposes of consultation under section 7 of the Act, we intend to retain recognition of each DPS in light of available scientific information relating to their uniqueness and significance. Under this approach, these DPSs will be treated as interim recovery units with respect to application of the jeopardy standard until an approved recovery plan is developed. Formal establishment of bull trout recovery units will occur during the recovery planning process.

Current Status and Conservation Needs

In recognition of available scientific information relating to their uniqueness and significance, five segments of the coterminous United States population of the bull trout are considered essential to the survival and recovery of this species and are identified as interim recovery units: 1) Jarbidge River, 2) Klamath River, 3) Columbia River, 4) Coastal-Puget Sound, and 5) St. Mary-Belly River (USFWS 2002a, pp. iv, 2, 7, 98; 2004a, Vol. 1 & 2, p. 1; 2004b, p. 1). Each of

these interim recovery units is necessary to maintain the bull trout's distribution, as well as its genetic and phenotypic diversity, all of which are important to ensure the species' resilience to changing environmental conditions.

A summary of the current status and conservation needs of the bull trout within these interim recovery units is provided below and a comprehensive discussion is found in the Service's draft recovery plans for the bull trout (USFWS 2002a, pp. vi-viii; 2004a, Vol. 2 p. iii-x; 2004b, pp. iii-xii).

The conservation needs of bull trout are often generally expressed as the four "Cs": cold, clean, complex, and connected habitat. Cold stream temperatures, clean water quality that is relatively free of sediment and contaminants, complex channel characteristics (including abundant large wood and undercut banks), and large patches of such habitat that are well connected by unobstructed migratory pathways are all needed to promote conservation of bull trout at multiple scales ranging from the coterminous to local populations (a local population is a group of bull trout that spawn within a particular stream or portion of a stream system). The recovery planning process for bull trout (USFWS 2002a, pp. 49-50; 2004a, Vol 1 & 2 pp. 12-18; 2004b, pp. 60-86) has also identified the following conservation needs: 1) maintenance and restoration of multiple, interconnected populations in diverse habitats across the range of each interim recovery unit, 2) preservation of the diversity of life-history strategies, 3) maintenance of genetic and phenotypic diversity across the range of each interim recovery unit, and 4) establishment of a positive population trend. Recently, it has also been recognized that bull trout populations need to be protected from catastrophic fires across the range of each interim recovery unit (Rieman et al. 2003).

Central to the survival and recovery of bull trout is the maintenance of viable core areas (USFWS 2002a, pp. 53-54; 2004a, Vol. 1 pp. 210-218, Vol 2. pp. 61-62; 2004b, pp. 15-30, 64-67). A core area is defined as a geographic area occupied by one or more local bull trout populations that overlap in their use of rearing, foraging, migratory, and overwintering habitat. Each of the interim recovery units listed above consists of one or more core areas. There are 121 core areas recognized across the coterminous range of the bull trout (USFWS 2002a, pp. 6, 48, 98; 2004a, Vol. 1 p. vi, Vol. 2 pp. 14, 134; 2004b, pp. iv, 2; 2005, p. ii).

Jarbidge River Interim Recovery Unit

This interim recovery unit currently contains a single core area with six local populations. Less than 500 resident and migratory adult bull trout, representing about 50 to 125 spawning adults, are estimated to occur in the core area. The current condition of the bull trout in this interim recovery unit is attributed to the effects of livestock grazing, roads, incidental mortalities of released bull trout from recreational angling, historic angler harvest, timber harvest, and the introduction of non-native fishes (USFWS 2004b). The draft bull trout recovery plan (USFWS 2004b) identifies the following conservation needs for this interim recovery unit: 1) maintain the current distribution of the bull trout within the core area, 2) maintain stable or increasing trends in abundance of both resident and migratory bull trout in the core area, 3) restore and maintain suitable habitat conditions for all life history stages and forms, and 4) conserve genetic diversity and increase natural opportunities for genetic exchange between resident and migratory forms of

the bull trout. An estimated 270 to 1,000 spawning bull trout per year are needed to provide for the persistence and viability of the core area and to support both resident and migratory adult bull trout (USFWS 2004b).

Klamath River Interim Recovery Unit

This interim recovery unit currently contains three core areas and seven local populations. The current abundance, distribution, and range of the bull trout in the Klamath River Basin are greatly reduced from historical levels due to habitat loss and degradation caused by reduced water quality, timber harvest, livestock grazing, water diversions, roads, and the introduction of non-native fishes (USFWS 2002a). Bull trout populations in this interim recovery unit face a high risk of extirpation (USFWS 2002a). The draft Klamath River bull trout recovery plan (USFWS 2002a) identifies the following conservation needs for this interim recovery unit: 1) maintain the current distribution of bull trout and restore distribution in previously occupied areas, 2) maintain stable or increasing trends in bull trout abundance, 3) restore and maintain suitable habitat conditions for all life history stages and strategies, 4) conserve genetic diversity and provide the opportunity for genetic exchange among appropriate core area populations. Eight to 15 new local populations and an increase in population size from about 2,400 adults currently to 8,250 adults are needed to provide for the persistence and viability of the three core areas (USFWS 2002a).

Columbia River Interim Recovery Unit

The Columbia River interim recovery unit includes bull trout residing in portions of Oregon, Washington, Idaho, and Montana. Bull trout are estimated to have occupied about 60 percent of the Columbia River Basin, and presently occur in 45 percent of the estimated historical range (Quigley and Arbelbide 1997, p. 1177). This interim recovery unit currently contains 97 core areas and 527 local populations. About 65 percent of these core areas and local populations occur in central Idaho and northwestern Montana. The Columbia River interim recovery unit has declined in overall range and numbers of fish (63 FR 31647). Although some strongholds still exist with migratory fish present, bull trout generally occur as isolated local populations in headwater lakes or tributaries where the migratory life history form has been lost. Though still widespread, there have been numerous local extirpations reported throughout the Columbia River basin. In Idaho, for example, bull trout have been extirpated from 119 reaches in 28 streams (IDFG, in litt. 1995). The draft Columbia River bull trout recovery plan (USFWS 2002c) identifies the following conservation needs for this interim recovery unit: 1) maintain or expand the current distribution of the bull trout within core areas, 2) maintain stable or increasing trends in bull trout abundance, 3) restore and maintain suitable habitat conditions for all bull trout life history stages and strategies, and 4) conserve genetic diversity and provide opportunities for genetic exchange.

This interim recovery unit currently contains 97 core areas and 527 local populations. About 65 percent of these core areas and local populations occur in Idaho and northwestern Montana. The condition of the bull trout within these core areas varies from poor to good. All core areas have been subject to the combined effects of habitat degradation and fragmentation caused by the following activities: dewatering; road construction and maintenance; mining; grazing; the

blockage of migratory corridors by dams or other diversion structures; poor water quality; incidental angler harvest; entrainment into diversion channels; and introduced non-native species. The Service completed a core area conservation assessment for the 5-year status review and determined that, of the 97 core areas in this interim recovery unit, 38 are at high risk of extirpation, 35 are at risk, 20 are at potential risk, 2 are at low risk, and 2 are at unknown risk (USFWS 2005, pp. 2, Map A, and pp. 73-83).

Coastal-Puget Sound Interim Recovery Unit

Bull trout in the Coastal-Puget Sound interim recovery unit exhibit anadromous, adfluvial, fluvial, and resident life history patterns. The anadromous life history form is unique to this interim recovery unit. This interim recovery unit currently contains 14 core areas and 67 local populations (USFWS 2004a). Bull trout are distributed throughout most of the large rivers and associated tributary systems within this interim recovery unit. Bull trout continue to be present in nearly all major watersheds where they likely occurred historically, although local extirpations have occurred throughout this interim recovery unit. Many remaining populations are isolated or fragmented and abundance has declined, especially in the southeastern portion of the interim recovery unit. The current condition of the bull trout in this interim recovery unit is attributed to the adverse effects of dams, forest management practices (e.g., timber harvest and associated road building activities), agricultural practices (e.g., diking, water control structures, draining of wetlands, channelization, and the removal of riparian vegetation), livestock grazing, roads, mining, urbanization, poaching, incidental mortality from other targeted fisheries, and the introduction of non-native species. The draft Coastal-Puget Sound bull trout recovery plan (USFWS 2004a) identifies the following conservation needs for this interim recovery unit: 1) maintain or expand the current distribution of bull trout within existing core areas, 2) increase bull trout abundance to about 16,500 adults across all core areas, and 3) maintain or increase connectivity between local populations within each core area.

St. Mary-Belly River Interim Recovery Unit

This interim recovery unit currently contains six core areas and nine local populations (USFWS 2002b). Currently, bull trout are widely distributed in the St. Mary-Belly River drainage and occur in nearly all of the waters that it inhabited historically. Bull trout are found only in a 1.2-mile reach of the North Fork Belly River within the United States. Redd count surveys of the North Fork Belly River documented an increase from 27 redds in 1995 to 119 redds in 1999. This increase was attributed primarily to protection from angler harvest (USFWS 2002b). The current condition of the bull trout in this interim recovery unit is primarily attributed to the effects of dams, water diversions, roads, mining, and the introduction of non-native fishes (USFWS 2002b). The draft St. Mary-Belly River bull trout recovery plan (USFWS 2002b) identifies the following conservation needs for this interim recovery unit: 1) maintain the current distribution of the bull trout and restore distribution in previously occupied areas, 2) maintain stable or increasing trends in bull trout abundance, 3) restore and maintain suitable habitat conditions for all life history stages and forms, 4) conserve genetic diversity and provide the opportunity for genetic exchange, and 5) establish good working relations with Canadian interests because local bull trout populations in this interim recovery unit are comprised mostly of migratory fish, whose habitat is mostly in Canada.

Life History

Bull trout exhibit both resident and migratory life history strategies. Both resident and migratory forms may be found together, and either form may produce offspring exhibiting either resident or migratory behavior (Rieman and McIntyre 1993, pp. 1-18) . Resident bull trout complete their entire life cycle in the tributary (or nearby) streams in which they spawn and rear. The resident form tends to be smaller than the migratory form at maturity and also produces fewer eggs (Fraley and Shepard 1989, p. 1; Goetz 1989, pp. 15-16). Migratory bull trout spawn in tributary streams where juvenile fish rear 1 to 4 years before migrating to either a lake (adfluvial form), river (fluvial form) (Fraley and Shepard 1989, pp. 135-137; Goetz 1989, pp. 22-25), or saltwater (anadromous form) to rear as subadults and to live as adults (Cavender 1978, pp. 139, 165-68; McPhail and Baxter 1996, p. 14; WDFW et al. 1997, pp. 17-18, 22-26). Bull trout normally reach sexual maturity in 4 to 7 years and may live longer than 12 years. They are iteroparous (they spawn more than once in a lifetime). Repeat- and alternate-year spawning has been reported, although repeat-spawning frequency and post-spawning mortality are not well documented (Fraley and Shepard 1989, pp. 135-137; Leathe and Graham 1982, p. 95; Pratt 1992, p. 6; Rieman and McIntyre 1996, p. 133).

The iteroparous reproductive strategy of bull trout has important repercussions for the management of this species. Bull trout require passage both upstream and downstream, not only for repeat spawning but also for foraging. Most fish ladders, however, were designed specifically for anadromous semelparous salmonids (fishes that spawn once and then die, and require only one-way passage upstream). Therefore, even dams or other barriers with fish passage facilities may be a factor in isolating bull trout populations if they do not provide a downstream passage route. Additionally, in some core areas, bull trout that migrate to marine waters must pass both upstream and downstream through areas with net fisheries at river mouths. This can increase the likelihood of mortality to bull trout during these spawning and foraging migrations.

Growth varies depending upon life-history strategy. Resident adults range from 6 to 12 inches total length, and migratory adults commonly reach 24 inches or more (Goetz 1989, pp. 29-32; Pratt 1984, p. 13) The largest verified bull trout is a 32-pound specimen caught in Lake Pend Oreille, Idaho, in 1949 (Simpson and Wallace 1982).

Habitat Characteristics

Bull trout have more specific habitat requirements than most other salmonids (Rieman and McIntyre 1993, p. 7). Habitat components that influence bull trout distribution and abundance include water temperature, cover, channel form and stability, valley form, spawning and rearing substrate, and migratory corridors (Fraley and Shepard 1989, pp. 137, 141; Goetz 1989, pp. 19-26; Bond in Hoelscher and Bjornn 1989, p. 57; Howell and Buchanan 1992, p. 1; Pratt 1992, p. 6; Rich 1996, pp. 35-38; Rieman and McIntyre 1993, pp. 4-7; Rieman and McIntyre 1995, pp. 293-294; Sedell and Everest 1991, p. 1; Watson and Hillman 1997, pp. 246-250). Watson and Hillman (1997, pp. 247-249) concluded that watersheds must have specific physical characteristics to provide the habitat requirements necessary for bull trout to successfully spawn and rear and that these specific characteristics are not necessarily present throughout these

watersheds. Because bull trout exhibit a patchy distribution, even in pristine habitats (Rieman and McIntyre 1993, p. 7), bull trout should not be expected to simultaneously occupy all available habitats (Rieman et al. 1997, p. 1560).

Migratory corridors link seasonal habitats for all bull trout life histories. The ability to migrate is important to the persistence of bull trout (Gilpin, in litt. 1997, pp. 4-5; Rieman and McIntyre 1993, p. 7; Rieman et al. 1997, p. 1114). Migrations facilitate gene flow among local populations when individuals from different local populations interbreed or stray to nonnatal streams. Local populations that are extirpated by catastrophic events may also become reestablished by bull trout migrants. However, it is important to note that the genetic structuring of bull trout indicates there is limited gene flow among bull trout populations, which may encourage local adaptation within individual populations, and that reestablishment of extirpated populations may take a long time (Rieman and McIntyre 1993, p. 7; Spruell et al. 1999, pp. 118-120). Migration also allows bull trout to access more abundant or larger prey, which facilitates growth and reproduction. Additional benefits of migration and its relationship to foraging are discussed below under "Diet."

Cold water temperatures play an important role in determining bull trout habitat quality, as these fish are primarily found in colder streams (below 15 °C or 59 °F), and spawning habitats are generally characterized by temperatures that drop below 9 °C (48 °F) in the fall (Fraley and Shepard 1989, p. 133; Pratt 1992, p. 6; Rieman and McIntyre 1993, p. 7).

Thermal requirements for bull trout appear to differ at different life stages. Spawning areas are often associated with cold-water springs, groundwater infiltration, and the coldest streams in a given watershed (Baxter et al. 1997, pp. 426-427; Pratt 1992, p. 6; Rieman and McIntyre 1993, p. 7; Rieman et al. 1997, p. 1117). Optimum incubation temperatures for bull trout eggs range from 2 °C to 6 °C (35 °F to 39 °F) whereas optimum water temperatures for rearing range from about 6 °C to 10 °C (46 °F to 50 °F) (Buchanan and Gregory 1997, pp. 121-122; Goetz 1989, pp. 22-24; McPhail and Murray 1979, pp. 41, 50, 53, 55). In Granite Creek, Idaho, Bonneau and Scarnecchia (1996) observed that juvenile bull trout selected the coldest water available in a plunge pool, 8 °C to 9 °C (46 °F to 48 °F), within a temperature gradient of 8 °C to 15 °C (4 °F to 60 °F). In a landscape study relating bull trout distribution to maximum water temperatures, Dunham et al. (2003) found that the probability of juvenile bull trout occurrence does not become high (i.e., greater than 0.75) until maximum temperatures decline to 11 °C to 12 °C (52 °F to 54 °F).

Although bull trout are found primarily in cold streams, occasionally these fish are found in larger, warmer river systems throughout the Columbia River basin (Buchanan and Gregory 1997, pp. 121-122; Fraley and Shepard 1989, pp. 135-137; Rieman and McIntyre 1993, p. 2; Rieman and McIntyre 1995, p. 288; Rieman et al. 1997, p. 1114). Availability and proximity of cold water patches and food productivity can influence bull trout ability to survive in warmer rivers (Myrick et al. 2002). For example, in a study in the Little Lost River of Idaho where bull trout were found at temperatures ranging from 8 °C to 20 °C (46 °F to 68 °F), most sites that had high densities of bull trout were in areas where primary productivity in streams had increased following a fire (Bart Gamett, pers. comm. 2002).

All life history stages of bull trout are associated with complex forms of cover, including large woody debris, undercut banks, boulders, and pools (Fraley and Shepard 1989, pp. 135-137; Goetz 1989, pp. 22-25; Hoelscher and Bjornn 1989, p. 54; Pratt 1992, p. 6; Rich 1996, pp. 35-38; Sedell and Everest 1991, p. 1; Sexauer and James 1997, pp. 367-369; Thomas 1992, pp. 4-5; Watson and Hillman 1997, pp. 247-249). Maintaining bull trout habitat requires stability of stream channels and maintenance of natural flow patterns (Rieman and McIntyre 1993, p. 7). Juvenile and adult bull trout frequently inhabit side channels, stream margins, and pools with suitable cover (Sexauer and James 1997, pp. 367-369). These areas are sensitive to activities that directly or indirectly affect stream channel stability and alter natural flow patterns. For example, altered stream flow in the fall may disrupt bull trout during the spawning period, and channel instability may decrease survival of eggs and young juveniles in the gravel from winter through spring (Fraley and Shepard 1989, pp. 135-137; Pratt 1992, p. 6; Pratt and Huston 1993, pp. 70-72). Pratt (1992, p. 6) indicated that increases in fine sediment reduce egg survival and emergence.

Bull trout typically spawn from August through November during periods of increasing flows and decreasing water temperatures. Preferred spawning habitat consists of low-gradient stream reaches with loose, clean gravel (Fraley and Shepard 1989, p. 135). Redds are often constructed in stream reaches fed by springs or near other sources of cold groundwater (Goetz 1989, p. 15; Pratt 1992, p. 8; Rieman and McIntyre 1996, p. 133). Depending on water temperature, incubation is normally 100 to 145 days (Pratt 1992, p. 8). After hatching, fry remain in the substrate, and time from egg deposition to emergence may surpass 200 days. Fry normally emerge from early April through May, depending on water temperatures and increasing stream flows (Ratliff and Howell 1992 in Howell and Buchanan 1992, pp. 10, 15; Pratt 1992, pp. 5-6).

Early life stages of fish, specifically the developing embryo, require the highest inter-gravel dissolved oxygen (IGDO) levels, and are the most sensitive life stage to reduced oxygen levels. The oxygen demand of embryos depends on temperature and on stage of development, with the greatest IGDO required just prior to hatching.

A literature review conducted by the Washington Department of Ecology (WDOE 2002) indicates that adverse effects of lower oxygen concentrations on embryo survival are magnified as temperatures increase above optimal (for incubation). In a laboratory study conducted in Canada, researchers found that low oxygen levels retarded embryonic development in bull trout (Giles and Van der Zweep 1996, pp. 54-55). Normal oxygen levels seen in rivers used by bull trout during spawning ranged from 8 to 12 mg/L (in the gravel), with corresponding instream levels of 10 to 11.5 mg/L (Stewart et al. 2007). In addition, IGDO concentrations, water velocities in the water column, and especially the intergravel flow rate, are interrelated variables that affect the survival of incubating embryos (ODEQ 1995). Due to a long incubation period of 220+ days, bull trout are particularly sensitive to adequate IGDO levels. An IGDO level below 8 mg/L is likely to result in mortality of eggs, embryos, and fry.

Migratory forms of bull trout may develop when habitat conditions allow movement between spawning and rearing streams and larger rivers, lakes or nearshore marine habitat where foraging opportunities may be enhanced (Brenkman and Corbett 2005, pp. 1073, 1079-1080; Frissell 1993, p. 350; Goetz et al. 2004, pp. 45, 55, 60, 68, 77, 113-114, 123, 125-126). For example, multiple life history forms (e.g., resident and fluvial) and multiple migration patterns have been

noted in the Grande Ronde River (Baxter 2002). Parts of this river system have retained habitat conditions that allow free movement between spawning and rearing areas and the mainstem Snake River. Such multiple life history strategies help to maintain the stability and persistence of bull trout populations to environmental changes. Benefits to migratory bull trout include greater growth in the more productive waters of larger streams, lakes, and marine waters; greater fecundity resulting in increased reproductive potential; and dispersing the population across space and time so that spawning streams may be recolonized should local populations suffer a catastrophic loss (Frissell 1999, pp. 15-16; MBTSG 1998, pp. iv, 48-50; Rieman and McIntyre 1993, pp. 18-19; USFWS 2004a, Vol. 2, p. 63). In the absence of the migratory bull trout life form, isolated populations cannot be replenished when disturbances make local habitats temporarily unsuitable. Therefore, the range of the species is diminished, and the potential for a greater reproductive contribution from larger fish with higher fecundity is lost (Rieman and McIntyre 1993, pp. 1-18).

Diet

Bull trout are opportunistic feeders, with food habits primarily a function of size and life-history strategy. A single optimal foraging strategy is not necessarily a consistent feature in the life of a fish, because this strategy can change as the fish progresses from one life stage to another (i.e., juvenile to subadult). Fish growth depends on the quantity and quality of food that is eaten (Gerking 1994), and as fish grow, their foraging strategy changes as their food changes, in quantity, size, or other characteristics. Resident and juvenile migratory bull trout prey on terrestrial and aquatic insects, macrozooplankton, and small fish (Boag 1987, p. 58; Donald and Alger 1993, pp. 239-243; Goetz 1989, pp. 33-34). Subadult and adult migratory bull trout feed on various fish species (Brown 1994, p. 21; Donald and Alger 1993, p. 242; Fraley and Shepard 1989, p. 135; Leathe and Graham 1982, p. 95). Bull trout of all sizes other than fry have been found to eat fish up to half their length (Beauchamp and VanTassell 2001). In nearshore marine areas of western Washington, bull trout feed on Pacific herring (*Clupea pallasi*), Pacific sand lance (*Ammodytes hexapterus*), and surf smelt (*Hypomesus pretiosus*) (Goetz et al. 2004, p. 114; WDFW et al. 1997, p. 23).

Bull trout migration and life history strategies are closely related to their feeding and foraging strategies. Migration allows bull trout to access optimal foraging areas and exploit a wider variety of prey resources. Optimal foraging theory can be used to describe strategies fish use to choose between alternative sources of food by weighing the benefits and costs of capturing one source of food over another. For example, prey often occur in concentrated patches of abundance ("patch model" ; (Gerking 1994). As the predator feeds in one patch, the prey population is reduced, and it becomes more profitable for the predator to seek a new patch rather than continue feeding on the original one. This can be explained in terms of balancing energy acquired versus energy expended. For example, in the Skagit River system, anadromous bull trout make migrations as long as 121 miles between marine foraging areas in Puget Sound and headwater spawning grounds, foraging on salmon eggs and juvenile salmon along their migration route (WDFW et al. 1997). Anadromous bull trout also use marine waters as migration corridors to reach seasonal habitats in non-natal watersheds to forage and possibly overwinter (Brenkman and Corbett 2005, p. 1079; Goetz et al. 2004, pp. 36, 60).

Changes in Status of the Coastal-Puget Sound Interim Recovery Unit

Although the status of bull trout in Coastal-Puget Sound interim recovery unit has been improved by certain actions, it continues to be degraded by other actions, and it is likely that the overall status of the bull trout in this population segment has not improved since its listing on November 1, 1999. Improvement has occurred largely through changes in fishing regulations and habitat-restoration projects. Fishing regulations enacted in 1994 either eliminated harvest of bull trout or restricted the amount of harvest allowed, and this likely has had a positive influence on the abundance of bull trout. Improvement in habitat has occurred following restoration projects intended to benefit either bull trout or salmon, although monitoring the effectiveness of these projects seldom occurs. On the other hand, the status of this population segment has been adversely affected by a number of Federal and non-Federal actions, some of which were addressed under section 7 of the Act. Most of these actions degraded the environmental baseline; all of those addressed through formal consultation under section 7 of the Act permitted the incidental take of bull trout.

Section 10(a)(1)(B) permits have been issued for Habitat Conservation Plans (HCP) completed in the Coastal-Puget Sound population segment. These include: 1) the City of Seattle's Cedar River Watershed HCP, 2) Simpson Timber HCP (now Green Diamond Resources), 3) Tacoma Public Utilities Green River HCP, 4) Plum Creek Cascades HCP, 5) Washington State Department of Natural Resources (WSDNR) State Trust Lands HCP, 6) West Fork Timber HCP, and 7) WSDNR Forest Practices HCP. These HCPs provide landscape-scale conservation for fish, including bull trout. Many of the covered activities associated with these HCPs will contribute to conserving bull trout over the long-term; however, some covered activities will result in short-term degradation of the baseline. All HCPs permit the incidental take of bull trout.

Changes in Status of the Columbia River Interim Recovery Unit

The overall status of the Columbia River interim recovery unit has not changed appreciably since its listing on June 10, 1998. Populations of bull trout and their habitat in this area have been affected by a number of actions addressed under section 7 of the Act. Most of these actions resulted in degradation of the environmental baseline of bull trout habitat, and all permitted or analyzed the potential for incidental take of bull trout. The Plum Creek Cascades HCP, Plum Creek Native Fish HCP, Storedahl Daybreak Mine HCP, and WSDNR Forest Practices HCP addressed portions of the Columbia River population segment of bull trout.

Changes in Status of the Klamath River Interim Recovery Unit

Improvements in the Threemile, Sun, and Long Creek local populations have occurred through efforts to remove or reduce competition and hybridization with non-native salmonids, changes in fishing regulations, and habitat-restoration projects. Population status in the remaining local populations (Boulder-Dixon, Deming, Brownsworth, and Leonard Creeks) remains relatively unchanged. Grazing within bull trout watersheds throughout the recovery unit has been curtailed. Efforts at removal of non-native species of salmonids appear to have stabilized the Threemile and positively influenced the Sun Creek local populations. The results of similar

efforts in Long Creek are inconclusive. Mark and recapture studies of bull trout in Long Creek indicate a larger migratory component than previously expected.

Although the status of specific local populations has been slightly improved by recovery actions, the overall status of Klamath River bull trout continues to be depressed. Factors considered threats to bull trout in the Klamath Basin at the time of listing – habitat loss and degradation caused by reduced water quality, past and present land use management practices, water diversions, roads, and non-native fishes – continue to be threats today.

Changes in Status of the Saint Mary-Belly River Interim Recovery Unit

The overall status of bull trout in the Saint Mary-Belly River interim recovery unit has not changed appreciably since its listing on November 1, 1999. Extensive research efforts have been conducted since listing, to better quantify populations of bull trout and their movement patterns. Limited efforts in the way of active recovery actions have occurred. Habitat occurs mostly on Federal and Tribal lands (Glacier National Park and the Blackfeet Nation). Known problems due to instream flow depletion, entrainment, and fish passage barriers resulting from operations of the U.S. Bureau of Reclamation's Milk River Irrigation Project (which transfers Saint Mary-Belly River water to the Missouri River Basin) and similar projects downstream in Canada constitute the primary threats to bull trout and to date they have not been adequately addressed under section 7 of the Act. Plans to upgrade the aging irrigation delivery system are being pursued, which has potential to mitigate some of these concerns but also the potential to intensify dewatering. A major fire in August 2006 severely burned the forested habitat in Red Eagle and Divide Creeks, potentially affecting three of nine local populations and degrading the baseline.

LITERATURE CITED

Battin, J., M.W. Wiley, M.H. Ruckelshaus, R.N. Palmer, E. Korb, K.K. Bartz, and H. Imaki. 2007. Projected impacts of climate change on salmon habitat restoration. Proceedings of the National Academy of Sciences of the United States of America 104(16):6720-6725.

Baxter, C.V. 2002. Fish movement and assemblage dynamics in a Pacific Northwest riverscape. Doctoral dissertation. Oregon State University, Corvallis, OR.

Baxter, J.S., E.B. Taylor, and R.H. Devlin. 1997. Evidence for natural hybridization between dolly varden (*Salvelinus malma*) and bull trout (*Salvelinus confluentus*) in a northcentral British Columbia watershed. Canadian Journal of Fisheries and Aquatic Sciences 54:421-429.

Beauchamp, D.A., and J.J. VanTassell. 2001. Modeling seasonal trophic interactions of adfluvial bull trout in Lake Billy Chinook, Oregon. Transactions of the American Fisheries Society 130:204-216.

Boag, T.D. 1987. Food habits of bull char (*Salvelinus confluentus*), and rainbow trout (*Salmo gairdneri*), coexisting in a foothills stream in northern Alberta. Canadian Field-Naturalist 101(1):56-62.

Bond, C.E. 1992. Notes on the nomenclature and distribution of the bull trout and the effects of human activity on the species. Pages 1-4 *In* P.J. Howell, and D.V. Buchanan, eds. Proceedings of the Gearhart Mountain bull trout workshop, Oregon Chapter of the American Fisheries Society, Corvallis, OR.

Bonneau, J.L., and D.L. Scarnecchia. 1996. Distribution of juvenile bull trout in a thermal gradient of a plunge pool in Granite Creek, Idaho. Transactions of the American Fisheries Society 125(4):628-630.

Brenkman, S.J., and S.C. Corbett. 2005. Extent of anadromy in bull trout and implications for conservation of a threatened species. North American Journal of Fisheries Management 25:1073-1081.

Brewin, P.A., and M.K. Brewin. 1997. Distribution maps for bull trout in Alberta. Pages 209-216 *In* W.C. Mackay, M.K. Brewin, and M. Monita, eds. Friends of the Bull Trout Conference Proceedings, Bull Trout Task Force (Alberta), c/o Trout Unlimited, Calgary.

Brown, L.G. 1994. The zoogeography and life history of Washington native charr. Washington Department of Fish and Widlife, Fisheries Management Division, Report # 94-04, Olympia, WA, November, 1992. 47 pp.

Buchanan, D.V., and S.V. Gregory. 1997. Development of water temperature standards to protect and restore habitat for bull trout and other cold water species in Oregon. Pages 119-126 *In* W.C. Mackay, M.K. Brewing, and M. Monita, eds. Friends of the Bull Trout Conference Proceedings, , Alberta, Canada.

Cavender, T.M. 1978. Taxonomy and distribution of the bull trout, *Salvelinus confluentus* (Suckley), from the American Northwest. California Fish and Game 64(3):139-174.

Donald, D.B., and D.J. Alger. 1993. Geographic distribution, species displacement, and niche overlap for lake trout and bull trout in mountain lakes. Canadian Journal of Zoology 71:238-247.

Dunham, J., B. Rieman, and G. Chandler. 2003. Influence of temperature and environmental variables on the distribution of bull trout within streams at the southern margin of its range. North American Journal of Fisheries Management 23:894-905.

Fraley, J.J., and B.B. Shepard. 1989. Life history, ecology and population status of migratory bull trout (*Salvelinus confluentus*) in the Flathead Lake and River system, Montana. Northwest Science 63:133-143.

Frissell, C.A. 1993. Topology of extinction and endangerment of native fishes in the Pacific Northwest and California. Conservation Biology 7(2):342-354.

Frissell, C.A. 1999. An ecosystem approach to habitat conservation for bull trout: groundwater and surface water protection. Flathead Lake Biological Station, University of Montana, Open File Report Number 156-99, Polson, MT. 46 pp.

Gamett, B.L. 2002. Telephone conversation between Bart L. Gamett, Salmon-Challis National Forest, and Shelley Spalding, USFWS, re: relationship between water temperature and bull trout distribution and abundance in the Little Lost River, Idaho. June 20, 2002.

Gerking, S.D. 1994. Feeding ecology of fish. Academic Press, San Diego, California.

Giles, M.A., and M. Van der Zweep. 1996. Dissolved Oxygen Requirements for Fish of the Peace, Athabasca and Slave River Basins: A Laboratory Study of Bull Trout *(Salveninus Confluentus)* and Mountain Whitefish *(Prosopium Williamsoni)* , Northern River Basins Study Technical Report No. 120 ed.

Gilpin, M. 1997. Memo to Shelly Spalding, Montana Department of Fish, Wildlife, and Parks. Connectivity on the Clark Fork River: The Bigger Picture. August 27, 1997.

Goetz, F. 1989. Biology of the bull trout, *Salvelinus confluentus*, a literature review. Willamette National Forest, Eugene, Oregon.

Goetz, F., E.D. Jeanes, and E.M. Beamer. 2004. Bull trout in the nearshore. U.S. Army Corps of Engineers, Preliminary draft, Seattle, Washington, June, 2004. 396 pp.

Hoelscher, B., and T.C. Bjornn. 1989. Habitat, density, and potential production of trout and char in Pend Oreille Lake tributaries. Idaho Department of Fish and Game, Project F-710R-10, Subproject III, Job No. 8., Boise, Idaho.

Howell, P.J., and D.V. Buchanan. 1992. Proceedings of the Gearhart Mountain bull trout workshop. Oregon Chapter of the American Fisheries Society, Corvallis, Oregon.

IDFG (Idaho Department of Fish and Game). 1995. List of streams compiled by IDFG where bull trout have been extirpated.

Leary, R.F., and F.W. Allendorf. 1997. Genetic confirmation of sympatric bull trout and Dolly Varden in western Washington. Transactions of the American Fisheries Society 126:715-720.

Leathe, S.A., and P.J. Graham. 1982. Flathead Lake fish food habits study. US EPA, Region VIII, Water Division, Contract R008224-01-4, Denver, Colorado, October, 1982. 209 pp.

MBTSG (The Montana Bull Trout Scientific Group). 1998. The relationship between land management activities and habitat requirements of bull trout. Montana Fish, Wildlife, and Parks, Helena, MT, May 1998. 77 pp.

McPhail, J.D., and J.S. Baxter. 1996. A review of bull trout (*Salvelinus confluentus*) life-history and habitat use in relation to compensation and improvement opportunities. Department of Zoology, University of British Columbia, Fisheries Management Report Number 104, Vancouver, BC. 31 pp.

McPhail, J.D., and C.B. Murray. 1979. The early life-history and ecology of dolly varden (*Salvelinus Malma*) in the upper Arrow Lakes. Department of Zoology and Institute of Animal Resource Ecology, Fort Steele, British Columbia. 113 pp.

Myrick, C.A., F.T. Barrow, J. Dunham, B.L. Gamett, G.R. Haas, J.T. Peterson, B. Rieman, L.A. Weber, and A.V. Zale. 2002. Bull trout temperature thresholds: Peer review summary. U.S. Fish and Wildlife Service, Lacey, Washington. 13 pp.

ODEQ (Oregon Department of Environmental Quality). 1995. 1992-1994 water quality standards review: dissolved oxygen - final issue paper. Oregon Department of Environmental Quality, Portland, OR.

Pratt, K.L. 1984. Habitat use and species interactions of juvenile cutthroat, *Salmo clarki*, and bull trout, *Salvelinus confluentus*, in the upper Flathead River basin. Master's Thesis. University of Idaho, Moscow, ID.

Pratt, K.L. 1992. A review of bull trout life history. Pages 5-9 *In* P.J. Howell, and D.V. Buchanan, eds. Proceedings of the Gearhart Mountain bull trout workshop, Oregon Chapter of the American Fisheries Society, Corvallis, OR.

Pratt, K.L., and J.E. Huston. 1993. Status of bull trout (*Salvelinus confluentus*) in Lake Pend Oreille and the lower Clark Fork River. Washington Water Power Company, Spokane, WA. 200 pp.

Quigley, T.M., and S.J. Arbelbide. 1997. An assessment of ecosystem components in the interior Columbia Basin and portions of the Klamath and Great Basins: Volume 3. U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station 3:1174-1185.

Rich, C.F. 1996. Influence of abiotic and biotic factors on occurrence of resident Bull Trout in fragmented habitats, Western Montana. Master's Thesis. Montana State University, Bozeman, MT.

Rieman, B.E., D. Isaak, S. Adams, D. Horan, D. Nagel, C.H. Luce, and D. Myers. 2007. Anticipated climate warming effects on bull trout habitats and populations across the interior Columbia River Basin. Transactions of the American Fisheries Society 136(6):1552-1565.

Rieman, B.E., D. Lee, D. Burns, R.E. Gresswell, M.K. Young, R. Stowell, and P. Howell. 2003. Status of native fishes in western United States and issues for fire and fuels management. Forest Ecology and Management 178(1-2):197-211.

Rieman, B.E., D.C. Lee, and R.F. Thurow. 1997. Distribution, status, and likely future trends of bull trout within the Columbia River and Klamath River basins. North American Journal of Fisheries Management 7:1111-1125.

Rieman, B.E., and J.D. McIntyre. 1993. Demographic and habitat requirements for conservation of bull trout. U.S. Department of Agriculture, Forest Service, Intermountain Research Station, General Technical Report INT-302, Ogden, Utah. 38 pp.

Rieman, B.E., and J.D. McIntyre. 1995. Occurrence of bull trout in naturally fragmented habitat patches of varied size. Transactions of the American Fisheries Society 124(3):285-296.

Rieman, B.E., and J.D. McIntyre. 1996. Spatial and temporal variability in bull trout redd counts. North American Journal of Fisheries Management 16:132-141.

Sedell, J.R., and F.H. Everest. 1991. Historic changes in pool habitat for Columbia River Basin salmon under study for TES listing. Pacific Northwest Research Station, Draft U.S. Department of Agriculture Report, Corvallis, Oregon. 6 pp.

Sexauer, H.M., and P.W. James. 1997. Microhabitat use by juvenile trout in four streams located in the eastern Cascades, Washington. Pages 361-370 *In* W.C. McKay, M.K. Brewin, and M. Monita, eds. Friends of the Bull Trout Conference Proceedings, Bull Trout Task Force (Alberta), c/o Trout Unlimited, Calgary, Alberta, Canada.

Simpson, J.C., and R.L. Wallace. 1982. Fishes of Idaho. University of Idaho Press, Moscow, ID.

Spruell, P., B.E. Rieman, K.L. Knudsen, F.M. Utter, and F.W. Allendorf. 1999. Genetic population structure within streams: Microsatellite analysis of bull trout populations. Ecology of Freshwater Fish 8:114-121.

Stewart, D.B., N.J. Mochnacz, C.D. Sawatzky, T.J. Carmichael, and J.D. Reist. 2007. Fish life history and habitat use in the Northwest territories: Bull trout (*Salvelinus confluentus*). Department of Fisheries and Oceans, Canadian Manuscript Report of Fisheries and Aquatic Sciences 2801, Winnipeg, MB, Canada, 2007. 54 pp.

Thomas, G. 1992. Status of bull trout in Montana. Montana Department of Fish, Wildlife and Parks, Helena, MT. 83 pp.

USFWS. 2002a. Bull trout (*Salvelinus confluentus*) draft recovery plan - Chapter 2: Klamath River. U.S. Fish and Wildlife Service, Portland, Oregon.

USFWS. 2002b. Bull trout (*Salvelinus confluentus*) draft recovery plan - Chapter 25: Saint Mary-Belly River. U.S. Fish and Wildlife Service, Portland, Oregon.

USFWS. 2002c. Chapter 20 of the bull trout *(Salvelinus confluentus)* draft recovery plan: Lower Columbia Recovery Unit, Washington. USFWS, Region 1, Portland, Oregon. 102 pp.

USFWS. 2004a. Draft Recovery Plan for the Coastal-Puget Sound distinct population segment of bull trout (*Salvelinus confluentus*). Volume I: Puget Sound Management Unit, 389+xvii pp and Volume II: Olympic Peninsula Management Unit, 277+xvi pp, Portland, Oregon.

USFWS. 2004b. Draft recovery plan for the Jarbridge River distinct population segment of the bull trout (*Salvelinus confluentus*). U.S. Fish and Wildlife Service, Portland, Oregon. xii + 132 pp.

USFWS. 2005. Bull trout core area template - complete core area by core area analysis. U.S. Fish and Wildlife Service, Portland, Oregon. 662 pp.

Watson, G., and T.W. Hillman. 1997. Factors affecting the distribution and abundance of bull trout: an investigation at hierarchical scales. North American Journal of Fisheries Management 17(2):237-252.

WDFW, FishPro Inc., and Beak Consultants. 1997. Grandy Creek trout hatchery biological assessment. Washington Department of Fish and Wildlife, Olympia, WA, March 1997. 47 pp.

WDOE. 2002. Evaluating criteria for the protection of freshwater aquatic life in Washington's surface water quality standards - dissolved oyxgen: Draft discussion paper and literature summary. Washington Department of Ecology, Publication Number 00-10-071, Olympia, WA, December 2002. 90 pp.

APPENDIX C: Status of Designated Critical Habitat (Bull Trout; Coterminous Range)

Appendix C:
Status of Designated Critical Habitat (Bull Trout; Coterminous Range)

Legal Status

Current Designation

The Service published a final critical habitat designation for the coterminous United States population of the bull trout on October 18, 2010 (70 FR 63898); the rule becomes effective on November 17, 2010. A justification document was also developed to support the rule and is available on our website (http://www.fws.gov/pacific/bulltrout). The scope of the designation involved the species' coterminous range, which includes the Jarbidge River, Klamath River, Columbia River, Coastal-Puget Sound, and Saint Mary-Belly River population segments (also considered as interim recovery units)1. Rangewide, the Service designated reservoirs/lakes and stream/shoreline miles as bull trout critical habitat (Table 1). Designated bull trout critical habitat is of two primary use types: 1) spawning and rearing, and 2) foraging, migration, and overwintering (FMO).

Table 1. Stream/shoreline distance and reservoir/lake area designated as bull trout critical habitat by state.

State	Stream/Shoreline Miles	Stream/Shoreline Kilometers	Reservoir /Lake Acres	Reservoir/ Lake Hectares
Idaho	8,771.6	14,116.5	170,217.5	68,884.9
Montana	3,056.5	4,918.9	221,470.7	89,626.4
Nevada	71.8	115.6	-	-
Oregon	2,835.9	4,563.9	30,255.5	12,244.0
Oregon/Idaho	107.7	173.3	-	-
Washington	3,793.3	6,104.8	66,308.1	26,834.0
Washington (marine)	753.8	1,213.2	-	-
Washington/Idaho	37.2	59.9	-	-
Washington/Oregon	301.3	484.8	-	-
Total	19,729.0	31,750.8	488,251.7	197,589.2

The 2010 revision increases the amount of designated bull trout critical habitat by approximately 76 percent for miles of stream/shoreline and by approximately 71 percent for acres of lakes and reservoirs compared to the 2005 designation.

This rule also identifies and designates as critical habitat approximately 1,323.7 km (822.5 miles) of streams/shorelines and 6,758.8 ha (16,701.3 acres) of lakes/reservoirs of unoccupied habitat to address bull trout conservation needs in specific geographic areas in several areas not occupied at the time of listing. No unoccupied habitat was included in the 2005 designation. These

1 The Service's 5 year review (USFWS 2008, pg. 9) identifies six draft recovery units. Until the bull trout draft recovery plan is finalized, the current five interim recovery units are in affect for purposes of section 7 jeopardy analysis and recovery. The adverse modification analysis does not rely on recovery units.

unoccupied areas were determined by the Service to be essential for restoring functioning migratory bull trout populations based on currently available scientific information. These unoccupied areas often include lower main stem river environments that can provide seasonally important migration habitat for bull trout. This type of habitat is essential in areas where bull trout habitat and population loss over time necessitates reestablishing bull trout in currently unoccupied habitat areas to achieve recovery.

The final rule continues to exclude some critical habitat segments based on a careful balancing of the benefits of inclusion versus the benefits of exclusion. Critical habitat does not include: 1) waters adjacent to non-Federal lands covered by legally operative incidental take permits for habitat conservation plans (HCPs) issued under section 10(a)(1)(B) of the Endangered Species Act of 1973, as amended (Act), in which bull trout is a covered species on or before the publication of this final rule; 2) waters within or adjacent to Tribal lands subject to certain commitments to conserve bull trout or a conservation program that provides aquatic resource protection and restoration through collaborative efforts, and where the Tribes indicated that inclusion would impair their relationship with the Service; or 3) waters where impacts to national security have been identified (75 FR 63898). Excluded areas are approximately 10 percent of the stream/shoreline miles and 4 percent of the lakes and reservoir acreage of designated critical habitat. Each excluded area is identified in the relevant Critical Habitat Unit (CHU) text, as identified in paragraphs (e)(8) through (e)(41) of the final rule. See Tables 2 and 3 for the list of excluded areas. It is important to note that the exclusion of waterbodies from designated critical habitat does not negate or diminish their importance for bull trout conservation. Because exclusions reflect the often complex pattern of land ownership, designated critical habitat is often fragmented and interspersed with excluded stream segments.

Table 2.—Stream/shoreline distance excluded from bull trout critical habitat based on tribal ownership or other plan.

Ownership and/or Plan	Kilometers	Miles
Lewis River Hydro Conservation Easements	7.0	4.3
DOD – Dabob Bay Naval	23.9	14.8
HCP – Cedar River (City of Seattle)	25.8	16.0
HCP – Washington Forest Practices Lands	1,608.30	999.4
HCP – Green Diamond (Simpson)	104.2	64.7
HCP – Plum Creek Central Cascades (WA)	15.8	9.8
HCP – Plum Creek Native Fish (MT)	181.6	112.8
HCP–Stimson	7.7	4.8
HCP – WDNR Lands	230.9	149.5
Tribal – Blackfeet	82.1	51.0
Tribal – Hoh	4.0	2.5
Tribal – Jamestown S’Klallam	2.0	1.2
Tribal – Lower Elwha	4.6	2.8
Tribal – Lummi	56.7	35.3
Tribal – Muckleshoot	9.3	5.8
Tribal – Nooksack	8.3	5.1
Tribal – Puyallup	33.0	20.5
Tribal – Quileute	4.0	2.5

Ownership and/or Plan	Kilometers	Miles
Tribal – Quinault	153.7	95.5
Tribal – Skokomish	26.2	16.3
Tribal – Stillaguamish	1.8	1.1
Tribal – Swinomish	45.2	28.1
Tribal – Tulalip	27.8	17.3
Tribal – Umatilla	62.6	38.9
Tribal – Warm Springs	260.5	161.9
Tribal – Yakama	107.9	67.1
Total	3,094.9	1,923.1

Table 3. Lake/Reservoir area excluded from bull trout critical habitat based on tribal ownership or other plan.

Ownership and/or Plan	Hectares	Acres
HCP – Cedar River (City of Seattle)	796.5	1,968.2
HCP – Washington Forest Practices Lands	5,689.1	14,058.1
HCP – Plum Creek Native Fish	32.2	79.7
Tribal – Blackfeet	886.1	2,189.5
Tribal – Warm Springs	445.3	1,100.4
Total	7,849.3	19,395.8

Conservation Role and Description of Critical Habitat

The conservation role of bull trout critical habitat is to support viable core area populations (75 FR 63898:63943 [October 18, 2010]). The core areas reflect the metapopulation structure of bull trout and are the closest approximation of a biologically functioning unit for the purposes of recovery planning and risk analyses. CHUs generally encompass one or more core areas and may include FMO areas, outside of core areas, that are important to the survival and recovery of bull trout.

Thirty-two CHUs within the geographical area occupied by the species at the time of listing are designated under the revised rule. Twenty-nine of the CHUs contain all of the physical or biological features identified in this final rule and support multiple life-history requirements. Three of the mainstem river units in the Columbia and Snake River basins contain most of the physical or biological features necessary to support the bull trout's particular use of that habitat, other than those physical biological features associated with Primary Constituent Elements (PCEs) 5 and 6, which relate to breeding habitat.

The primary function of individual CHUs is to maintain and support core areas, which 1) contain bull trout populations with the demographic characteristics needed to ensure their persistence and contain the habitat needed to sustain those characteristics (Rieman and McIntyre 1993, p. 19); 2) provide for persistence of strong local populations, in part, by providing habitat conditions that encourage movement of migratory fish (MBTSG 1998, pp. 48-49; Rieman and McIntyre 1993, pp. 22-23); 3) are large enough to incorporate genetic and phenotypic diversity, but small enough to ensure connectivity between populations (Hard 1995, pp. 314-315; Healey and Prince 1995, p. 182; MBTSG 1998, pp. 48-49; Rieman and McIntyre 1993, pp. 22-23); and 4) are distributed

throughout the historic range of the species to preserve both genetic and phenotypic adaptations (Hard 1995, pp. 321-322; MBTSG 1998, pp. 13-16; Rieman and Allendorf 2001, p. 763; Rieman and McIntyre 1993, p. 23).

The Olympic Peninsula and Puget Sound CHUs are essential to the conservation of amphidromous bull trout, which are unique to the Coastal-Puget Sound population segment. These CHUs contain marine nearshore and freshwater habitats, outside of core areas, that are used by bull trout from one or more core areas. These habitats, outside of core areas, contain PCEs that are critical to adult and subadult foraging, overwintering, and migration.

Primary Constituent Elements for Bull Trout

Within the designated critical habitat areas, the PCEs for bull trout are those habitat components that are essential for the primary biological needs of foraging, reproducing, rearing of young, dispersal, genetic exchange, or sheltering. Based on our current knowledge of the life history, biology, and ecology of this species and the characteristics of the habitat necessary to sustain its essential life-history functions, we have determined that the following PCEs are essential for the conservation of bull trout.

1. Springs, seeps, groundwater sources, and subsurface water connectivity (hyporheic flows) to contribute to water quality and quantity and provide thermal refugia.

2. Migration habitats with minimal physical, biological, or water quality impediments between spawning, rearing, overwintering, and freshwater and marine foraging habitats, including but not limited to permanent, partial, intermittent, or seasonal barriers.

3. An abundant food base, including terrestrial organisms of riparian origin, aquatic macroinvertebrates, and forage fish.

4. Complex river, stream, lake, reservoir, and marine shoreline aquatic environments, and processes that establish and maintain these aquatic environments, with features such as large wood, side channels, pools, undercut banks and unembedded substrates, to provide a variety of depths, gradients, velocities, and structure.

5. Water temperatures ranging from 2 °C to 15 °C (36 °F to 59 °F), with adequate thermal refugia available for temperatures that exceed the upper end of this range. Specific temperatures within this range will depend on bull trout life-history stage and form; geography; elevation; diurnal and seasonal variation; shading, such as that provided by riparian habitat; streamflow; and local groundwater influence.

6. In spawning and rearing areas, substrate of sufficient amount, size, and composition to ensure success of egg and embryo overwinter survival, fry emergence, and young-of-the-year and juvenile survival. A minimal amount of fine sediment, generally ranging in size from silt to coarse sand, embedded in larger substrates, is characteristic of these conditions. The size and amounts of fine sediment suitable to bull trout will likely vary from system to system.

7. A natural hydrograph, including peak, high, low, and base flows within historic and seasonal ranges or, if flows are controlled, minimal flow departure from a natural hydrograph.

8. Sufficient water quality and quantity such that normal reproduction, growth, and survival are not inhibited.

9. Sufficiently low levels of occurrence of non-native predatory (e.g., lake trout, walleye, northern pike, smallmouth bass); interbreeding (e.g., brook trout); or competing (e.g., brown trout) species that, if present, are adequately temporally and spatially isolated from bull trout.

The revised PCE's are similar to those previously in effect under the 2005 designation. The most significant modification is the addition of a ninth PCE to address the presence of nonnative predatory or competitive fish species. Although this PCE applies to both the freshwater and marine environments, currently no non-native fish species are of concern in the marine environment, though this could change in the future.

Note that only PCEs 2, 3, 4, 5, and 8 apply to marine nearshore waters identified as critical habitat. Also, lakes and reservoirs within the CHUs also contain most of the physical or biological features necessary to support bull trout, with the exception of those associated with PCEs 1 and 6. Additionally, all except PCE 6 apply to FMO habitat designated as critical habitat.

Critical habitat includes the stream channels within the designated stream reaches and has a lateral extent as defined by the bankfull elevation on one bank to the bankfull elevation on the opposite bank. Bankfull elevation is the level at which water begins to leave the channel and move into the floodplain and is reached at a discharge that generally has a recurrence interval of 1 to 2 years on the annual flood series. If bankfull elevation is not evident on either bank, the ordinary high-water line must be used to determine the lateral extent of critical habitat. The lateral extent of designated lakes is defined by the perimeter of the waterbody as mapped on standard 1:24,000 scale topographic maps. The Service assumes in many cases this is the full-pool level of the waterbody. In areas where only one side of the waterbody is designated (where only one side is excluded), the mid-line of the waterbody represents the lateral extent of critical habitat.

In marine nearshore areas, the inshore extent of critical habitat is the mean higher high-water (MHHW) line, including the uppermost reach of the saltwater wedge within tidally influenced freshwater heads of estuaries. The MHHW line refers to the average of all the higher high-water heights of the two daily tidal levels. Marine critical habitat extends offshore to the depth of 10 meters (m) (33 ft) relative to the mean low low-water (MLLW) line (zero tidal level or average of all the lower low-water heights of the two daily tidal levels). This area between the MHHW line and minus 10 m MLLW line (the average extent of the photic zone) is considered the habitat most consistently used by bull trout in marine waters based on known use, forage fish availability, and ongoing migration studies and captures geological and ecological processes

important to maintaining these habitats. This area contains essential foraging habitat and migration corridors such as estuaries, bays, inlets, shallow subtidal areas, and intertidal flats.

Adjacent shoreline riparian areas, bluffs, and uplands are not designated as critical habitat. However, it should be recognized that the quality of marine and freshwater habitat along streams, lakes, and shorelines is intrinsically related to the character of these adjacent features, and that human activities that occur outside of the designated critical habitat can have major effects on physical and biological features of the aquatic environment.

Activities that cause adverse effects to critical habitat are evaluated to determine if they are likely to "destroy or adversely modify" critical habitat by no longer serving the intended conservation role for the species or retaining those PCEs that relate to the ability of the area to at least periodically support the species. Activities that may destroy or adversely modify critical habitat are those that alter the PCEs to such an extent that the conservation value of critical habitat is appreciably reduced (75 FR 63898:63943; USFWS 2004, Vol. 1. pp. 140-193, Vol. 2. pp. 69-114). The Service's evaluation must be conducted at the scale of the entire critical habitat area designated, unless otherwise stated in the final critical habitat rule (USFWS and NMFS 1998, pp. 4-39). Thus, adverse modification of bull trout critical habitat is evaluated at the scale of the final designation, which includes the critical habitat designated for the Klamath River, Jarbidge River, Columbia River, Coastal-Puget Sound, and Saint Mary-Belly River population segments. However, we consider all 32 CHUs to contain features or areas essential to the conservation of the bull trout (75 FR 63898:63901, 63944). Therefore, if a proposed action would alter the physical or biological features of critical habitat to an extent that appreciably reduces the conservation function of one or more critical habitat units for bull trout, a finding of adverse modification of the entire designated critical habitat area may be warranted (75 FR 63898:63943).

Current Critical Habitat Condition Rangewide

The condition of bull trout critical habitat varies across its range from poor to good. Although still relatively widely distributed across its historic range, the bull trout occurs in low numbers in many areas, and populations are considered depressed or declining across much of its range (67 FR 71240). This condition reflects the condition of bull trout habitat. The decline of bull trout is primarily due to habitat degradation and fragmentation, blockage of migratory corridors, poor water quality, past fisheries management practices, impoundments, dams, water diversions, and the introduction of nonnative species (63 FR 31647, June 10 1998; 64 FR 17112, April 8, 1999).

There is widespread agreement in the scientific literature that many factors related to human activities have impacted bull trout and their habitat, and continue to do so. Among the many factors that contribute to degraded PCEs, those which appear to be particularly significant and have resulted in a legacy of degraded habitat conditions are as follows: 1) fragmentation and isolation of local populations due to the proliferation of dams and water diversions that have eliminated habitat, altered water flow and temperature regimes, and impeded migratory movements (Dunham and Rieman 1999, p. 652; Rieman and McIntyre 1993, p. 7); 2) degradation of spawning and rearing habitat and upper watershed areas, particularly alterations in sedimentation rates and water temperature, resulting from forest and rangeland practices and

intensive development of roads (Fraley and Shepard 1989, p. 141; MBTSG 1998, pp. ii - v, 20-45); 3) the introduction and spread of nonnative fish species, particularly brook trout and lake trout, as a result of fish stocking and degraded habitat conditions, which compete with bull trout for limited resources and, in the case of brook trout, hybridize with bull trout (Leary et al. 1993, p. 857; Rieman et al. 2006, pp. 73-76); 4) in the Coastal-Puget Sound region where amphidromous bull trout occur, degradation of mainstem river FMO habitat, and the degradation and loss of marine nearshore foraging and migration habitat due to urban and residential development; and 5) degradation of FMO habitat resulting from reduced prey base, roads, agriculture, development, and dams.

Effects of Climate Change on Bull Trout Critical Habitat

One objective of the final rule was to identify and protect those habitats that provide resiliency for bull trout use in the face of climate change. Over a period of decades, climate change may directly threaten the integrity of the essential physical or biological features described in PCEs 1, 2, 3, 5, 7, 8, and 9. Protecting bull trout strongholds and cold water refugia from disturbance and ensuring connectivity among populations were important considerations in addressing this potential impact. Additionally, climate change may exacerbate habitat degradation impacts both physically (e.g., decreased base flows, increased water temperatures) and biologically (e.g., increased competition with non-native fishes).

Consulted on Effects for Critical Habitat

The Service has formally consulted on the effects to bull trout critical habitat throughout its range. Section 7 consultations include actions that continue to degrade the environmental baseline in many cases. However, long-term restoration efforts have also been implemented that provide some improvement in the existing functions within some of the critical habitat units.

LITERATURE CITED

Dunham, J.B. and B.E. Rieman. 1999. Metapopulation structure of bull trout: influences of physical, biotic, and geometrical landscape characteristics. Ecological Applications 9(2):642-55.

Fraley, J.J. and B.B. Shepard. 1989. Life history, ecology and population status of migratory bull trout (*Salvelinus confluentus*) in the Flathead Lake and River system, Montana. Northwest Science 63:133-43.

Hard, J. 1995. A quantitative genetic perspective on the conservation of intraspecific diversity. American Fisheries Society Symposium 17:304-26.

Healey, M.C. and A. Prince. 1995. Scales of variation in life history tactics of Pacific salmon and the conservation of phenotype and genotype. American Fisheries Society Symposium 17:176-84.

Leary, R.F., F.W. Allendorf, and S.H. Forbes. 1993. Conservation genetics of bull trout in the Columbia and Klamath River drainages. Conservation Biology 7(4):856-65.

MBTSG (The Montana Bull Trout Scientific Group). 1998. The relationship between land management activities and habitat requirements of bull trout. Montana Fish, Wildlife, and Parks, Helena, MT, May 1998, 77 pp.

Rieman, B.E. and F.W. Allendorf. 2001. Effective population size and genetic conservation criteria for bull trout. North American Journal of Fisheries Management 21:756-64.

Rieman, B.E. and J.D. McIntyre. 1993. Demographic and habitat requirements for conservation of bull trout. General Technical Report INT-302. U.S. Department of Agriculture, Forest Service, Intermountain Research Station, Ogden, Utah, 38 pp.

Rieman, B.E., J.T. Peterson, and D.E. Myers. 2006. Have brook trout (*Salvelinus fontinalis*) displaced bull trout (*Salvelinus confluentus*) along longitudinal gradients in central Idaho streams? Canadian Journal of Fish and Aquatic Sciences 63:63-78.

USFWS (U.S. Fish and Wildlife Service). 2004. Draft Recovery Plan for the Coastal-Puget Sound distinct population segment of bull trout (*Salvelinus confluentus*). Volume I: Puget Sound Management Unit, 389+xvii pp and Volume II: Olympic Peninsula Management Unit, 277+xvi pp. Portland, Oregon.

USFWS (U.S. Fish and Wildlife Service) and NMFS (National Marine Fisheries Service). 1998. Endangered Species Consultation Handbook: Procedures for conducting consultation and conference activities under Section 7 of the Endangered Species Act. U.S. GPO:2004-690-278. March 1998.

APPENDIX D: Core Area Summaries (Bull Trout)

APPENDIX D: Core Area Summaries (Bull Trout)

Puyallup Core Area

The Puyallup core area comprises the Puyallup, Mowich, and Carbon Rivers; the White River system, which includes the Clearwater, Greenwater, and the West Fork White Rivers; and Huckleberry Creek. Glacial sources in several watersheds drain the north and west sides of Mount Rainier and significantly influence water, substrate, and channel conditions in the mainstem reaches. The location of many of the basin's headwater reaches within Mount Rainier National Park and designated wilderness areas (Clearwater Wilderness, Norse Peak Wilderness) provides relatively pristine habitat conditions in these portions of the watershed.

Anadromous, fluvial, and potentially resident bull trout occur within local populations in the Puyallup River system. Bull trout occur throughout most of the system although spawning occurs primarily in the headwater reaches. Anadromous and fluvial bull trout use the mainstem reaches of the Puyallup, Carbon, and White Rivers to forage and overwinter, while the anadromous form also uses Commencement Bay and likely other nearshore areas within Puget Sound. Habitat conditions within the lower mainstem Puyallup and White Rivers have been highly degraded, retaining minimal instream habitat complexity. In addition, habitat conditions within Commencement Bay and adjoining nearshore areas have been severely degraded as well, with very little intact intertidal habitat remaining.

The Puyallup core area has the southernmost, anadromous bull trout population in the Puget Sound Management Unit (USFWS 2004, Vol. 2 p. 19). Consequently, maintaining the bull trout population in this core area is critical to maintaining the overall distribution of migratory bull trout in the management unit.

The status of the bull trout core area population is based on four key elements necessary for long-term viability: 1) number and distribution of local populations, 2) adult abundance, 3) productivity, and 4) connectivity (USFWS 2004, Vol 2 p. 215).

<u>Number and Distribution of Local Populations</u>

Five local populations occur in the Puyallup core area: 1) Upper Puyallup and Mowich Rivers, 2) Carbon River, 3) Upper White River, 4) West Fork White River, and 5) Greenwater River. The Clearwater River is identified as a potential local population, as bull trout are known to use this river and it appears to provide suitable spawning habitat, but the occurrence of reproduction there is unknown (USFWS 2004, Vol 2 pp. 119-121).

Information about the distribution and abundance of bull trout in this core area is limited because observations have generally been incidental to other fish species survey work. Spawning occurs in the upper reaches of this basin where higher elevations produce the cold water temperatures required by bull trout egg and juvenile survival. Based on current survey data, bull trout spawning in this core area occurs earlier in the year (i.e., September) than typically observed in other Puget Sound core areas (Marks et al. 2002). The known spawning areas in local populations are few in number and not widespread. The majority of spawning sites are located

in streams within Mount Rainier National Park, with two exceptions, Silver Creek and Silver Springs (Ladley, in litt. 2006; Marks et al. 2002).

Rearing likely occurs throughout the Upper Puyallup, Mowich, Carbon, Upper White, West Fork White, and Greenwater Rivers. However, sampling indicates most rearing is confined to the upper reaches of the basin. The mainstem reaches of the White, Carbon, and Puyallup Rivers probably provide the primary freshwater foraging, migration, and overwintering habitat for migratory bull trout within this core area.

With fewer than 10 local populations, the Puyallup core area is considered to be at intermediate risk of extirpation and adverse effects from random naturally occurring events.

Adult Abundance

Rigorous abundance estimates are generally not available for local populations in the Puyallup core area. Currently, fewer than 100 adults probably occur in each of the local populations in the White River system, based on adult counts at Mud Mountain Dam's Buckley Diversion fish trap. Although these counts may not adequately account for fluvial migrants that do not migrate downstream of the facility, these counts do indicate few anadromous bull trout and few mainstem fluvial bull trout return to local populations in the White River system. Therefore, the bull trout population in the Puyallup core area is considered at increased risk of extirpation until sufficient information is collected to properly assess adult abundance in each local population.

Productivity

Due to the current lack of long-term, comprehensive trend data, the bull trout population in the Puyallup core area is considered at increased risk of extirpation until sufficient information is collected to properly assess productivity.

Connectivity

Migratory bull trout are likely present in most local populations in the Puyallup core area. However, the number of adult bull trout expressing migratory behavior within each local population appears to be very low compared to other core areas. Although connectivity between the Upper Puyallup and Mowich Rivers local population and other Puyallup core area local populations was reestablished with the creation of an upstream fish ladder at Electron Dam in 2000, this occurred after approximately 100 years of isolation. Very low numbers of migratory bull trout continue to be passed upstream at the Mud Mountain Dam's Buckley Diversion fish trap. The overall low abundance of migratory life history forms limits the possibility for genetic exchange and local population refounding, as well as limits more diverse foraging opportunities to increase size of spawners and therefore, overall fecundity within the population. Consequently, the bull trout population in the Puyallup core area is at intermediate risk of extirpation from habitat isolation and fragmentation.

Changes in Environmental Conditions and Population Status

Since the bull trout listing, the Service has issued Biological Opinions that exempted incidental take in the Puyallup core area. These incidental take exemptions were in the form of harm and harassment, primarily from hydrologic impacts associated with increased impervious surface, temporary sediment increases during in-water work, habitat loss or alteration, and handling of fish. None of these projects were determined to result in jeopardy to bull trout. The combined effects of actions evaluated under these Biological Opinions have resulted in short-term and long-term adverse effects to bull trout and degradation of bull trout habitat within the core area.

Of particular note, in 2003 the Service issued a Biological Opinion (FWS Ref. No. 1-3-01-F-0476) on the State Route 167 North Sumner Interchange Project. This project was located in Pierce County in the White River portion of the Puyallup watershed and was proposed by Washington State Department of Transportation. The project's direct and indirect impacts and cumulative impacts within the action area included urbanization of approximately 600 acres of land. We anticipated that conversion of this land to impervious surface would result in the permanent loss and/or degradation of aquatic habitat for bull trout and their prey species through reduced base flows, increased peak flows, increased temperatures, loss of thermal refugia, degradation of water quality, and the degradation of the aquatic invertebrate community and those species dependent upon it (bull trout prey species). These impacts will result in thermal stress and disrupt normal behavioral patterns. Incidental take of fluvial, adfluvial, and anadromous bull trout in the form of harassment due to thermal stress and the disruption of migrating and foraging behaviors was exempted for this project. These adverse effects were expected to continue in perpetuity.

Section 10(a)(1)(B) permits have also been issued for HCPs that address bull trout in this core area. Although these HCPs may result in both short and/or long-term negative effects to bull trout and their habitat, the anticipated long-term beneficial effects are expected to maintain or improve the overall baseline status of the species. Additionally, capture and handling, and indirect mortality, during implementation of section 6 and section 10(a)(1)(A) permits have directly affected some individual bull trout in this core area.

The number of non-Federal actions occurring within the Puyallup core area since the bull trout were listed is unknown. However, activities conducted on a regular basis, such as emergency flood control, development, and infrastructure maintenance affect riparian and instream habitat which typically results in negative affects to bull trout and their habitat.

Threats

Threats to bull trout in the Puyallup core area include:

- Extensive past and ongoing timber harvest and harvest-related activities, such as road maintenance and construction, continue to affect bull trout spawning and rearing areas in the upper watershed.

- Agricultural practices, such as bank armoring, riparian clearing, and non-point discharges of chemical applications continue to affect foraging, migration, and overwintering habitats for bull trout in the lower watershed.

- Dams and diversions have significantly affected migratory bull trout in the core area. Until upstream passage was recently restored, the Electron Diversion Dam isolated bull trout in the Upper Puyallup and Mowich Rivers local population for nearly 100 years and has drastically reduced the abundance of migratory bull trout in the Puyallup River. Buckley Diversion and Mud Mountain Dam have significantly affected the White River system in the past by impeding or precluding adult and juvenile migration and degrading foraging, migration, and overwintering habitats in the mainstem. Despite improvements to these facilities, passage related impacts continue today but to a lesser degree.

- Urbanization, road construction, residential development, and marine port development associated with the city of Tacoma, have significantly reduced habitat complexity and quality in the lower mainstem rivers and associated tributaries, and have largely eliminated intact nearshore foraging habitats for anadromous bull trout in Commencement Bay.

- The presence of brook trout in many parts of the Puyallup core area and their potential to increase in distribution, including into Mount Rainer National Park waters, are considered significant threats to bull trout. Because of their early maturation and competitive advantage over bull trout in degraded habitats, brook trout in the upper Puyallup and Mowich Rivers local population is of highest concern because of past isolation of bull trout and the level of habitat degradation in this area.

- Until the early 1990s, bull trout fisheries probably significantly reduced the overall bull trout population within this and other core areas in Puget Sound. Current legal and illegal fisheries in the Puyallup core area may continue to significantly limit recovery of the population because of the low numbers of migratory adults.

- Water quality has been degraded due to municipal and industrial effluent discharges resulting from development, particularly in the lower mainstem Puyallup River and Commencement Bay.

- Water quality has also been degraded by stormwater discharge associated with runoff from impervious surface. Impervious surface in the Puyallup watershed increased by 12 percent between 1990 and 2001 (PSAT 2007).

- Major flood events in November 2006 significantly impacted instream habitats within the Puyallup River system. These events are assumed to have drastically impacted bull trout brood success for the year, due to significant scour and channel changes that occurred after peak spawning. Significant impacts to rearing juvenile bull trout were also likely, further impacting the future recruitment of adult bull trout.

- In November 2006, an 18,000 gallon diesel spill in the head waters of Spring Creek (Hebert, in litt. 2006), a bull trout spawning area of the Upper White River local population, likely impacted the available instream spawning habitat. The duration of ongoing contamination of instream habitats by residual diesel is unknown.

LITERATURE CITED

Hebert, C. 2006. Email from C. Herbert to Jeff Krausmann, USFWS, regarding Crystal Mt. diesel spill - update. November 7, 2006.

Ladley, R. 2006. Email from Russ Ladley, NPS, to Jeffrey Chan, USFWS, regarding bull trout telemetry update. September 29, 2006.

Marks, E.L., T.G. Sebastian, R.C. Ladley, and B.E. Smith. 2002. 2001-2002 annual salmon, steelhead, and char report: Puyallup River watershed. Puyallup Tribal Fisheries, Puyallup, Washington, 2002. 17 pp.

PSAT (Puget Sound Action Team). 2007. State of the Sound 2007. Puget Sound Action Team, PSAT 07-01, Olympia, Washington, July 22, 2007. 96 pp.

USFWS. 2004. Draft Recovery Plan for the Coastal-Puget Sound distinct population segment of bull trout (*Salvelinus confluentus*). Volume I: Puget Sound Management Unit, 389+xvii pp and Volume II: Olympic Peninsula Management Unit, 277+xvi pp, Portland, Oregon.

Snohomish-Skykomish Core Area

The Snohomish-Skykomish core area comprises the Snohomish, Skykomish, and Snoqualmie Rivers and their tributaries. Bull trout occur throughout the Snohomish River system downstream of barriers to anadromous fish. Bull trout are not known to occur upstream of Snoqualmie Falls, upstream of Spada Lake on the Sultan River, in the upper forks of the Tolt River, above Deer Falls on the North Fork Skykomish River, or above Alpine Falls on the Tye River.

Fluvial, resident, and anadromous life history forms of bull trout occur in the Snohomish River/Skykomish core area. A large portion of the migratory segment of this population is anadromous. There are no lake systems within the basin that support an adfluvial population. However, anadromous and fluvial forms occasionally forage in a number of lowland lakes connected to the mainstem rivers.

The mainstems of the Snohomish, Skykomish, North Skykomish, and South Fork Skykomish Rivers provide important foraging, migrating, and overwintering habitat for subadult and adult bull trout. The amount of key spawning and early rearing habitat is more limited, in comparison with many other core areas, because of the topography of the basin. Rearing bull trout occur

throughout most of the accessible reaches of the basin and extensively use the lower estuary, nearshore marine areas, and Puget Sound for extended rearing.

The status of the bull trout core area population is based on four key elements necessary for long-term viability: 1) number and distribution of local populations, 2) adult abundance, 3) productivity, and 4) connectivity (USFWS 2004, Vol. 1, p. 215).

Number and Distribution of Local Populations

Four local populations have been identified: (1) North Fork Skykomish River (including Goblin and West Cady Creeks), (2) Troublesome Creek (resident form only), (3) Salmon Creek, and (4) South Fork Skykomish River. With only four local populations, bull trout in this core area are considered at increased risk of extirpation and adverse effects from random naturally occurring events (see "Life History" in Bull Trout Status of the Species, in Appendices, p. 5).

Adult Abundance

The Snohomish-Skykomish core area probably supports between 500 and 1,000 adults. However, this core area remains at risk of genetic drift. Most of the spawners in the core area occur in the North Fork Skykomish local population. Redd counts within the North Fork Skykomish local population peaked at over 530 in 2002 (USFWS 2004, Vol. 1, p. 103), but have recently declined to just over 240 in 2005 and 2006 (WDFW 2007, p. 17). This is one of two local populations in the core area (the other is South Fork Skykomish River) that support more than 100 adults, which minimizes the deleterious effects of inbreeding. The Troublesome Creek population is mainly a resident population with few migratory fish. Although adult abundance is unknown in this local population, it is probably stable due to intact habitat conditions. The Salmon Creek local population likely has fewer than 100 adults. Although spawning and early rearing habitat in the Salmon Creek area is in good to excellent condition, this local population is at risk of inbreeding depression because of the low number of adults. Monitoring of the South Fork Skykomish local population indicates increasing numbers of adult migrants. This local population recently exceeded 100 adults (Jackson, in litt. 2004) and is not considered at risk of inbreeding depression. Fishing is allowed in this system.

Productivity

Long-term redd counts for the North Fork Skykomish local population indicate increasing population trends. Productivity of the Troublesome Creek and Salmon Creek local populations is unknown but presumed stable, as the available spawning and early rearing habitats are considered to be in good to excellent condition. In the South Fork Skykomish local population, new spawning and rearing areas are being colonized, resulting in increasing numbers of spawners. Sampling of the North Fork and South Fork Skykomish local population areas indicates the overall productivity of bull trout in the Snohomish-Skykomish core area is increasing.

Connectivity

Migratory bull trout occur in three of the four local populations in the Snohomish-Skykomish core area (North Fork Skykomish, Salmon Creek, and South Fork Skykomish). The lack of connectivity with the Troublesome Creek local population is a natural condition. The connectivity between the other three local populations diminishes the risk of extirpation of the bull trout in the core area from habitat isolation and fragmentation.

Changes in Environmental Conditions and Population Status

Since the bull trout listing, Federal actions occurring in the Snohomish-Skykomish core area have caused harm to, or harassment of, bull trout. These actions include statewide Federal restoration programs that include riparian restoration, replacement of fish passage barriers, and fish habitat improvement projects; federally funded transportation projects involving repair and protection of roads and bridges; and section 10(a)(1)(B) permits for Habitat Conservation Plans addressing forest management practices. Capture and handling during implementation of section 6 and section 10(a)(1)(A) permits have directly affected bull trout in the Snohomish-Skykomish core area.

The number of non-Federal actions occurring in the Snohomish-Skykomish core area since the bull trout listing is unknown. However, activities conducted on a regular basis, such as emergency flood control, development, and infrastructure maintenance, affect riparian and instream habitat and probably negatively affect bull trout.

Threats

Threats to bull trout in the Snohomish-Skykomish core area include:

- Loss of habitat that can provide thermal and high-flow refuge. Armoring the riparian areas results in the loss of natural river functions.
    - Bank armoring to protect homes, towns, and roads built in the rivers natural channel migration zones results in the river's inability to develop side- and off-channel habitat that bull trout need for survival.
    - Bank armoring is also associated with reduced riparian vegetation and shading, which eliminates prey sources and thermal refuge for bull trout.
- Degraded habitat conditions from timber harvests and associated activities, including roads, sedimentation, and fertilization, especially in the upper watershed, where spawning occurs.
- Blocked fish passage, altered stream morphology, and degraded water quality in the lower watershed resulting from agricultural and livestock practices.
- Injury and/or mortality from illegal harvest or incidental hooking/netting, which may occur where recreational fishing is allowed by the Washington Department of Fish and Wildlife.

- Degraded water quality from municipal and industrial effluent discharges and development.
- Loss of nearshore foraging habitat and prey from continual development along riparian areas, especially from residential, commercial, and transportation construction, which usually substantiate the need for bank armoring to protect the river's natural migratory process.

LITERATURE CITED

Jackson, C. 2004. Email from Chad Jackson, WDFW, to Jeff Chan, WFWO, regarding bull trout South Fork of the Skykomish River fish traps and North Fork Skykomish redd counts. Email string dated November 26, 2004 through December 29, 2004. 2004.

USFWS. 2004. Draft Recovery Plan for the Coastal-Puget Sound distinct population segment of bull trout (*Salvelinus confluentus*). Volume I: Puget Sound Management Unit, 389+xvii pp and Volume II: Olympic Peninsula Management Unit, 277+xvi pp, Portland, Oregon.

WDFW. 2007. 2006 bull trout report: section 6(c)(1) Endangered Species Act - report to the U.S. Fish and Wildlife Service on hatchery, stock assessment, and research activities that have the potential to take listed Washington coastal-Puget Sound DPS bull trout (*Salvelinus confluentus*). Washington Department of Fish and Wildlife, Olympia, WA.

Lower Skagit Core Area

The Lower Skagit core area comprises the Skagit basin downstream of Seattle City Light's Diablo Dam, including the mainstem Skagit River and the Cascade, Sauk, Suiattle, White Chuck, and Baker River including the lake systems (Baker Lake and Lake Shannon) upstream of upper and lower Baker Dams.

Bull trout, which occur throughout the Lower Skagit core area, include fluvial, adfluvial, resident, and anadromous life history forms. Resident life history forms, found in several locations in the core area, often occur with migratory life history forms. Adfluvial bull trout occur in Baker, Shannon, and Gorge Lakes. Fluvial bull trout forage and overwinter in the larger pools of the upper portion of the mainstem Skagit River and, to a lesser degree, in the Sauk River (Kraemer 2003; WDFW et al. 1997).

Many bull trout extensively use the lower estuary and nearshore marine areas for extended rearing and subadult and adult foraging. Key spawning and early rearing habitat, found in the upper portion of much of the basin, is generally on federally protected lands, including North Cascades National Park, North Cascades Recreation Area, Glacier Peak Wilderness, and Henry M. Jackson Wilderness Area.

The status of the bull trout core area population is based on four key elements necessary for long-term viability: 1) number and distribution of local populations, 2) adult abundance, 3) productivity, and 4) connectivity (USFWS 2004).

Number and Distribution of Local Populations

Nineteen local populations were identified in the draft recovery plan (USFWS 2004) 1) Bacon Creek, 2) Baker Lake, 3) Buck Creek, 4) Cascade River, 5) Downey Creek, 6) Forks of Sauk River, 7) Goodell Creek, 8) Illabot Creek, 9) Lime Creek, 10) Lower White Chuck River, 11) Milk Creek, 12) Newhalem Creek, 13) South Fork Cascade River, 14) Straight Creek, 15) Sulphur Creek, 16) Tenas Creek, 17) Upper South Fork Sauk River, 18) Upper Suiattle River, and 19) Upper White Chuck River. Although initially identified as potential local populations in the draft recovery plan (USFWS 2004), Stetattle Creek and Sulphur Creek (Lake Shannon), each now meets the definition of local population based on subsequent observations of juvenile bull trout and prespawn migratory adult bull trout (R2 Resource Consultants and Puget Sound Energy 2005; Shannon, in litt. 2004). With 21 local populations, the bull trout in the Lower Skagit core area is at diminished risk of extirpation and adverse effects from random naturally- occurring events (see "Life History").

Adult Abundance

The Lower Skagit core area, with a spawning population of migratory bull trout that numbers in the thousands, is probably the largest population in Washington (Kraemer 2001). Consequently, the bull trout population in this core area is not considered at risk from genetic drift.

The majority of local populations in the core area include 100 adults or more; therefore, they are at a diminished risk of extirpation. However, some local populations probably have fewer than 100 adults and may be at risk from inbreeding depression. There is some risk of extirpation of the following local populations due to their lower numbers of adults; however, other factors, such as stable or increasing population trends may reduce this risk. Fewer than 100 migratory adults and a limited number of resident fish use the Forks of the Sauk River; however, the migratory component appears abundant and is increasing (Kraemer 2003). Fewer than 100 adults probably occur in Tenas Creek, but this local population is presumed to be increasing. The Straight Creek local population includes fewer than 100 migratory adults and an unknown number of resident fish (Kraemer 2001), but the migratory component appears stable. The Lime Creek local population probably has fewer than 100 migratory adults, but resident and migratory components are considered abundant. The South Fork Cascade River local population probably has fewer than 100 migratory adults (Kraemer 2001); however, resident and migratory components are considered stable. Based on recent observations, the Sulphur Creek local population in the Lake Shannon system also has fewer than 100 adults (R2 Resource Consultants and Puget Sound Energy 2006). Prior to 2004, Goodell Creek supported more than 100 adult spawners. In October 2003, a large landslide in Goodell Creek blocked access to the majority of spawning habitat for migratory bull trout in the Goodell Creek local population. Adult counts of migratory bull trout in 2004 and 2005 have been fewer than 100 individuals (Downen 2006) in

this local population. In the Baker Lake local population, annual peak counts of 85 adults have been recorded between 2001 and 2005 (R2 Resource Consultants and Puget Sound Energy 2006). Since the most upstream accessible habitat was not surveyed in these efforts, and bull trout typically spawn as far upstream as they can within a stream system, this would suggest that on average there may be at least 100 adults in this local population. Total adult abundances in Newhalem and Stettatle Creek local populations are unknown.

Productivity

Long-term redd counts in the index areas of the Lower Skagit core area generally indicate stable to increasing population trends (USFWS 2004). Therefore, this core area is not considered at risk of extirpation at this time. Recent declines in redd counts may indicate a potential change to this long-term trend (Downen 2006). Redd counts conducted by WDFW between 2002 and 2005 show a significant downward trend in Bacon, Goodell, and Illabot Creeks, and the Sauk River. However, Downey Creek had a significant increase in the reported redd counts between these years. The reason for these changes is unknown.

Connectivity

The presence of migratory bull trout in most of the local populations indicates the bull trout in the Lower Skagit core area has a diminished risk of extirpation from habitat isolation and fragmentation. However, the lack of connectivity of the Baker Lake and Sulphur Creek local populations in the Baker River system and Stetattle Creek local population in the Gorge Lake system with other local populations in the core area is a concern with respect to long-term persistence, life history expression, and refounding. In addition, there is currently only partial connectivity within the Baker Lake system, with no upstream passage for adults within Lake Shannon at upper Baker Dam.

Changes in Environmental Conditions and Population Status

Since the bull trout listing, Federal actions occurring in the Lower Skagit core area have caused harm to, or harassment of, bull trout. These actions include statewide Federal restoration programs that include riparian restoration, replacement of fish passage barriers, and fish habitat improvement projects; federally funded transportation projects involving repair and protection of roads and bridges; and section 10(a)(1)(B) permits for Habitat Conservation Plans addressing forest management practices. Capture and handling, and indirect mortality, during implementation of section 6 and section 10(a)(1)(A) permits have negatively directly affected bull trout in the Lower Skagit core area.

The number of non-Federal actions occurring in the Lower Skagit core area since the bull trout listing is unknown. Activities conducted on a regular basis, such as emergency flood control, development, and infrastructure maintenance, affect riparian and instream habitat and probably have negatively affected bull trout and parts of their forage base.

Threats

Threats to bull trout in the Lower Skagit core area include:

- Gorge and Baker Dams restrict connectivity of the Stetattle Creek, Baker Lake, and Sulphur Creek (Lake Shannon) local populations with the majority of other local populations in the core area due to impaired fish passage.

- Operations of the Lower Baker Dam occasionally have significantly affected water quantity in the lower Baker and Skagit Rivers.

- Agricultural practices, residential development, and the transportation network, with related stream channel and bank modifications, have caused the loss and degradation of foraging, migration, and overwintering habitats in mainstem reaches of the major forks and in a number of the tributaries.

- Estuarine nearshore foraging habitats have been, and continue to be, negatively affected by agricultural practices and development activities.

LITERATURE CITED

Downen, M.R. 2006. Region 4 bull trout monitoring summary report, September 2006.

Kraemer, C. 2001. Draft: Puget Sound bull trout core areas - lower Skagit core area. Washington Department of Fish and Wildlife, Olympia, WA, July 31, 2001. 8 pp.

Kraemer, C. 2003. Management brief: Lower Skagit bull trout, age and growth information developed from scales collected from anadromous and fluvial char. Washington Department of Fish and Wildlife, Olympia, WA, January 1, 2003.

R2 Resource Consultants, and Puget Sound Energy. 2005. Native char investigations. results of 2004 activities and proposed 2005 activities. Baker River hydroelectric project (FERC No. 2150), FERC No.2150, April 2005. 57 pp.

R2 Resource Consultants, and Puget Sound Energy. 2006. Native char investigations. results of 2005 activities. Baker River hydroelectric project (FERC No. 2150), FERC No. 21050, Bellevue, Washington, January, 2006. 68 pp.

Shannon, J. 2004. Email from Jim Shannon, Taylor Associates, Inc., Seattle, WA, to Jeffrey Chan, Fish Biologist, USFWS, Re: Gorge Lake bulls. October 8, 2004.

USFWS. 2004. Draft Recovery Plan for the Coastal-Puget Sound distinct population segment of bull trout (*Salvelinus confluentus*). Volume I: Puget Sound Management Unit, 389+xvii pp and Volume II: Olympic Peninsula Management Unit, 277+xvi pp, Portland, Oregon.

WDFW, FishPro Inc., and Beak Consultants. 1997. Grandy Creek trout hatchery biological assessment. Washington Department of Fish and Wildlife, Olympia, WA.

APPENDIX E: Sediment Analysis Framework (2010)

APPENDIX E: Sediment Analysis Framework (2010)

DETERMINING EFFECTS FOR SECTION 7 CONSULTATIONS

There are numerous factors that can influence project-specific sediment effects on bull trout and other salmonids. These factors include the concentration and duration of sediment input, existing sediment conditions, stream conditions (velocity, depth, etc.) during construction, weather or climate conditions (precipitation, wind, etc.), fish presence or absence (bull trout plus prey species), and best management practice effectiveness. Many of these factors are unknown.

Newcombe and Jensen (1996) and Anderson et al. (1996) provide the basis for analyzing sediment effects to bull trout and other salmonids and their habitat. Newcombe and Jensen (1996) conducted a literature review of pertinent documents on sediment effects to salmonids and nonsalmonids. They developed a model that calculated the severity of ill effect (SEV) to fish based on the suspended sediment dose (exposure) and concentration. No data on bull trout were used in this analysis. Anderson et al. (1996), using the methods used by Newcombe and Jensen (1996), developed a model to estimate sediment impacts to salmonid habitat.

A 15-point scale was developed by Newcombe and Jensen (1996, p. 694) to qualitatively rank the effects of sediment on fish (Table 1). Using a similar 15-point scale, Anderson et al. (1996) ranked the effects of sediment on fish habitat (Table 2).

We analyzed the effects on different bull trout life history stages to determine when adverse effects of project-related sediment would occur. Table 3 shows the different ESA effect calls for bull trout based on severity of ill effect.

The effect determination for a proposed action

should consider all SEV values resulting from the action because sediment affects individual fish differently depending on life history stage and site-specific factors. For juvenile bull trout, an SEV of 5 is likely to warrant a "likely to adversely affect" (LAA) determination. However, abandonment of cover (SEV 2), or an avoidance response (SEV 3), may result in increased predation risk and mortality if habitat features are limiting in the project's stream reach. Therefore, a LAA determination may be warranted at an SEV 2 or 3 level in certain situations. For subadult and adult bull trout, however, abandonment of cover and avoidance may not be as important. A higher SEV score is more appropriate for adverse effects to subadult and adult bull trout. In all situations, we assume that SEV scores associated with adverse effects are also sufficient to represent a likelihood of harm or harass2.

Table 2 – Scale of the severity (SEV) of ill effects associated with excess suspended sediment on salmonid habitat.

SEV	Description of Effect
3	Measured change in habitat preference
7	Moderate habitat degradation – measured by a change in invertebrate community
10	Moderately severe habitat degradation – defined by measurable reduction in the productivity of habitat for extended period (months) or over a large area (square kilometers).
12	Severe habitat degradation – measured by long-term (years) alterations in the ability of existing habitats to support fish or invertebrates.
14	Catastrophic or total destruction of habitat in the receiving environment.

When evaluating impacts to habitat as a surrogate for species effects, adverse effects may be anticipated when there is a notable reduction in abundance of aquatic invertebrates, and an alteration in their community structure. These effects represent a reduction in food for bull trout and other salmonids, and correspond to an SEV of 7 – moderate habitat degradation.

Newcombe and Jensen (1996) used six data groups to conduct their analysis. These groups were 1) juvenile and adult salmonids (Figure 1), 2) adult salmonids (Figure 2), 3) juvenile salmonids (Figure 3), 4) eggs and larvae of salmonids and non-salmonids (Figure 4), 5) adult estuarine nonsalmonids (no figure provided), and 6) adult freshwater nonsalmonids (no figure provided). No explanation was provided for why juvenile and adult salmonids were combined for group 1. As juveniles are more adapted to turbid water (Newcombe 1994, p. 5), their SEV levels are generally lower than for adult salmonids given the same concentration and duration of sediment (Figures 1-3).

2 Harm and harass in this context refers to the FWS's regulatory definition at 50 CFR 17.3. E.g., Harm means "an act which actually kills or injures wildlife. Such an act may include significant habitat modification or degradation where it actually kills or injures wildlife by significantly impairing essential behavior patterns, including breeding, feeding, or sheltering."

Table 3 – ESA Effect calls for different bull trout life stages in relation to the duration of effect and severity of ill effect. Effect calls for habitat, specifically, are provided to assist with analysis of effects to individual bull trout.		
	SEV	**ESA Effect Call**
Egg/alevin	1 to 4	Not applicable - alevins are still in gravel and are not feeding.
	5 to 14	LAA - any stress to egg/alevin reduces survival
Juvenile	1 to 4	NLAA
	5 to 14	LAA
Subadult and Adult	1 to 5	NLAA
	6 to 14	LAA
Habitat	1 to 6	NLAA
	7 to 14	LAA due to indirect effects to bull trout

The figures of Newcombe and Jensen (1996) have been modified in this document. In each figure, values (in mg/L) are provided for each duration to determine when adverse effects would occur. Specific values are also given for when harm would be likely to occur. For example:

> Figure 1 – This figure is for both juveniles and adults. From Table 2, bull trout are "likely to be adversely affected" given an SEV of 5. On Figure 1, a sediment concentration of 99 mg/L for one hour is anticipated to be the maximum concentration for an SEV of 4. At 100 mg/L, an SEV of 5 occurs. In addition, one hour of exposure to 5,760 mg/L is the maximum for an SEV of 7. Exposure to 5,761 mg/L for one hour would warrant an SEV of 8. This would be the threshold between harassment and harm. An SEV of 7 would be harassment, and an SEV of 8 would be considered harm.

The following provides some guidance on use of the figures.

Definitions from Newcombe and Jensen (1996, p. 696). These definitions are provided for consultations that may have impacts to bull trout prey such as Chinook and coho salmon.

> Eggs and larvae – eggs, and recently hatched fish, including yolk-sac fry, that have not passed through final metamorphosis.
>
> Juveniles – fry, parr, and smolts that have passed through larval metamorphosis but are sexually immature.
>
> Adults – mature fish.

Bull trout use:

Newcombe and Jensen (1996) conducted their analysis for freshwater, therefore the use of the figures within this document in marine waters should be used with caution.

Figure 1 – Juvenile and Adult Salmonids. This figure should be used in foraging, migration and overwintering (FMO) areas. In FMO areas, downstream of local populations, both subadult and adult bull trout may be found.

Figure 2 – Adult Salmonids. This figure will not be used very often for bull trout. There may be circumstances, downstream of local population spawning areas that may have just adults, but usually this would not be the case. Justification for use of this figure should be stated in your consultation.

Figure 3 – Juvenile Salmonids. This figure should be used in local population spawning and rearing areas outside of the spawning period. During this time, only juveniles and sub-adults should be found in the area. Adults would migrate to larger stream systems or to marine water. If the construction of the project would occur during spawning, then Figure 1 should be used.

Figure 4 – Eggs and Alevins. This figure should be used if eggs or alevins are expected to be in the project area during construction.

Figure 5 – Habitat. This figure should be used for all projects to determine whether alterations to the habitat may occur from the project.

Background and Environmental Baseline

In determining the overall impact of a project on bull trout, and to specifically understand whether increased sediment may adversely affect bull trout, a thorough review of the environmental baseline and limiting factors in the stream and watershed is needed. The following websites and documents will help provide this information.

1. Washington State Conservation Commission's Limiting Factors Analysis. A limiting factors analysis has been conducted on watersheds within the State of Washington. Limiting factors are defined as "conditions that limit the ability of habitat to fully sustain populations of salmon, including all species of the family Salmonidae." These documents will provide information on the current condition of the individual watersheds within the State of Washington. The limiting factors website is http://salmon.scc.wa.gov. Copies of the limiting factors analysis can be found at the Western Washington Fish and Wildlife Library.

2. Washington Department of Fish and Wildlife's (1998) Salmonid Stock Inventory (SaSI). The Washington Department of Fish and Wildlife (WDFW) inventoried bull trout and Dolly Varden (*S. malma*) stock status throughout the State. The intent of the inventory is to help identify available information and to guide future restoration planning and implementation. SaSI defines the stock within the watershed, life history

forms, status and factors affecting production. Spawning distribution and timing for different life stages are provided (migration, spawning, etc.), if known. SaSi documents can be found at http://wdfw.wa.gov/fish/sasi/index.htm.

3. U.S. Fish and Wildlife Service's (USFWS 1998a) Matrix of Diagnostics/Pathways and Indicators (MPI). The MPI was designed to facilitate and standardize determination of project effects on bull trout. The MPI provides a consistent, logical line of reasoning to aid in determining when and where adverse effects occur and why they occur. The MPI provides levels or values for different habitat indicators to assist the biologist in determining the level of effects or impacts to bull trout from a project and how these impacts may cumulatively change habitat within the watershed.

4. Individual Watershed Resources. Other resources may be available within a watershed that will provide information on habitat, fish species, and recovery and restoration activities being conducted. The action agency may cite a publication or identify a local watershed group within the Biological Assessment or Biological Evaluation. These local groups provide valuable information specific to the watershed.

5. Washington State Department of Ecology (WDOE) - The WDOE has long- and short-term water quality data for different streams within the State. Data can be found at http://www.ecy.wa.gov/programs/eap/fw_riv/rv_main.html. Clicking on a stream or entering a stream name will provide information on current and past water quality data (when you get to this website, scroll down to the Washington map). This information will be useful for determining the specific turbidity/suspended sediment relationship for that stream (more information below).

6. Washington State Department of Ecology (WDOE) - The WDOE has also been collecting benthic macroinvertebrates and physical habitat data to describe conditions under natural and anthropogenic disturbed areas. Data can be found at http://www.ecy.wa.gov/programs/eap/fw_benth/index.htm. You can access monitoring sites at the bottom of the website.

7. U.S. Forest Service, Watershed Analysis Documents - The U.S. Forest Service (USFS) is required by the Record of Decision for Amendments to the USFS and Bureau of Land Management Planning Documents within the Range of the Northern Spotted Owl to conduct a watershed analysis for watersheds located on FS lands. The watershed analysis determines the existing condition of the watershed and makes recommendations for future projects that move the landscape towards desired conditions. Watershed analysis documents are available from individual National Forests or from the Forest Plan Division.

8. U.S. Fish and Wildlife Service - Bull Trout Recovery Plans and Critical Habitat Designations. The draft Bull Trout Recovery Plan for the Columbia River Distinct Population Segment (DPS) (also the Jarbidge River and the St. Mary-Belly River DPS) and the proposed and final critical habitat designations provide current species status, habitat requirements, and limiting factors for bull trout within specific individual

recovery units. These documents are available from the Endangered Species Division as well as the Service's web page (www.fws.gov).

These documents and websites provide baseline and background information on stream and watershed conditions. This information is critical to determining project-specific sediment impacts to the aquatic system. The baseline or background levels need to be analyzed with respect to the limiting factors within the watershed.

Consultation Sediment Analysis

The analysis in this section only applies to construction-related physiological and behavioral impacts, and the direct effects of fine sediment on current habitat conditions. Longer-term effects to habitat from project-induced channel adjustments, post-construction inputs of coarse sediment, and secondary fine sediment effects due to re-mobilization of sediment during the following runoff season, are not included in the quantitative part of this effects determination. Those aspects are only considered qualitatively.

The background or baseline sediment conditions within the project area or watershed will help to determine whether the project will have an adverse effect on bull trout. The following method should be followed to assist in reviewing effects determinations and quantifying take in biological opinions.

1) Determine what life stage(s) of bull trout will be affected by sedimentation from the project. Life history stages include eggs and alevins, juveniles, and sub-adults and adults. If projects adhere to approved work timing windows, very few should be constructed during periods when eggs and alevins are in the gravels. However, streambed or bank adjustments may occur later in time and result in increased sedimentation during the time of the year when eggs and alevins may be in the gravels and thus affected by the project.

2) Table 4 provides concentrations, durations, and SEV levels for different projects. This table will help in analyzing similar projects and to determine sediment level impacts associated with that type of project. Based on what life history stage is in the project area and what SEV levels may result from the project, a determination may be made on effects to bull trout. (Table 4 located on the Q drive: Q:\linked Literature Materials\Species & Issues & BO Templates with RefMan\Sediment Issue Paper)

3) Once a "likely to adversely affect" determination has been made for a project, the figures in Newcombe and Jensen (1996) or Anderson et al. (1996) are used to determine the concentration (mg/L) at which adverse effects3 and "take" will occur (see Figures 1-5). For example, if a project is located in FMO habitat, Figure 1 would be used to determine the concentrations at which adverse effects will occur. Since Figure 1 is used for both adults and juveniles, an SEV of 5 (for juveniles) is used (see Table 2). For (a.) the level when instantaneous adverse effects occur, find the SEV level of 5 in the one hour

3 For the remainder of the document, references to "adverse effects" also refer to harm and harass under 50 CFR 17.3.

column. The corresponding concentration is the instantaneous value where adverse effects occur. In this example, it is 148 mg/L. For (b), (c), and (d), adverse effects will occur when sediment concentrations exceed SEV 4 levels. The exact concentrations for this have been provided. For each category, find the SEV 4 levels and the corresponding concentration levels are the values used.

For impacts to individual bull trout, adverse effects would be anticipated in the following situations:

a. Any time sediment concentrations exceed 148 mg/L over background.
b. When sediment concentrations exceed 99 mg/L over background for more than one hour continuously.
c. When sediment concentrations exceed 40 mg/L over background for more than three hours cumulatively.
d. When sediment concentrations exceeded 20 mg/L over background for over seven hours cumulatively.

For habitat effects, use Figure 5 and the same procedure as above for individual bull trout. For example, adverse effects would be expected to occur in the following situations:

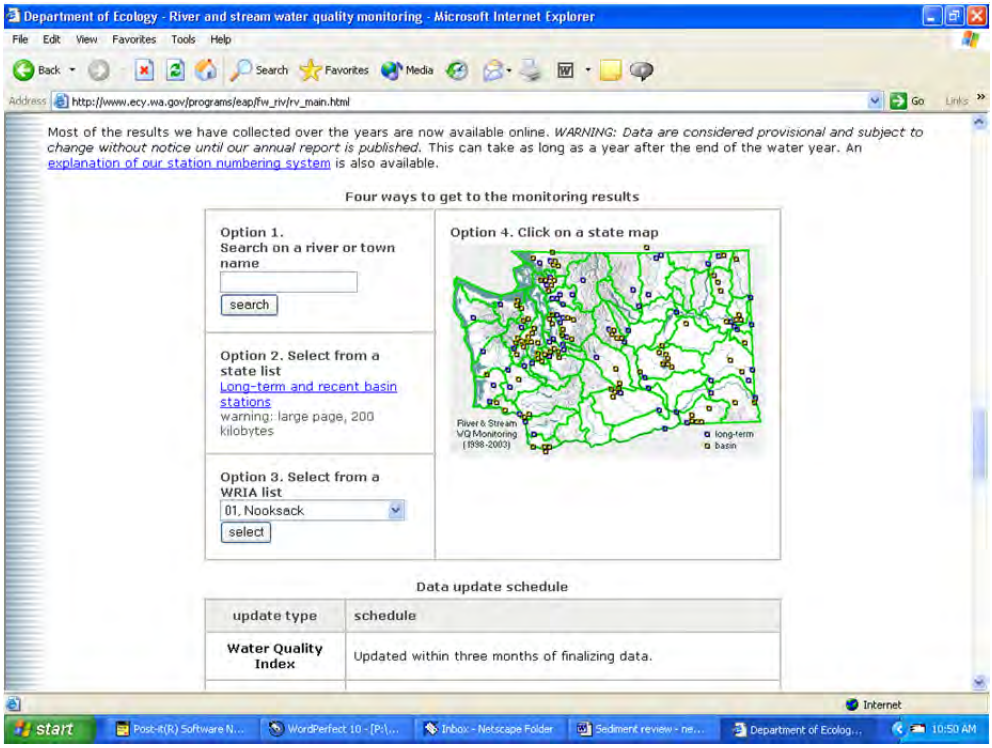
a. Any time sediment concentrations exceed 1,097 mg/L over background.
b. When sediment concentrations exceed 885 mg/L over background for more than one hour continuously.
c. When sediment concentrations exceed 345 mg/L over background for more than three hours cumulatively.
d. When sediment concentrations exceeded 167 mg/L over background for over seven hours cumulatively.

4) Because sediment sampling for concentration (mg/L) is labor intensive, many applicants prefer to monitor turbidity as a surrogate. To do this, the sediment concentration at which adverse effects to the species and/or habitat occurs is converted to NTUs. Two methods, regression analysis and turbidity to suspended solid ratio, are available for this conversion. The regression analysis method should be used first. If not enough data are available then the turbidity to suspended solid ratio method should be used.

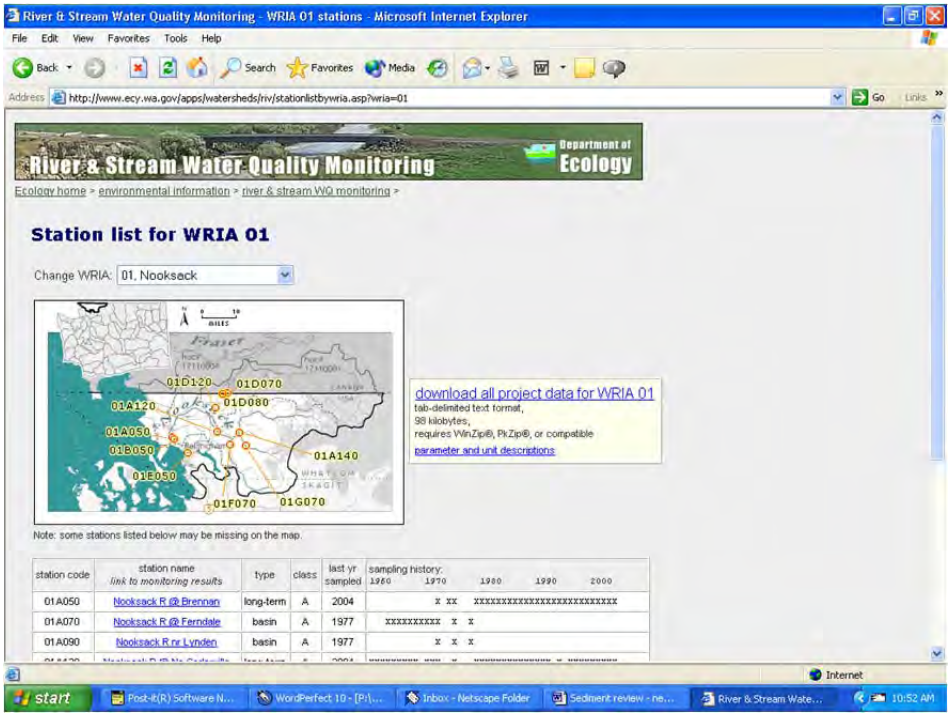
   a. Data – as described above in Background and Environmental Baseline, an attempt should be made to find turbidity and suspended solid information from the project area, action area, or the stream in which the project is being constructed. This information may be available from the Tribes, watershed monitoring groups, etc. Try to obtain information for the months in-water construction will occur, which is usually during the fish timing window (in most cases, July through September). If you are unable to find any data for the action area, use the WDOE water quality monitoring data. The following are the steps you need to go through to locate the information on the web and how to download the data:

i. Go to the WDOE webpage (http://www.ecy.wa.gov/programs/eap/fw_riv/rv_main.html).

ii. When you get to the website, the page will state "River and Stream Water Quality Monitoring." If you scroll down the page, you will see the following text and map.



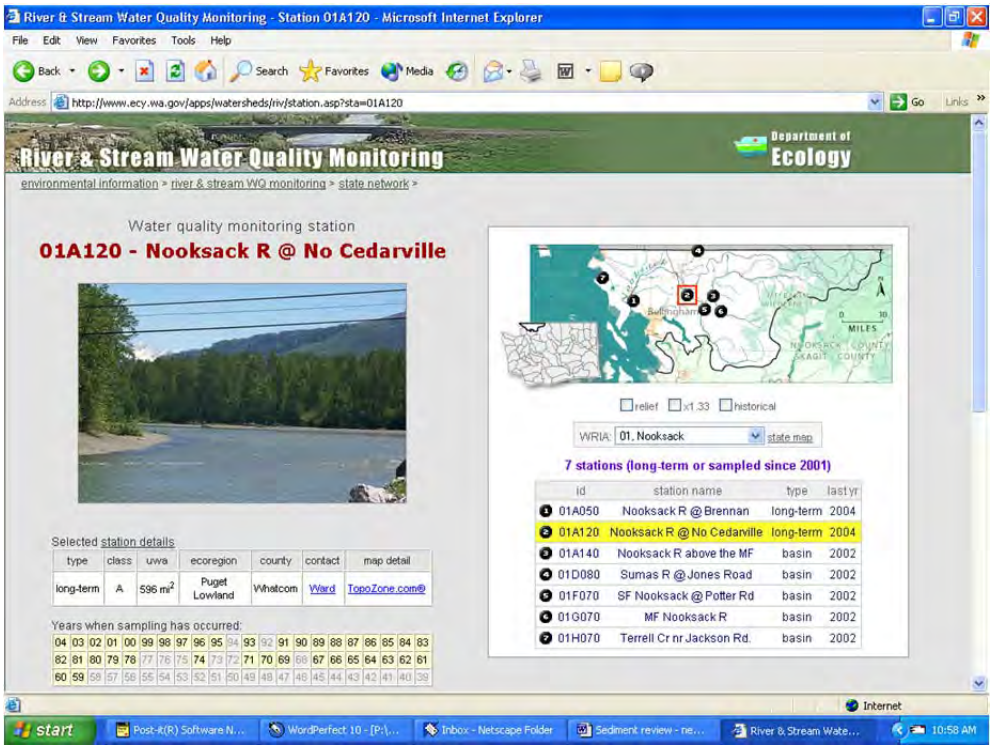
iii. The map shows all the water quality monitoring stations in Washington. You can click on a watershed, or go to Option 3, click on the down arrow and find your watershed. You will then get the following webpage. This is an example for the Nooksack River.



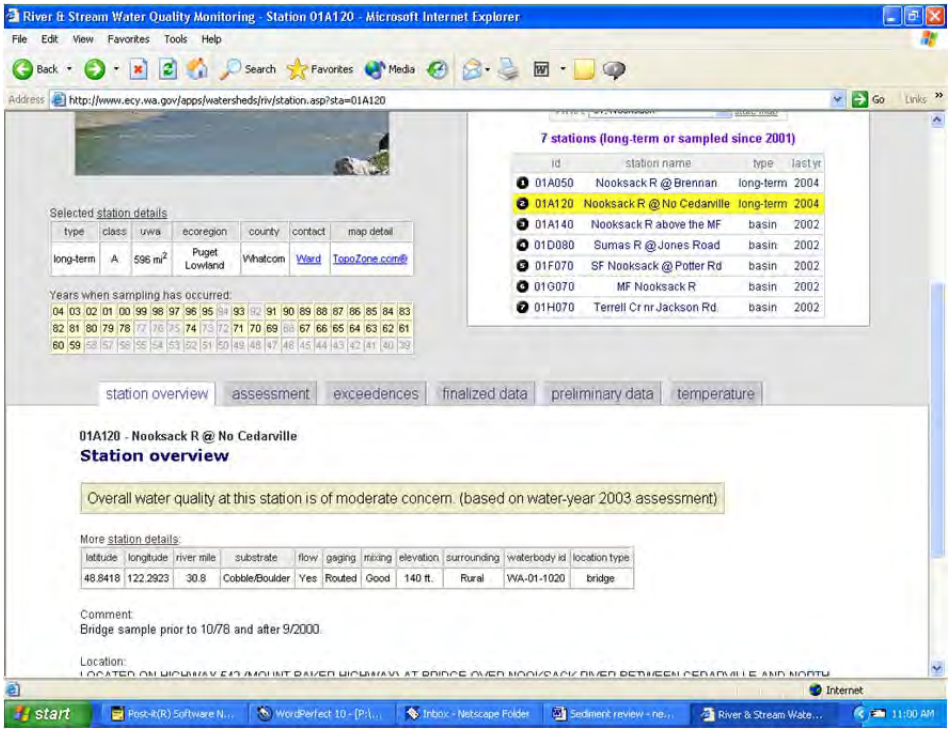
iv. This webpage shows you all the monitoring stations in this watershed. Scrolling down a little on the webpage, you get a list of the monitoring stations and the years that data were collected. The more years in which data were collected the better; however, you want to pick the monitoring station closest to the project site. If a project is located on a tributary, do not use data from the main river in the watershed. Find a monitoring station on a tributary and use that data. **Justification for the use of the data needs to be made in the BO.** The following language was used in the Anthracite Creek Bridge Scour BO. Changes to this paragraph to represent regression analysis are not italicized.

"*The guidance of Newcombe and Jensen (1996) requires a measurement of the existing suspended sediment concentration levels (mg/L) and duration of time that sediment impacts would occur. The Service used data available on the Washington Department of Ecology (WDOE) website to determine a ratio of turbidity (NTU) to suspended solids (mg/L)*(website to find the correlation between turbidity and suspended solids) *in Anthracite Creek. No water quality data was available for Anthracite Creek, so the Service used water quality monitoring data from a different tributary within the Snohomish River watershed. Patterson Creek, which is a tributary to the Snoqualmie River, was used to determine the ratio of turbidity to suspended solids* (correlation between turbidity and suspended solids). *The Service believes that Patterson Creek would have very comparable water quality data as Anthracite Creek. The turbidity to suspended solid ratio for Patterson Creek is 1:2.4 during the proposed months of construction (July through September).*" Delete the last sentence for regression analysis or put in the equation used for analysis and the R^2.

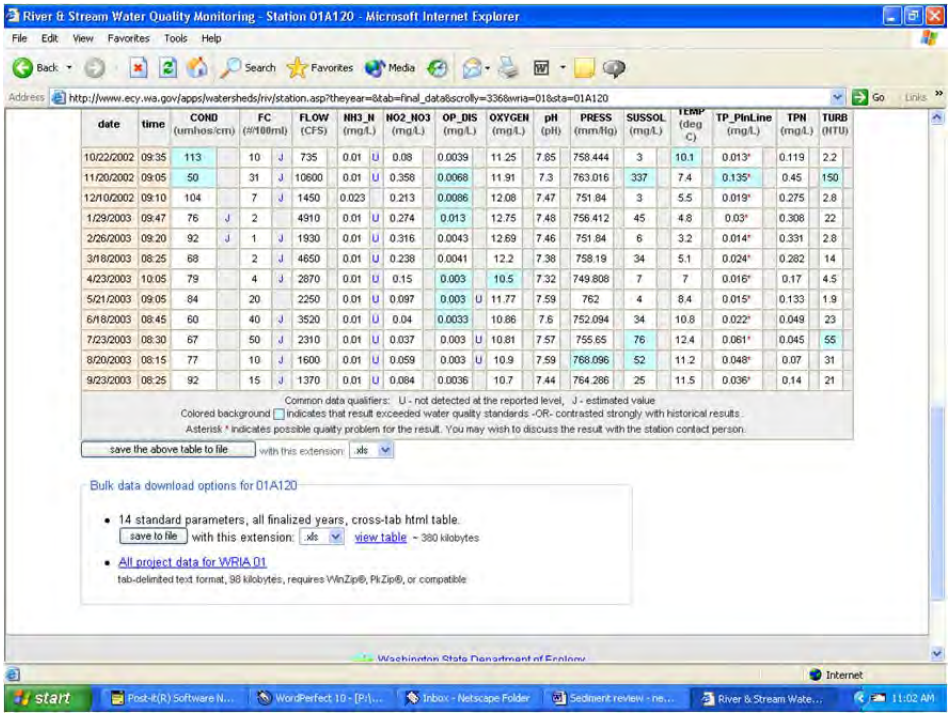
v. When you select the monitoring station, the following webpage appears. This monitoring station is on the Nooksack River at North Cedarville.



vi. Moving down the webpage, you find the following. The page shows the years data were collected and 4 to 6 tabs that provide different information. Click on the finalized data tab.



vii. Selecting the finalized data, a new page comes up; scrolling down that page you see the following. The top part of the page shows the finalized data for the most recent year data were collected. Below the data is a box that says “Bulk data download options...” Click on the “save to file” button for the 14 standardized data parameters. Follow the instructions to save this file. This saves all the data from that monitoring station so the regression analysis can be conducted.



River & Stream Water Quality Monitoring - Station 01A120 - Microsoft Internet Explorer

File Edit View Favorites Tools Help

Back Search Favorites Media

Address http://www.ecy.wa.gov/apps/watersheds/riv/station.asp?theyear=&tab=final_data&scrolly=336&wria=01&sta=01A120 Go Links

date	time	COND (umhos/cm)		FC (#/100ml)		FLOW (CFS)	NH3_N (mg/L)		NO2_NO3 (mg/L)	OP_DIS (mg/L)	OXYGEN (mg/L)	pH (pH)	PRESS (mm/Hg)	SUSSOL (mg/L)	TEMP (deg C)	TP_PlnLine (mg/L)	TPN (mg/L)	TURB (NTU)
10/22/2002	09:35	113		10	J	735	0.01	U	0.08	0.0039	11.25	7.85	758.444	3	10.1	0.013*	0.119	2.2
11/20/2002	09:05	50		31	J	10600	0.01	U	0.358	0.0068	11.91	7.3	763.016	337	7.4	0.135*	0.45	150
12/10/2002	09:10	104		7	J	1450	0.023		0.213	0.0086	12.08	7.47	751.84	3	5.5	0.019*	0.275	2.8
1/29/2003	09:47	76	J	2		4910	0.01	U	0.274	0.013	12.75	7.48	756.412	45	4.8	0.03*	0.308	22
2/26/2003	09:20	92	J	1	J	1930	0.01	U	0.316	0.0043	12.69	7.46	751.84	6	3.2	0.014*	0.331	2.8
3/18/2003	08:25	68		2	J	4650	0.01	U	0.238	0.0041	12.2	7.38	758.19	34	5.1	0.024*	0.282	14
4/23/2003	10:05	79		4	J	2870	0.01	U	0.15	0.003	10.5	7.32	749.808	7	7	0.016*	0.17	4.5
5/21/2003	09:05	84		20		2250	0.01	U	0.097	0.003	U 11.77	7.59	762	4	8.4	0.015*	0.133	1.9
6/18/2003	08:45	60		40	J	3520	0.01	U	0.04	0.0033	10.86	7.6	752.094	34	10.8	0.022*	0.049	23
7/23/2003	08:30	67		50	J	2310	0.01	U	0.037	0.003	U 10.81	7.57	755.65	76	12.4	0.061*	0.045	55
8/20/2003	08:15	77		10	J	1600	0.01	U	0.059	0.003	U 10.9	7.59	768.096	52	11.2	0.048*	0.07	31
9/23/2003	08:25	92		15	J	1370	0.01	U	0.084	0.0036	10.7	7.44	764.286	25	11.5	0.036*	0.14	21

Common data qualifiers: U - not detected at the reported level, J - estimated value

Colored background Indicates that result exceeded water quality standards -OR- contrasted strongly with historical results.

Asterisk * indicates possible quality problem for the result. You may wish to discuss the result with the station contact person.

save the above table to file with this extension: .xls

Bulk data download options for 01A120

- 14 standard parameters, all finalized years, cross-tab html table.
  save to file with this extension: .xls view table - 380 kilobytes
- All project data for WRIA 01
  tab-delimited text format, 98 kilobytes, requires WinZip®, PkZip®, or compatible

Washington State Department of Ecology

Internet

start Post-it(R) Software N... WordPerfect 10 - [P:\... Inbox - Netscape Folder Sediment review - ne... River & Stream Wate... 11:02 AM

viii. Open Excel and open the file that was just downloaded. Verify that all data appear to be available. After you have worked with these files, you will get an idea if something appears wrong. If the data looks like something is wrong, verify it by comparing the data to the finalized data on the webpage (look at each year's finalized data). After the file is open, delete all columns except the date, sussol (mg/L) and turb (NTU).

ix. Next delete the rows that do not need to be included. Only save the months in which the project will be constructed. For example, if work will be conducted during the work timing window of July 15 through August 31, delete all rows except those that contain data for July and August. The data consist of one data collection point each month. In addition, delete any values that have a "U" or "J" in the column to the right of the NTU value. This data may not be accurate; data may not be detectable at reported level or is an estimated value. The blue cells indicate the value exceeds water quality standards or contrasted strongly with historical results.

x. After deleting the unnecessary columns and rows, your data should contain 5 columns. You can now delete the columns to the right of the values. This will give you 3 columns. The first being the date, the second column contains the suspended solid data (mg/L) and the third column the turbidity (NTU) data.

b. Regression analysis. Once you have the data reduced to the months construction will occur, you can determine the relationship between turbidity and suspended

solids using regression. The following steps will provide the regression equation using the data obtained above. These steps are for Excel 2007.

i. With your mouse, highlight both columns of data (suspended solid and turbidity), but do not include the heading information.

ii. Then click on “Insert”, “Scatter” and then the graph that does not have any lines on it (should be the upper left graph).

iii. The graph is placed on your Excel sheet, so move it over so you can see all the data and the graph.

iv. Now add the trendline to the graph. This is done by clicking (left button) once on any of the points on the graph. Then right click. A window pops open and click on “Add Trendline.” A “Format Trendline” window appears. Make sure Linear is checked, and down on the bottom, check Display Equation on chart and Display R-squared value on chart. Click on close.

    1. The X and Y data are opposite of what you want so you need to swap the values. This is done by left clicking once anywhere on the graph and then right click and click on “select data.” A window pops open and you want to click on Edit. An Edit Series window appears and you want to click on the little red arrow next to Series X values. This allows you to select the data in the table. Upon clicking the red arrow, you will see the column under sussol (mg/L) being selected by a moving line around the cells. Select the data under Turb (NTU) by left clicking and holding the button down and drag all the way down to the last cell in that column. The whole column should have the moving line around all the cells. Click on the little red arrow in the Edit Series window. That will expand out the window and you will do the same for the Series Y values. Click on the red arrow next to that, then left click and hold and select all the cells in the column under Sussol (mg/L), and then click on the red arrow again. When the Edit Series window expands, click on OK, and then click on OK.

v. The equation that you want to use for your conversion from NTUs to suspended solids is now on the graph. Hopefully, your R-squared value is also high. This gives you an indication of how well your data fits the line. A one (1) is perfect. If this number is low (and a ballpark figure is less than 0.60) then you may want to consider using the ratio method to determine your conversion from NTUs to suspended solids.

    1. Outliers – sometimes there will be data that will be far outside the norm. These values can be deleted and that will help increase your R-squared value. If you are good at statistics there are ways of

determining outliers. If not, you will probably just use the data as is, unless you think something is really not right, then you may want to delete those data points.

vi. Using the equation for the regression analysis, convert the sediment concentrations found for when adverse effects occur to bull trout and their habitat (number 3 above) to NTUs. For our example, let's say our NTU to suspended solid equation is: $y = 1.6632x - 0.5789$. Adverse effects would then occur at (solve for x):

For impacts to the species adverse effect would occur in the following situations:

a. Any time sediment concentrations exceed 89 NTU over background.
b. When sediment concentrations exceed 60 NTU over background for more than one hour continuously.
c. When sediment concentrations exceed 24 NTU over background for more than three hours cumulatively.
d. When sediment concentrations exceeded 12 NTU over background for over seven hours cumulatively.

For impacts to habitat

a. Any time sediment concentrations exceed 660 NTU over background.
b. When sediment concentrations exceed 532 NTU over background for more than one hour continuously.
c. When sediment concentrations exceed 208 NTU over background for more than three hours cumulatively.
d. When sediment concentrations exceeded 101 NTU over background for over seven hours cumulatively.

c. Turbidity:suspended solid ratio: To calculate the turbidity to suspended solid ratio you need to download the same data off the Ecology website as described above. Sometimes the monitoring stations have limited amount of data and by running the regression analysis it is possible to get a negative slope (an increase in turbidity results in a decrease in suspended solids). This is very unlikely to occur in a stream. Other times you have so few data points that the R^2 value shows that the correlation between suspended solid and turbidity is not very good. When R^2 values are below 0.60, determine the turbidity to suspended solid ratio. The following are the steps needed to calculate the turbidity to suspended solid ratio.

i. After you deleted all the columns and rows of data you do not need, you should have 3 columns of data. The first being the date, the second column contains the suspended solid data (mg/L) and the third column the turbidity (NTU) data.

ii. Calculate the average turbidity and suspended solid value for all data. Average the turbidity column and average the suspended solid column.

iii. Calculate the turbidity to suspended solid value for the average turbidity and average suspended solid value obtained in ii. Divide the average suspended solid value by the average turbidity value.

iv. If any outliers are identified, they should be deleted. Recalculate the turbidity:suspended solid ratio if outliers have been removed (should automatically be done when values are deleted).

vii. Using the turbidity to suspended solid ratio, convert the sediment concentrations found for when adverse effects occur to bull trout and their habitat (number 3 above) to NTUs. For our example, let's say our NTU to suspended solid ratio is 2.1. Adverse effects to the species would then occur in the following situations:

a. Any time sediment concentrations exceed 70 NTU over background.
b. When sediment concentrations exceed 47 NTU over background for more than one hour continuously.
c. When sediment concentrations exceed 19 NTU over background for more than three hours cumulatively.
d. When sediment concentrations exceeded 10 NTU over background for over seven hours cumulatively.

Adverse effects to the species through habitat impacts would occur in the following situations:

a. Any time sediment concentrations exceed 522 NTU over background.
b. When sediment concentrations exceed 421 NTU over background for more than one hour continuously.
c. When sediment concentrations exceed 164 NTU over background for more than three hours cumulatively.
d. When sediment concentrations exceeded 80 NTU over background for over seven hours cumulatively.

5) Determine how far downstream adverse effects and take will occur. There is no easy answer for determining this. Table 4 provides some sediment monitoring data for a variety of projects. These data can be used to determine the downstream extent of sediment impacts for a project. Note that in Table 4 there is not a single downstream point that can always be used because sediment conveyance and mixing characteristics are different for each stream. **An explanation of how the distance downstream was determined needs to be included in each BO.**

Figure 1 – Severity of ill effect scores for juvenile and adult salmonids. The individual boxes provide the maximum concentration for that SEV. The concentration between 4 and 5 represents the threshold for harassment, and the concentration between 7 and 8 represents the threshold for harm.

Juvenile and Adult Salmonids
Average severity of ill effect scores

Concentration (mg/L)	1	3	7	1	2	6	2	7	4	11	30
	Hours			Days			Weeks		Months		
162755	10	11	11	12	12	13	14	14	-	-	-
59874	9	10	10	11	12	12	13	13	14	-	-
22026	8	9	10	10	11	11	12	13	13	14	-
8103	8	8	9	10	10	11	11	12	13	13	14
2981	5760 7	8	8	9	9	10	11	11	12	12	13
1097	6	2335 7	1164 7	8	9	9	10	10	11	12	12
403	5	6	7	491 7	8	9	9	10	10	11	12
148	5	5	6	7	214 7	8	8	9	10	10	11
55	99 4	5	5	6	6	95 7	8	8	9	9	10
20	3	40 4	20 4	5	6	6	42 7	8	8	9	9
7	3	3	4	8 4	5	6	6	18 7	8 7	8	9
3	2	2	3	4	4 4	5	5	6	7	4 7	8
1	1	2	2	3	3	2 4	5	5	6	7	2 7

Figure 2 - Severity of ill effect scores for adult salmonids. The individual boxes provide the maximum concentration for that SEV. The concentration between 5 and 6 represents the threshold for harassment, and the concentration between 7 and 8 represents the threshold for harm.

Adult Salmonids
Average severity of ill effect scores

Concentration (mg/L)											
162755	11	11	12	12	13	13	14	14	-	-	-
59874	10	10	11	11	12	12	13	13	14	14	-
22026	9	10	10	11	11	12	12	13	13	14	14
8103	8	9	9	10	10	11	11	12	12	13	13
2981	8	8	9	9	10	10	11	11	12	12	13
1097	2190 7	8	8	8	9	9	10	10	11	11	12
403	6	1095 7	642 7	8	8	9	9	10	10	11	11
148	156 5	6	6	331 7	175 7	8	8	9	9	10	10
55	5	78 5	6	6	7	94 7	8	8	9	9	9
20	4	4	46 5	24 5	6	6	50 7	27 7	8	8	9
7	3	4	4	5	12 5	6	6	7	14 7	8 7	8
3	2	3	3	4	4	7 5	4 5	6	6	7	4 7
1	2	2	3	3	4	4	5	2 5	1 5	6	6
	1	3	7	1	2	6	2	7	4	11	30
	Hours			Days			Weeks		Months		

Figure 3 - Severity of ill effect scores for juvenile salmonids. The individual boxes provide the maximum concentration for that SEV. The concentration between 4 and 5 represents the threshold for harassment, and the concentration between 7 and 8 represents the threshold for harm.

Juvenile Salmonids
Average severity of ill effect scores

Concentration (mg/L)											
162755	9	10	11	11	12	13	14	14	-	-	-
59874	9	9	10	11	11	12	13	14	14	-	-
22026	8	9	9	10	11	11	12	13	13	14	-
8103	13119 7	8	9	9	10	11	11	12	13	13	14
2981	6	4448 7	8	9	9	10	11	11	12	13	13
1097	6	6	1931 7	8	9	9	10	11	11	12	13
403	5	6	6	687 7	8	9	9	10	11	11	12
148	197 4	5	6	6	254 7	8	9	9	10	11	11
55	4	67 4	5	6	6	96 7	8	8	9	10	11
20	3	4	29 4	5	6	6	36 7	8	8	9	10
7	2	3	4	10 4	5	6	6	13 7	8	8	9
3	1	2	3	4	4 4	5	6	6	5 7	8	8
1	1	1	2	3	4	1 4	5	6	6	8	8
	1	3	7	1	2	6	2	7	4	11	30
	Hours			Days			Weeks		Months		

Figure 4 - Severity of ill effect scores for eggs and alevins of salmonids. The individual boxes provide the maximum concentration for that SEV. The concentration between 4 and 5 represents the threshold for both harassment and harm to eggs and alevins.

Eggs and Alevins of Salmonids
Average severity of ill effect scores

Concentration (mg/L)											
162755	7	9	10	11	12	13	14	-	-	-	-
59874	7	8	9	10	12	13	14	-	-	-	-
22026	7	8	9	10	11	12	13	-	-	-	-
8103	7	8	9	10	11	12	13	14	-	-	-
2981	6	7	8	10	11	12	13	14	-	-	-
1097	6	7	8	9	10	11	12	14	-	-	-
403	6	7	8	9	10	11	12	13	14	-	-
148	5	6	7	9	10	11	12	13	14	-	-
55	5	6	7	8	9	10	12	13	14	-	-
20	5	6	7	8	9	10	11	12	13	-	-
7	11 4	5	7	8	9	10	11	12	13	14	-
3	4	5	6	7	8	10	11	12	13	14	-
1	4	5	6	7	8	9	10	11	13	14	-
	1	3	7	1	2	6	2	7	4	11	30
	Hours			Days			Weeks		Months		

Figure 5 - Severity of ill effect scores for salmonid habitat. The individual boxes provide the maximum concentration for that SEV. The concentration between 6 and 7 represents the threshold for anticipating adverse effects to bull trout through habitat modifications.

Salmonid Habitat
Average severity of ill effect scores

Concentration (mg/L)	1	3	7	1	2	6	2	7	4	11	30
	Hours			Days			Weeks		Months		
162755	11	12	12	13	14	-	-	-	-	-	-
59874	10	11	12	12	13	14	-	-	-	-	-
22026	9	10	11	11	12	13	14	14	-	-	-
8103	8	9	10	11	11	12	13	14	14	-	-
2981	8	8	9	10	11	11	12	13	13	14	-
1097	7	7	8	9	10	10	11	12	13	13	14
403	885 6	7	7	8	9	10	10	11	12	12	13
148	5	345 6	167 6	7	8	9	9	10	11	12	12
55	4	5	6	68 6	7	8	9	9	10	11	11
20	3	4	5	5	29 6	7	8	8	9	10	11
7	2	3	4	5	5	12 6	7	7	8	9	10
3	2	2	3	4	5	5	5 6	7	8	8	9
1	1	1	2	3	4	4	5	2 6	7	7	8

Reference List

1. Anderson, P. G., B. R. Taylor, and G. C. Balch. 1996. Quantifying the effects of sediment release on fish and their habitats.Canadian Manuscript Report of Fisheries and Aquatic Sciences 2346.

2. 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.

3. Newcombe, C. P. 1994. Suspended sediment in aquatic ecosystems: ill effects as a function of concentration and duration of exposure. Victoria, British Columbia.

NOAA Fisheries Biological Opinion

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Northwest Region
7600 Sand Point Way N.E., Bldg. 1
Seattle, Washington 98115

Refer to NMFS Tracking No.: 2010/05723

May 20, 2011

Daniel M Mathis
Federal Highway Administration
Suite 501, Evergreen Plaza
711 South Capitol Way
Olympia, Washington 98501-1284

Re: Endangered Species Act Section 7 Formal Consultation and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Consultation for the SR 520 Bridge Replacement Project, (Cedar River, HUC 171100120302), King County, Washington

Dear Mr. Mathis: Dan

The enclosed document contains a Biological Opinion (Opinion) prepared by the National Marine Fisheries Service (NMFS) pursuant to section 7(a)(2) of the Endangered Species Act (ESA) on the effects of the project referenced above. In this Opinion, the NMFS concludes that the proposed action is not likely to jeopardize the continued existence of Puget Sound (PS) Chinook salmon or PS steelhead and is not likely to destroy or adversely modify PS Chinook salmon critical habitat.

As required by section 7 of the ESA, the NMFS provides an incidental take statement with the Opinion. The incidental take statement describes a reasonable and prudent measure that is necessary to minimize incidental take. The take statement sets forth nondiscretionary terms and conditions. Incidental take from actions that meet these terms and conditions will be exempt from the ESA take prohibition.

This document also includes a description of the action's likely effects on Essential Fish Habitat pursuant to section 305(b) of the Magnuson-Stevens Fishery Conservation and Management Act (MSA), and includes 11 conservation recommendations, which are a subset of the ESA Terms and Conditions. Federal agencies are required to provide a detailed written response to NMFS' EFH conservation recommendations within 30 days of receipt of these recommendations [50 CFR 600.920(j)(1)].

The response must include a description of measures proposed to avoid, mitigate, or offset the adverse affects that the activity has on EFH. If the response is inconsistent with the EFH conservation recommendations, the response must explain the reasons for not following the recommendations, including the scientific justification for any disagreements over the anticipated effects of the proposed action and the measures needed to avoid, minimize, mitigate, or offset such effects.

If you have questions regarding this consultation, please contact Michael Grady of the Washington State Habitat Office at (206) 526-4645, or by electronic mail at Michael.Grady@noaa.gov.

Sincerely,

for William W. Stelle, Jr.
Regional Administrator

Enclosure

cc: Paul Wagner, WSDOT
Randolph Everett, FHWA
Phil Bloch, WSDOT
Karen Walter, Muckleshoot Indian Tribe

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F/NWR/2010/05723

Endangered Species Act (ESA) Section 7(a)(2) Biological Opinion, Section 7(a)(2) "Not Likely to Adversely Affect" Determination, Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat (EFH) Consultation

SR 520 Bridge Replacement Project

NMFS Consultation Number: 2010/05723

Action Agency: Federal Highway Administration

Affected Species and Determinations:

ESA-Listed Species	Status	Is Action Likely to Adversely Affect Species or Critical Habitat?	Is Action Likely To Jeopardize the Species?	Is Action Likely To Destroy or Adversely Modify Critical Habitat?
Puget Sound steelhead (*Oncorhynchus mykiss*)	Threatened	Yes	No	N/A
Puget Sound Chinook salmon (*O. tshawytscha*)	Threatened	Yes	No	No
yelloweye rockfish (*Sebastes ruberrimus*)	Threatened	No	No	N/A
canary rockfish (*S. pinniger*)	Threatened	No	No	N/A
bocaccio (*S. paucispinis*)	Endangered	No	No	N/A
Southern Resident killer whales (*Orcinus orca*).	Endangered	No	No	No

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

Consultation Conducted By: National Marine Fisheries Service, Northwest Region

Issued By:

for William W. Stelle, Jr.
Regional Administrator

Date: May 20, 2011

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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 biological opinion (opinion) and incidental take statement portions of this document were prepared by the National Marine Fisheries Service (NMFS) in accordance with section 7(b) of the Endangered Species Act (ESA) of 1973, as amended (16 U.S.C. 1531, et seq.), and implementing regulations at 50 CFR 402. The NMFS also completed an Essential Fish Habitat (EFH) consultation. It was prepared 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. The opinion and EFH conservation recommendations are both in compliance with section 515 of the Treasury and General Government Appropriations Act of 2001 (Public Law 106-5444) ("Data Quality Act") and underwent pre-dissemination review.

1.2 Consultation History

Since May 2007, the Washington State Department of Transportation (WSDOT) and the Federal Highway Administration (FHWA), the U.S. Fish and Wildlife Service (USFWS) and NMFS, other regulatory agencies, and the Muckleshoot Indian Tribe Fisheries Division (MITFD) have been participating in a resource agency coordination process on the proposed action. The goal of the coordination was to facilitate collaboration with regulatory agencies and the MITFD as the project progresses through National Environmental Policy Act (NEPA) and State Environmental Policy Act (SEPA) documentation, ESA consultation, project design, and permitting.

In July 2007, WSDOT, FHWA, USFWS, and NMFS began participating in biweekly meetings of the ESA Steering Group. The intent of the Steering Group is to discuss and attempt to resolve technical issues related to the State Route (SR) 520 Bridge Replacement Project and its effects on listed species and designated critical habitats. On December 7, 2010, the FHWA submitted a biological assessment (BA) to the NMFS for the SR 520 Bridge Replacement Project and requested consultations under both the ESA and MSA. The proposed project will be carried out by the WSDOT and will be partially funded by the FHWA. This opinion is based on information provided in the December 7, 2010 BA and information WSDOT and FHWA provided to NMFS between May 2007 and April 2011. A complete record of this consultation is on file at Washington State Habitat Office in Lacey, Washington.

Table 1. FHWA ESA Determinations[1]

Species	Federal Status	Species Determination	Critical Habitat Determination	Listing/ Designation Date
Puget Sound Chinook salmon (*Oncorhynchus tshawytscha)*	Threatened	LAA[2]	LAA	Jun. 28, 2005 70 FR 37160/ Sept. 2, 2005 70 FR 52630
Puget Sound steelhead (*Oncorhynchus mykiss*)	Threatened	LAA	Not applicable	Jun. 11, 2007 72 FR 26722
Puget Sound/Georgia Basin DPS boccacio (*Sebastes paucispinis*)	Endangered	NLAA[3]	Not applicable	Apr. 28, 2010, 75 FR 22276
Puget Sound/Georgia Basin DPS canary rockfish (*S. pinniger*)	Threatened	NLAA	Not applicable	Apr. 28, 2010, 75 FR 22276
Puget Sound/Georgia Basin DPS yelloweye rockfish (*S. ruberrimus*)	Threatened	NLAA	Not applicable	Apr. 28, 2010, 75 FR 22276
southern resident killer whale (*Orcinus orca*)	Endangered	NLAA	NLAA	Nov. 18, 2005, 70 FR 69903/ Nov. 29, 2006 71 FR 69054

[1] The NMFS agreed with these determinations and initiated consultation accordingly.
[2] LAA = likely to adversely affect
[3] NLAA = not likely to adversely affect

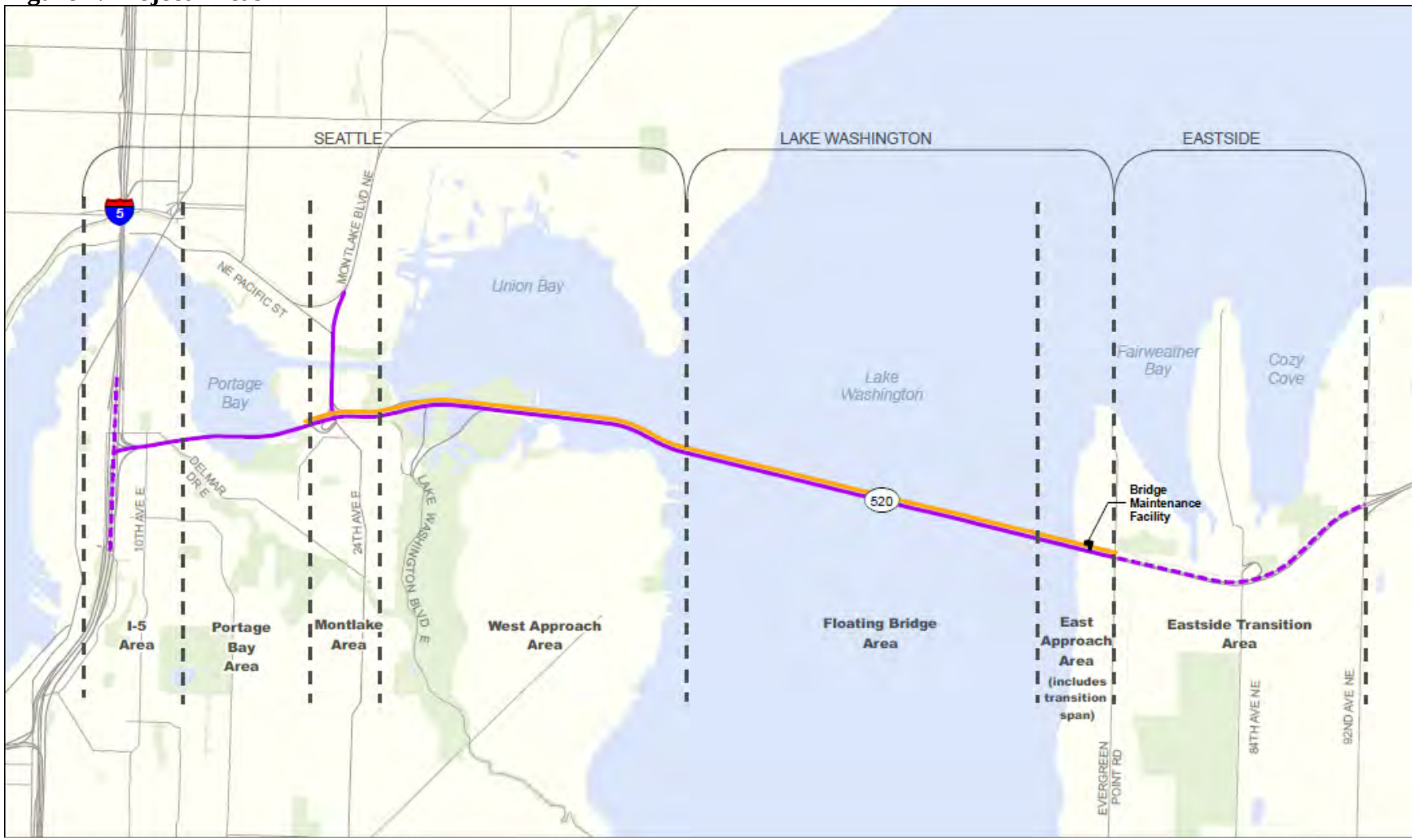
1.3 Proposed Action

"Action" means all activities or programs of any kind authorized, funded, or carried out, in whole or in part, by Federal agencies. Interrelated actions are those that are part of a larger action and depend on the larger action for their justification. Interdependent actions are those that have no independent utility apart from the action under consideration.

The SR 520 Bridge Replacement Project will widen SR 520 from four lanes to six (two general purpose lanes and one high occupancy vehicle (HOV) lane in each direction) from Interstate 5 (I-5) in Seattle to Evergreen Point Road in the City of Medina (WSDOT 2010). The proposed action includes the construction of pontoons in Commencement Bay and the Port of Olympia, the transport of already-constructed pontoons from Grays Harbor and Puget Sound to Lake Washington, the outfitting of pontoons in Puget Sound, the widening of SR 520 between I-5 and

Medina (which includes the construction bridges across Portage Bay, Union Bay, and Lake Washington), and habitat improvement projects.

Figure 1. Project Areas



1.3.1 Pontoon Construction

The new floating bridge will have a total of 77 pontoons (21 longitudinal pontoons, two cross pontoons, and 54 supplemental stability pontoons (SSPs). WSDOT will construct the longitudinal and cross pontoons and 10 SSPs (33 total) as part of the separate Pontoon Construction Project (NMFS tracking number: 2010/0331) to replace the existing bridge in the event of an emergency. WSDOT will moor these pontoons in Grays Harbor, and, if the Evergreen Point Bridge does not fail, WSDOT will use those pontoons to construct the new, six-lane floating bridge.

The WSDOT will construct the other 44 supplemental stability pontoons at existing facilities in the Port of Tacoma (23 SSPs) and the Port of Olympia (21 SSPs) between August 2012 and February 2014. Fifty-eight precast gravity and fluke anchors for the floating bridge will also be fabricated at these facilities.

1.3.1.1 Port of Olympia Facility

The Port of Olympia site is on the West Bay of Budd Inlet in Thurston County, WA. WSDOT will construct the 21 SSPs on upland concrete slabs (casting beds). Piles will support the casting beds. Once a pontoon is cured, WSDOT will either move it to an upland storage facility or load it onto a barge. Onsite stormwater facilities and temporary construction stormwater best management practices (BMPs) will treat stormwater and construction process water to prevent any water quality degradation to Puget Sound.

1.3.1.2 Port of Tacoma

The Port of Tacoma site is on Blair Waterway, an inlet of Commencement Bay. The Concrete Technology Corporation (CTC) facility can build five SSPs at a time. WSDOT will cast SSPs on casting beds similar to those described for the Port of Olympia site and within the CTC casting basin. WSDOT will launch all of these SSPs through the CTC casting basin. After a cycle of pontoons is completed, the gate is removed, and the basin floods to allow the pontoons to float. After tug boats remove the pontoons, they will return the gates to their original position. Seawater is then allowed to drain with the ebbing tide through three ports. Pumps will then remove the remainder of the water. WSDOT will follow NMFS-approved, WSDOT fish handling protocols to remove any fish trapped to the maximum extent practical (WSDOT 2009a).

Before the first set of pontoons is constructed and after the construction of each cycle of pontoon is completed, the basin will be thoroughly cleaned (pressure washed) to prevent delivery of contaminants to the Blair Waterway. The constructed pontoons will also be pressure washed within the casting basin before transport. WSDOT estimates 10 CTC gate openings to launch the 23 SSPs between August 2012 and June 2014. WSDOT will not need to outfit the SSPs, so they will tow them directly to Lake Washington. Any anchors that WSDOT constructs at this site will not require any gate openings.

1.3.1.3 Pontoon Outfitting and Moorage

The WSDOT will outfit the longitudinal and cross pontoons at existing commercial shipping or mooring facilities in Puget Sound and in the SR 520 right-of-way in Lake Washington. Potential locations include the Ports of Bellingham, Everett, Seattle, Tacoma, Olympia, and Grays Harbor. Outfitting of pontoons could take up to 4 months in these port locations. At most, seven pontoons will be moored simultaneously. WSDOT will temporarily moor pontoons in Puget Sound at existing facilities used for mooring large vessels. Once outfitting construction is completed, WSDOT will tow the pontoons into Lake Washington.

The tow from Grays Harbor to Lake Washington is 250 nautical miles. The tug boats will travel at slow speeds, and each trip will take approximately 76 hours (including 27 hours in the open ocean). Pontoons towed from the CTC site or the Port of Olympia site will follow shipping lanes to Lake Washington. WSDOT will transport pontoons between August 2012 and August 2014.

1.3.2 Roadway and Bridge Construction

The roadway portion of the proposed action will reconstruct SR 520 from I-5 to the City of Medina. From west to east (Seattle to Medina) the project includes the following elements:

- I-5 interchange area
- Portage Bay Bridge (PBB)
- Montlake
- West approach
- Floating bridge
- East approach and maintenance facility

WSDOT will use drilled shafts for the foundations of all in-water columns and footings. To construct these shafts, WSDOT will lower a casing pipe to the substrate and vibrate it down leaving the top above the waterline. After the casing has been installed, a crane-mounted auger will drill the shaft. It may be necessary to fill the casings with a bentonite (clay) slurry to support the walls of the boring hole. WSDOT will contain the boring spoils, including any bentonite slurry, and transport it off site by barge or load it into dump trucks for hauling to a disposal site. After excavating the shaft, they will lower a reinforcing steel shaft cage and pump concrete into the casing, displacing the water or slurry. WSDOT will contain, collect, and treat the water or slurry prior to reuse or disposal. The casing pipe will remain and form the top of the shaft.

1.3.2.1 Interstate 5 Interchange

Activities in this area include roadway reconstruction, excavation and embankment grading, retaining wall and abutment construction, and paving. None of the work in this area will take place in-water. Existing PGIS measures 16.70 acres in this area. The project will add 0.05 acres

of PGIS for a total of 16.75 acres. WSDOT will construct a bioswale to treat stormwater from four acres of PGIS from this area. The bioswale will direct stormwater to Lake Union via the City of Seattle's East Allison Street outfall. This outfall also carries untreated stormwater from City of Seattle PGIS outside of the action area.

1.3.2.2 Portage Bay Bridge (PBB)

The WSDOT will replace the existing PBB with a wider structure for the two general purpose lanes and an HOV lane in each direction (six lanes total). The new bridge will have larger but fewer columns than the existing bridge. It will begin just east of Delmar Drive, extend across Portage Bay to Montlake Boulevard. To accommodate four lanes of traffic for the duration of the project, WSDOT will temporarily widen the existing PBB to the south.

The bridge will range between 105 and 143 feet wide compared to the 61- to 75-foot-wide existing bridge. The maximum over-water height of the western half of the new bridge will increase from 55 feet to approximately 62 feet, and the height of the eastern half will increase from 5 to 16 feet. Total over-water cover resulting from the Portage Bay Bridge will be approximately 4.5 acres. This is an increase of approximately 1.4 acres from the existing condition.

This portion of the action area contains 9.81 acres of existing PGIS. The project will add 2.19 acres of PGIS for a total of 12.00 acres. WSDOT will construct two stormwater treatment facilities, a bioswale and a constructed wetland, to treat stormwater from 11.64 acres of PGIS from this area. These BMPs will direct stormwater to two existing outfalls to Portage Bay, PB 1 and PB 2. The PB 1 outfall discharges near the west shore of Portage Bay and PB 2 near the east shore.

The WSDOT will construct mudline footings for three bents (a row of columns) on the west side of Portage Bay. Mudline footings are rectangular concrete blocks embedded into the lake bed and supported by 10 drilled shafts. The footings tie the multiple shafts together and distribute the load from the columns. These three footings will occupy approximately 12,500 square feet (0.3 acre) of substrate.

Fifty in-water columns (ranging in size from seven by seven feet to seven by 10 feet) will support the PBB. The columns will be either on top of a mudline footing or directly on top of a drilled shaft. Each of the three mudline footings will support five columns extending from the top of the footing to the bottom of the superstructure. The remaining 35 columns will be supported by individual drilled shafts. Eighty-two, seven-foot diameter drilled shafts will support the columns and footings of the new PBB. Sixty-five of these shafts will be in-water. To isolate the drilled shaft construction from the water, WSDOT will construct the drilled shafts within a casing pipe or within cofferdams.

The WSDOT will construct work bridges along the outer edge of the north and south sides of the proposed structure. The work bridges will not exceed 4.1 acres (1.9 acres over open water). Approximately 900, 24- to 30-inch steel piles will support the work bridges.

The WSDOT will temporarily widen the existing bridge to the south. Traffic will use this widened section during construction of the northern half of the new bridge. Following construction, traffic will be shifted to the newly constructed northern half of the new bridge to allow demolition of the existing and temporary south bridge lanes and the construction of the new southern half of the PBB.

Construction activities for the PBB will occur over a 5- to 6-year period. The following is an estimate of when, during this period, the various elements will be constructed. However, some activities may occur in different construction years than described below if construction progresses faster or slower than WSDOT's current estimates. All in-water work will occur within the windows described below. These windows are designed to minimize impacts to PS Chinook, PS steelhead, and other aquatic resources.

1.3.2.2.1 Portage Bay Bridge Construction Year 1 (2013-14). During the first construction year, WSDOT will construct work bridges along the south and north sides of the existing PBB. WSDOT will drive the 900 steel piles at a rate of approximately 16 piles per day to construct the work bridges. WSDOT will drive theses piles using both vibratory and impact hammers between September 1 and April 30. Vibratory driving will be used for the initial stages of pile driving, finishing with impact driving to achieve adequate load-bearing capacities. WSDOT will use a bubble curtain to attenuate underwater sound during all impact driving.

Once the work bridges are complete, WSDOT will build the temporary bridge south of the existing bridge. Approximately 42 temporary 8-foot-diameter drilled shafts will support the columns of the temporary bridge. The vibratory driving of the casing pipes will occur between August 16 and April 30. Work within the casings will take place throughout this construction year.

1.3.2.2.2 Portage Bay Bridge Construction Year 2 (2014-15). After traffic shifts to the temporary widening, WSDOT will demolish the northern portion of the existing PBB, beginning with the removal of the superstructure and the in-water vibratory removal (or cutting) of approximately 44 to 45 columns (roughly half the existing columns).

Construction of the new north substructure will follow the progression of demolition. WSDOT will construct three mudline footings supported by 18 drilled shafts for the three western most in-water bents. Three cofferdams will isolate the mudline footing construction from the water. The cofferdams will occupy approximately 8,200 square feet of substrate for the one year period they remain in place. WSDOT will construct the cofferdams by vibrating interlocking sheet piles 20 feet into the substrate. After completion of the cofferdam, they will remove any trapped fish using NMFS-approved, WSDOT fish handling protocols to the maximum extent practical (WSDOT 2009a). The area within the cofferdam will then be excavated below the existing mudline with a clamshell bucket, sealed with concrete, and dewatered. All excavated soils will be transferred into dump trucks on the work bridge or contained on work barges and hauled off site for disposal. The water coming out of the cofferdam will be treated before being discharged. Appropriate BMPs, such as containment tarps, will prevent excavated material from entering the water.

In addition to the mudline footings, WSDOT will construct 21 in-water drilled shafts within casing pipes to support individual columns for the northern half of the new bridge. The installation of the pipe casings and construction of the drilled shafts (within both the pipe casings and cofferdams) will follow the same construction procedures described for Construction Year 1. Installation of the cofferdams and pipe casings will take place between August 16 and April 30.

As elements of the substructure are completed, construction of the superstructure can begin. WSDOT will construct falsework from the work bridges to support concrete forms for the superstructure. Two hundred additional piles will support the falsework. WDSOT will drive these piles between September 1 and April 30. Once the falsework and concrete forms are completed, the cast-in-place girders and false arches will be poured.

1.3.2.2.3 Portage Bay Bridge Construction Year 3 (2015-16). In the third construction year, WSDOT will shift traffic to the new northern half of the bridge and will demolish the southern half of the existing bridge (including the temporary widening) using the same demolition methods described above.

1.3.2.2.4 Portage Bay Bridge Construction Year 4 (2016-17). Construction of the southern half of the substructure will begin in construction year 4. WSDOT will construct three mudline footings supported by 12 drilled shafts for the three western-most in-water bents. Three cofferdams will isolate the mudline footing construction from the water. The cofferdams will occupy approximately 5,500 square feet of substrate. In addition to the mudline footings, WSDOT will construct 14 in-water drilled shafts within casing pipes to support individual columns for the new bridge. Construction of the pipe casings, cofferdams, and drilled shafts will follow the same construction procedures described for Construction Years 1 and 2, and as in previous years, installation of the cofferdams and pipe casings will take place between August 16 and April 30.

When the arches are completed, the north work bridge and falsework will be removed. This work will consist of vibratory removal of 650 piles.

1.3.2.2.5 Portage Bay Bridge Construction Year 5 (2017-18). During construction year 5, as construction of the southern half of the substructure progresses, construction of the southern half of the superstructure will begin. This will require the installation of 200 additional falsework piles using the same methods described above.

1.3.2.2.6 Portage Bay Bridge Construction Year 6 (2018-19). During construction year 6 (the final construction year), WSDOT will complete the southern half of the superstructure and false arch. Construction year 6 will also include stormwater routing, bridge lighting, and roadway striping. The south work bridge and falsework will be dismantled, including the remaining 650 piles; and site cleanup and demobilization will conclude the construction activities.

1.3.2.3 Montlake Interchange

The WSDOT will widen the Montlake interchange to the north to accommodate a shift in the alignment of the highway and ramps. They will also demolish the Montlake Boulevard and 24th

Avenue East overpasses and replace them with a lid, and construct a new bascule bridge over the Montlake Cut. Construction will occur over about a 4-year period and will include roadway reconstruction, excavation, retaining wall and abutment construction, and paving. Most of these construction activities will occur in upland areas and will not affect aquatic habitats. Staging areas include portions of a parking lot on the University of Washington campus, the unused R.H. Thomson Expressway ramps, the closed Lake Washington Boulevard ramps, and WSDOT right-of-way adjacent to SR 520.

This part of the action area has 0.21 acre of existing PGIS. The project will add 0.20 acre of PGIS for a total of 0.41 acre. WSDOT will route stormwater from this area to the combined sewer system. The West Point Wastewater Treatment Plant treats water from the combined sewer system and discharges it to Puget Sound. The existing Montlake Cut Bascule Bridge does not currently collect any water for treatment because the deck is steel grating. The proposed second bascule bridge will also have a steel-grated deck and will not collect stormwater.

The WSDOT will construct a new bascule bridge over the Montlake Cut, east of the existing bascule bridge. The bottom of the arched bridge will be approximately 35 feet above the water near the piers and approximately 46 feet above the water at mid-span. The new bridge will be approximately 60 feet wide and 150 feet long. Total over-water cover will be approximately 0.2 acre.

The construction will be staged from the shoreline. Except for the temporary use of barges to install the bridge leaves, no in-water construction will be necessary. Upland cofferdams will isolate pier construction from the water. After completing the upland pier supports, the bridge leaves will be attached to the piers. A barge-mounted derrick will lift the leaves into position. The barge work will require closing the Montlake Cut to boat traffic periodically over a 3- to 4-week period for less than 48 hours at a time.

1.3.2.4 West Approach

The existing west approach will be replaced by two new bridges, eastbound and westbound, with a gap between them. The west approach will begin in Montlake and extend through Union Bay, across Foster Island, and out into Lake Washington, terminating at the beginning of the floating bridge.

This part of the action area contains 12.60 acres of existing PGIS (SR 520). The project will add 8.71 acres of PGIS for a total of 21.31 acres. WSDOT will direct stormwater from this area to a constructed wetland on the site currently occupied by the Museum of History and Industry (MOHAI). The constructed wetland will provide enhanced treatment which targets dissolved metals. Stormwater from this facility will discharge into Union Bay south of the Montlake cut.

The supports for the west approach bridges will be concrete columns on individual drilled shafts (no mudline footings). The superstructure will consist of precast-concrete girders (which will not require falsework) and the roadway deck. The spans of the new bridges will be longer than those of the existing bridge (i.e., the piers will be farther apart). The increase in span length will result in fewer in-water columns. Overall, the width of the new west approach will range

between 252 feet near Montlake to 112 feet at the west transition span, with a gap width ranging between 7 and 40 feet. The width of the existing west approach varies between 57 and 104 feet. The height of the bridge over water will increase from a minimum of less than 3 feet to about 12 feet near Montlake and from 45 to 48 feet near the west transition span. Total over-water cover resulting from the west approach structure will be approximately 19 acres: 8.4 acres in Union Bay and 10.6 acres in Lake Washington. This represents an increase of 2.5 acres of over-water cover in Union Bay and 5.8 acres in Lake Washington.

Forty-two bents, 39 in-water and three bents on Foster Island will support the west approach. Most span lengths will be 150 feet. Of the 254, 10-foot-diameter shafts supporting the west approach, 233 will occur in the water. The Union Bay section (Arboretum and Foster Island) will consist of 104 in-water shafts, and the Lake Washington section (east of Foster Island) will consist of 129 in-water shafts. Construction will include a temporary work bridges and construction barges.

Like the PBB, the west approach will require work bridges. The northern portion of the new west approach will be constructed first, with traffic diverted to this structure, while the existing west approach bridge is demolished and construction of the southern half of the new west approach begins. Construction activities in this area will occur over a 5- to 6-year period. As with the PBB, some activities may occur in different construction years than described below, and all in-water work will occur within the windows described below to minimize impacts to PS Chinook, PS steelhead, and other aquatic resources.

1.3.2.4.1 West Approach Construction Year 1 (2013-14). In the first construction year, WSDOT will construct work bridges and finger piers along the north side of the existing bridges. The work bridges will require driving 500 steel 24- to 30-inch piles in Union Bay (Arboretum and Foster Island) and 450 in Lake Washington (east of Foster Island). WSDOT will drive theses piles using the same methods described above between October 1 and April 30. WSDOT will use a bubble curtain to attenuate under water sound during all impact driving. The north work bridges will cover approximately seven acres. They will span from Montlake to Foster Island, and extend approximately 1,700 feet out into Lake Washington, to roughly the 10-foot depth.

Construction on the northern half of the bridge substructure will then begin in Union Bay (Arboretum and Foster Island) and Lake Washington (east of Foster Island). To maintain traffic flow, an interim connection between the new floating span (see the following discussion of construction year 2) and the existing west approach span will then be completed in Lake Washington. WSDOT will construct 84 drilled shafts, 60 in Union Bay and 24 in Lake Washington between, August 1 and March 31. The construction methods will be the same as those described for the PBB drilled shafts. WSDOT will construct the 24 shafts in Lake Washington from barges.

1.3.2.4.2 West Approach Construction Year 2 (2014-15). The WSDOT will continue the construction of the west approach north substructure in Lake Washington in the second construction year, including constructing another 72 drilled shafts. After WSDOT completes the substructure elements, they will begin construction of the northern half of the west approach

superstructure. The superstructure will be constructed from both the north work bridges and barges. The superstructure completed in this year will measure 5.1 acres in Union Bay and 7.5 in Lake Washington. WSDOT will drive 400 piles in Union Bay (with the same pile type and driving methods describe previously) to construct the south work bridge in Union Bay. The south work bridge will add an additional 4.3 acres of over-water cover.

1.3.2.4.3 West Approach Construction Year 3 (2015-16). After traffic switches to the interim connection, WSDOT will begin demolishing the east end of the existing west approach bridge from barges. The demolition will include removing the superstructure and 80 columns in Lake Washington and 89 columns in Union Bay. Construction will also include the southern work bridge, which will involve the driving of 1,100 steel piles and the addition of 7.6 acres of additional overwater shade (500 piles and 3.3 acres of shade in Lake Washington and 600 piles and 4.3 acres of shade in Union Bay). As work bridge construction advances in Union Bay, WSDOT will demolish the existing Lake Washington Boulevard ramps, including the removal or cutting of 89 in-water columns.

As the south work bridges are completed, WSDOT will begin the construction of the drilled shafts for the south half of the substructure (44 drilled shafts in Union Bay and 42 in Lake Washington). WSDOT will build the shafts and columns (10 piers) east of the work bridge (water depths greater than 10 feet) from barges.

1.3.2.4.4 West Approach Construction Year 4 (2016-17). In the fourth construction year, traffic will shift to the northern portion of the bridge and WSDOT will complete the demolition of the existing Union Bay Bridge, west-approach bridge, and the interim west approach connection. The demolition will include the removal of 170 columns. WSDOT will also dismantle the north work bridges in this year (including removing the 500 steel piles) and begin construction of the southern half of the superstructure.

1.3.2.4.5 West Approach Construction Year 5 (2017-18). The WSDOT will continue construction of the southern half of the superstructure this construction year and dismantle a portion of the north work bridge including removing 450 piles.

1.3.2.4.6 West Approach Construction Year 6 (2018-19). The WSDOT will complete construction of the southern half of the superstructure this construction year and dismantle the rest of the north work bridge, including removing 500 piles. The final stage of construction will be site cleanup and equipment demobilization.

1.3.2.5 Floating Bridge

The new floating span will be between 190 and 160 feet north of the existing bridge. The new six-lane floating bridge will consist of a single row of 21 longitudinal pontoons, 2 cross pontoons (one at each end of the floating bridge), and 54 supplemental stability pontoons. The new pontoons will have a deeper draft than the existing pontoons. New longitudinal pontoons will extend between 22 and 28 feet below the surface of the water, compared to the existing pontoons, which extend 7 to 14.5 feet below the water surface. The two cross pontoons will extend deeper (about 34 feet below the surface). The new, larger longitudinal pontoons and the

supplemental stability pontoons will accommodate the wider highway. The over-water area from the pontoons will increase from 10.8 acres to 19.9 acres. The roadway will extend beyond the width of the pontoons and will add an additional 0.9 acre of over-water cover for a total of 20.8 acres.

The existing floating bridge contains 17.28 acres of existing PGIS. The new bridge will have 20.56 acres of PGIS, an increase of 3.28 acres. The existing bridge does not have any stormwater treatment. WSDOT will treat stormwater on the new bridge using monthly high-efficiency sweeping, modified catch basins, and spill control lagoons. High-efficiency sweeping will be a broom sweeper followed by a regenerative air sweeper. The modified catch basins are larger than standard catch basin structures. The catch basins will direct stormwater to spill control lagoons built into the supplemental stability pontoons. Forty-four of the 54 supplemental stability pontoons will have 19- by 29-foot spill control lagoons in the center of the pontoons. Stormwater will mix with water in the spill control lagoons and dilute prior to flowing into Lake Washington.

As with the existing floating bridge, the pontoons for the new bridge will be anchored to the lake bottom. The new bridge will have 58 anchors, 45 fluke anchors and 13 gravity anchors. WSDOT will install the pontoons over a 3-year period, beginning in 2012 and ending in early 2015. Once traffic shifts to the new floating bridge, the existing floating bridge will be dismantled and the pontoon sections towed away. The old pontoon sections could be sold for other purposes or hauled to an existing facility for demolition and recycling.

1.3.2.6 East Approach and Bridge Maintenance Facility

The WSDOT will replace the existing east approach span with a higher and wider structure spanning from the east end of the floating bridge to the bluff on the Medina shoreline. Like the PBB, the east approach substructure will consist of drilled shafts, mudline footings, and concrete support columns. The superstructure will consist of cast-in-place concrete girders and the roadway deck. The combined width of the north and south structures will range from 134 to 152 feet, from west to east. The structure will be approximately 660 feet long.

The east approach will have five columns per bent. Bent one will be in-water, approximately 350 feet from the shoreline, and Pier two will be onshore. Each bent foundation will consist of ten 10-foot-diameter drilled shafts supporting two mudline footings. The in-water mudline footings for bent one will be 90 by 60 feet for the north bridge and 60 by 50 feet for the south bridge and together will occupy approximately 8,300 square feet of substrate. The two in-water footings will support a total of five rectangular bridge columns.

Existing PGIS measures 1.75 acres. The project will remove 0.05 acres of PGIS leaving a total of 1.70 acres. A bioswale will treat stormwater from this area and discharge it below the east approach bridge. NMFS previously consulted on the construction of the bioswale and the effects of the stormwater discharge for the SR 520 Eastside Transit and High Occupancy Vehicle Project (NMFS tracking number: 2009/03446).

The WSDOT will use falsework to support the concrete forms for the box girders. The new bridges will be 83 and 51 feet wide (north and south bridges, respectively) at the west end and 91 and 61 feet at the east end. The bottom of the bridge deck will range from 66 feet to 78 feet above the water. The over-water cover of the east approach will be 1.3 acres. This is an increase of one acre from existing conditions. WSDOT will construct the new east approach span between 2012 and 2015. Construction will take place from work bridges, barges, and land.

The WSDOT will construct a bridge maintenance facility underneath the east approach. The facility will include a maintenance building and a T-shaped dock for two work boats. The dock will extend 100 feet offshore and cover 1,500 square feet. WSDOT will remove two existing docks with a total area of 900 square feet resulting in a net increase of 600 square feet of over-water shading. Five drilled shafts and columns will support the dock. WSDOT will use a vibratory hammer to install 20 temporary piles to support the shaft drilling rig. As describe above, some activities may occur in different construction years than described below, and all in-water work will occur within the windows described below to minimize impacts to PS Chinook, PS steelhead, and other aquatic resources.

1.3.2.6.1 East Approach Construction Year 1 (2012-13). In the first construction year, WSDOT will construct the work bridges, finger piers, and falsework. WSDOT will drive 125, 24- to 30-inch steel piles to support these structures between August 16 and March 15. Construction methods for the work bridges will be the same as those for the PBB and west approach. The work bridges will cover 0.8 acre and extend 380 feet out into Lake Washington to a depth of 20 feet.

The WSDOT will construct the first bent by constructing 10 drilled shafts, then containing them within a cofferdam between September 1 and May 15. The cofferdam will cover 9,550 square feet of substrate. WSDOT will construct the two mudline footings for bent one within this cofferdam. After completing the mudline footings, WSDOT will construct the concrete support columns. WSDOT will also begin upland construction of the maintenance facility and the second bent during this construction year.

1.3.2.6.2 East Approach Construction Year 2 (2013-14). As the substructure construction continues, WSDOT will begin construction of the superstructure. Forty 24- to 30-inch steel piles will support the falsework for superstructure. WSDOT will drive these piles using vibratory and impact hammers between July 16 and March 15. WSDOT will complete the maintenance facility in this construction year.

1.3.2.6.3 East Approach Construction Year 3 (2014-15). In the third construction year, traffic will shift to the new east approach allowing WSDOT to demolish the existing east approach structure. The demolition will include removing 14 in-water columns. With the completion of the new superstructure and demolition of the existing structure, the work bridges and falsework will be dismantled and the 165 piles removed. The third construction year marks the final year for construction in the east approach area. The final stage of construction will consist of site cleanup and demobilization.

1.3.2.7 Lighting

Currently, SR 520 has lighting across the entire bridge. The new bridge will reduce the amount of light spillage to Lake Washington. Similar to the current roadway, the new SR 520 will have continuous lighting from I-5 to Foster Island and on both bridges crossing the Montlake Cut. Except for the interim west approach connection, no roadway lighting is proposed for the fixed portions of the bridge east of Foster Island. The east approach will have six lights to illuminate a transit merge point. Recessed lighting will illuminate the proposed bicycle and pedestrian path along the west approach and the new floating bridge. This will prevent walkway lighting from reaching the lake surface. WSDOT will shield the lights from I-5 to Foster Island and the east approach to minimize light spillage to aquatic habitat. WSDOT will also use construction lighting during construction activities. To the maximum extent practical, WSDOT will shield construction lights and direct them away from the water.

1.3.2.8 Habitat Projects

1.3.2.8.1 Washington Department of Natural Resources Site (mouth of the Cedar River). This three-acre Washington Department of Natural Resources (WDNR) site is on the Lake Washington shoreline just east of the mouth of the Cedar River in the City of Renton. There is a sheet metal flume about 650 feet long between upland areas and the Lake. The flume provides habitat for predators, such as smallmouth bass. The primary habitat enhancement goal is to increase growth and survival of emigrating Chinook salmon fry from the Cedar River by improving nearshore habitat.

The WSDOT proposes to remove most of the existing flume and restore 630 feet of shoreline. The flume will be removed in pieces, likely with a barged crane or a vibratory pile rig. Once the flume has been disassembled and removed from the site, the shoreline grade will be adjusted to a constant, gentle slope. WSDOT will place fine-grained substrate and gravel on the shoreline, place large woody debris (LWD), remove nonnative plant species by physical means, and plant the site with native trees and shrubs.

1.3.2.8.2 Cedar River Site (King County). The purpose of this habitat project is to create side channels and restore floodplain function in order to improve spawn and rearing habitat for PS Chinook salmon, PS steelhead, and other anadromous fish. The 17-acre site is on the lower Cedar River at river mile (RM) 5.3 in unincorporated King County. There are levees along the north and south banks at this site, disconnecting it from the floodplain. The site includes 23 separate parcels, distributed on both sides of the river. King County has acquired most of the parcels at the mitigation site and has removed some of the buildings from these parcels.

The WSDOT proposes to purchase the remaining private properties, setback the levees, and restore the floodplain. They will remove all structures and impervious surfaces from the site. WSDOT will setback the levees by removing the existing levees (about 500 linear feet of levee on the right bank and about 400 linear feet on the left bank), then constructing new levees away from the river to protect adjacent properties. WSDOT will grade the area to mimic a natural floodplain and replant with native vegetation.

1.3.2.8.3 Taylor Creek (Seattle Public Utilities). Taylor Creek is in southeast Seattle. It enters Lake Washington 1.7 miles from the mouth of the Cedar River. WSDOT will restore the portion of the Creek between Rainier Avenue and Lake Washington. The goal of this habitat project is to improve rearing conditions for juvenile Chinook salmon both within the lower reach of Taylor Creek and its mouth in Lake Washington. Currently, the Creek flows through residential properties in a confined channel. Seattle Public Utilities has purchased these parcels. WSDOT will remove all the structures, utilities, underground storage tanks, a residential dock, channel armoring, and floodplain fill. WSDOT will reconstruct the channel with a meanders and LWD to create pool riffle morphology. They will also remove large cobble from the delta and plant native riparian vegetation throughout the site.

1.3.2.8.4 Seward Park (City of Seattle). Seward Park is on the western shore of Lake Washington, between the Cedar River and I-90, in the City of Seattle. The goal of this habitat project is to increase growth and survival of emigrating Chinook salmon from the Cedar River by improving nearshore habitat. There are three habitat sites in Seward Park. Site 1 is in the southern portion of the peninsula east of the parking lot. This segment is approximately 250 feet long and has a concrete bulkhead (2.5 feet high and 3 feet wide). WSDOT will remove the bulkhead, grade the bank, place gravel, and plant riparian vegetation.

Site 2 is in the northeastern portion of the peninsula. WSDOT proposes to remove approximately 250 feet of a riprap bulkhead, grade the shoreline, place gravel, and plant riparian vegetation. Site 3 is located in the northwestern portion of the peninsula. The sum of the two lengths of this segment is approximately 400 feet, and it has very little riparian vegetation. A previous restoration project at this site graded the shoreline and placed LWD. WSDOT proposes to plant a five- to 10-foot strip of riparian vegetation at this site.

1.3.2.8.5 Magnuson Park. The goal of this habitat project is to improve migrating and rearing conditions for juvenile Chinook salmon primarily from the north Lake Washington population. Magnuson Park is on the west shore of Lake Washington north of Union Bay. There are four habitat sites in Magnuson Park. Site 1 is a 50-foot wide and 200-foot long area of shoreline south of the boat launch. WSDOT will remove concrete/asphalt rubble, grade the bank, place gravel and LWD, and plant riparian vegetation. Site 2 is located north of the boat launch. WSDOT will remove a 250-foot section of bulkhead at this site.

Site 3 is a 450-foot section of shoreline north of the designated swimming area. Mitigation actions at this site will include shoreline vegetation planting and installation of LWD to increase fish cover. Magnuson Park project 4 is located at the north end of the Magnuson Park shoreline. This segment is 350 feet long with very little riparian vegetation. Actions at this site include bank sloping along the 100 feet of low bank, shoreline vegetation planting, and installation of LWD along the entire segment to increase fish cover.

1.3.2.8.6 Bear Creek. The NMFS consulted with the USACE on this City of Redmond project in 2009 (NMFS tracking number: 2009/04429; USACE permit number NWS-2009-242). WSDOT's SR 520 Program funded eighty percent of the restoration at this site. The project will realign Bear Creek from its confluence with the Sammamish River to 3,000 feet upstream and

will include 1,440 feet of off-channel habitat, 1,300 feet of pool habitat, and 3,000 pieces of LWD. The restoration will improve rearing habitat for PS Chinook salmon and PS steelhead.

1.3.2.9 High Efficiency Sweeping Study

The WSDOT will work with stormwater experts (including those at NMFS and the NOAA Northwest Fisheries Science Center) to develop a study that evaluates the potential benefits of using high efficiency sweepers in addition to traditional stormwater treatment. The purpose of the study is to determine if high efficiency sweeping (a broom sweeper followed by a regenerative air sweeper) reduces effluent loadings and concentrations of pollutants (total suspended solids and total and dissolved copper and zinc) beyond the reductions from traditional stormwater treatment methods.

The study will occur within the project limits of the SR 520 Bridge Replacement Project after construction is complete. FHWA may abandon the study if, after negotiations between WSDOT, FHWA and NOAA Fisheries, the agencies agree:

1. The actions of the study significantly damage the noise walls or barriers on SR 520; or
2. An experimental design cannot be developed for the Montlake Interchange; or
3. WSDOT's contribution to the study would exceed $100,000.

The final design for the study will be developed jointly with FHWA, WSDOT, and NOAA Fisheries (including the Northwest Fisheries Science Center) and will be completed by December 31, 2011.

1.4 Action Area

"Action area" means all areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action (50 CFR 402.02). Table 2 describes the action area for this project.

Table 2. Action Area

Area	Extent	Basis
Blair Waterway of Commencement Bay	CTC casting basin, approximately 1.8 acres	extent of fish handling
southern Portage Bay	within 150 feet of the existing and new bridges	extent of elevated suspended sediment
southern Union Bay	within 150 feet of the existing and new bridges	extent of elevated suspended sediment
Lake Washington	within 70 feet of the new floating bridge	extent of injurious levels of dissolved zinc from stormwater discharges
Lake Washington (eastern shore)	within 1,775 feet of the temporary work bridges and falsework for the east approach	extent of injurious levels of underwater sound
DNR Parcel (Lake Washington)	within 150 feet of the 630 linear feet of shoreline enhancement	extent of elevated suspended sediment
Cedar River (RM) 5.3	900 feet of shoreline and 300 feet downstream of the levee removal	extent of elevated suspended sediment
Taylor Creek	750 linear feet of Taylor Creek and Lake Washington within 150 feet of the confluence	extent of elevated suspended sediment
Seward Park (Lake Washington)	within 150 feet of the 900 linear feet of shoreline enhancement	extent of elevated suspended sediment
Magnuson Park (Lake Washington)	within 150 feet of the 1,250 linear feet of shoreline enhancement	extent of elevated suspended sediment

2. ENDANGERED SPECIES ACT: BIOLOGICAL OPINION AND INCIDENTAL TAKE STATEMENT

The ESA establishes a national program for conserving threatened and endangered species of fish, wildlife, plants, and the habitat on which they depend. Section 7(a)(2) of the ESA requires Federal agencies to consult with the United States Fish and Wildlife Service, NMFS, or both, to ensure that their actions are not likely to jeopardize the continued existence of endangered or threatened species or adversely modify or destroy their designated critical habitat. Section 7(b)(3) requires that at the conclusion of consultation, the Service provide an opinion stating how the agencies' actions will affect listed species or their critical habitat. If incidental take is expected, Section 7(b)(4) requires the provision of an incidental take statement (ITS) specifying

the impact of any incidental taking, and including reasonable and prudent measures to minimize such impacts.

2.1 Introduction to the Biological Opinion

Section 7(a)(2) of the ESA requires Federal agencies, in consultation with NMFS, to insure that their actions are not likely to jeopardize the continued existence of endangered or threatened species, or adversely modify or destroy their designated critical habitat. The jeopardy analysis considers both survival and recovery of the species. The adverse modification analysis considers the impacts to the conservation value of the designated critical habitat.

"To jeopardize the continued existence of a listed species" means to engage in an action that 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). This biological opinion does not rely on the regulatory definition of 'destruction or adverse modification' of critical habitat at 50 C.F.R. 402.02. Instead, we have relied upon the statutory provisions of the ESA to complete the following analysis with respect to critical habitat.[1]

We will use the following approach to determine whether the proposed action described in Section 1.3 is likely to jeopardize listed species or destroy or adversely modify critical habitat:

- *Identify the rangewide status of the species and critical habitat likely to be adversely affected by the proposed action*. This section describes the current status of each listed species and its critical habitat relative to the conditions needed for recovery. For listed salmon and steelhead, NMFS has developed specific guidance for analyzing the status of the listed species' component populations in a "viable salmonid populations" (VSP) paper (McElhany et al. 2000). The VSP approach considers the abundance, productivity, spatial structure, and diversity of each population as part of the overall review of a species' status. For listed salmon and steelhead, the VSP criteria therefore encompass the species' "reproduction, numbers, or distribution" (50 CFR 402.02). In describing the range-wide status of listed species, we rely on viability assessments and criteria in technical recovery team documents and recovery plans, where available, that describe how VSP criteria are applied to specific populations, major population groups, and species. We determine the rangewide status of critical habitat by examining the condition of its physical or biological features (also called "primary constituent elements" or PCEs in some designations) - which were identified when the critical habitat was designated. Species and critical habitat status are discussed in Section 2.2.

- *Describe the environmental baseline for the proposed action*. The environmental baseline includes the past and present impacts of Federal, state, or private actions and other human activities *in the action area*. It includes the anticipated impacts of proposed Federal projects that have already undergone formal or early section 7 consultation and

[1] Memorandum from William T. Hogarth to Regional Administrators, Office of Protected Resources, NMFS (Application of the "Destruction or Adverse Modification" Standard Under Section 7(a)(2) of the Endangered Species Act) (November 7, 2005).

the impacts of state or private actions that are contemporaneous with the consultation in process. The environmental baseline is discussed in Section 2.3 of this opinion.

- *Analyze the effects of the proposed actions*. In this step, NMFS considers how the proposed action would affect the species' reproduction, numbers, and distribution or, in the case of salmon and steelhead, their VSP characteristics. NMFS also evaluates the proposed action's effects on critical habitat features. The effects of the action are described in Section 2.4 of this opinion.

- *Describe any cumulative effects.* Cumulative effects, as defined in NMFS' implementing regulations (50 CFR 402.02), are the effects of future state or private activities, not involving Federal activities, that are reasonably certain to occur within the action area. Future Federal actions that are unrelated to the proposed action are not considered because they require separate section 7 consultation. Cumulative effects are considered in Section 2.5 of this opinion.

- *Integrate and synthesize the above factors to assess the risk that the proposed action poses to species and critical habitat.* In this step, NMFS adds the effects of the action (Section 2.4) to the environmental baseline (Section 2.3) and the cumulative effects (Section 2.5) to assess whether the action could reasonably be expected to: (1) appreciably reduce the likelihood of both survival and recovery of the species in the wild by reducing its numbers, reproduction, or distribution; or (2) reduce the value of designated or proposed critical habitat for the conservation of the species. These assessments are made in full consideration of the status of the species and critical habitat (Section 2.2). Integration and synthesis occurs in Section 2.6 of this opinion.

- *Reach jeopardy and adverse modification conclusions*. Conclusions regarding jeopardy and the destruction or adverse modification of critical habitat are presented in Section 2.7. These conclusions flow from the logic and rationale presented in the Integration and Synthesis section (2.6).

2.2 Rangewide Status of the Species and Critical Habitat

2.2.1 Relevance of Climate to Status

Salmon throughout Washington are likely affected by climate change. Several studies have revealed that climate change has the potential to affect ecosystems in nearly all tributaries throughout the state (Battin et al. 2007; ISAB 2007). While the intensity of effects will vary by region (ISAB 2007), climate change is generally expected to alter aquatic habitat (water yield, peak flows, and stream temperature). As climate change alters the structure and distribution of rainfall, snowpack, and glaciations, each factor will in turn alter riverine hydrographs. Given the increasing certainty that climate change is occurring and is accelerating (Battin et al. 2007), NMFS anticipates salmonid habitats will be affected. Climate and hydrology models project significant reductions in both total snow pack and low-elevation snow pack in the Pacific Northwest over the next 50 years (Mote and Salathe 2009). These changes will shrink the extent of the snowmelt-dominated habitat available to salmon. Such changes may restrict our ability to

conserve diverse salmon life histories, especially spring-run Chinook salmon.

In Washington State, most models project warmer air temperatures, increases in winter precipitation, and decreases in summer precipitation. Average temperatures in Washington State are likely to increase 0.1-0.6ºC per decade (Mote and Salathe 2009). Warmer air temperatures will lead to more precipitation falling as rain rather than snow. As the snow pack diminishes, seasonal hydrology will shift to more frequent and severe early large storms, changing stream flow timing and increasing peak river flows, which may limit salmon survival (Mantua et al. 2009). The largest driver of climate-induced decline in salmon populations is projected to be the impact of increased winter peak flows, which scour the streambed and destroy salmon eggs (Battin et al. 2007).

Higher water temperatures and lower spawning flows, together with increased magnitude of winter peak flows are all likely to increase salmon mortality. Higher ambient air temperatures will likely cause water temperatures to rise (ISAB 2007). Salmon and steelhead require cold water for spawning and incubation. As climate change progresses and stream temperatures warm, thermal refugia will be essential to persistence of many salmonid populations. Thermal refugia are important for providing salmon and steelhead with patches of suitable habitat while allowing them to undertake migrations through or to make foraging forays into areas with greater than optimal temperatures. To avoid waters above summer maximum temperatures, juvenile rearing may be increasingly found only in the confluence of colder tributaries or other areas of cold water refugia (Mantua et al. 2009).

Climate change is expected to make recovery targets for these salmon populations more difficult to achieve. Habitat action can address the adverse impacts of climate change on salmon. Examples include restoring connections to historical floodplains and freshwater and estuarine habitats to provide fish refugia and areas to store excess floodwaters, protecting and restoring riparian vegetation to ameliorate stream temperature increases, and purchasing or applying easements to lands that provide important cold water or refuge habitat (Battin et al. 2007; ISAB 2007).

2.2.2 Status of Species

2.2.2.1 Status of Puget Sound Chinook salmon

2.2.2.1.1 Listing, Spatial Structure, and Diversity. The PS Chinook salmon ESU encompasses all runs of Chinook salmon from the Elwha River in the Strait of Juan de Fuca eastward, including rivers and streams flowing into Hood Canal, Puget Sound, and the Strait of Georgia in Washington. Of an estimated 31 original populations, there are 22 extant geographically distinct populations (Good et al. 2005).

Long-term trends in abundance and median population growth rates for naturally spawning populations of PS Chinook salmon indicate that approximately half of the populations are declining and the other half are increasing in abundance. Eight of the 22 populations are declining over the short term, and 11 or 12 populations are experiencing long-term declines (Good et al. 2005). Factors contributing to the downward trends are widespread blockages of

streams, degraded freshwater and marine habitat, poor forest practices in upper river tributaries, and urbanization and agriculture in lower tributaries and main stem rivers. Hatchery production and release of PS Chinook salmon are widespread, and more than half of the recent total escapement returned to hatcheries.

2.2.2.1.2 Life History. Generally, PS Chinook salmon adults spawn in freshwater rivers and large streams at elevations above the floodplain. The eggs are deposited in gravel that has well oxygenated water percolating through it (Healey 1991). The eggs over-winter and hatch in the gravel to become juveniles with a yolk-sac. At about the time the yolk sac is absorbed, the juveniles emerge from the gravel and begin to forage on their own. The juveniles forage and move downstream into estuaries where they continue to forage before moving into the North Pacific Ocean where they reside for one to six years (Healey 1991).

There are two typical life history strategies known as stream type and ocean type (Healey 1991; Myers et al. 1998). Timing of adult returns is dependent on the life history type. Stream type individuals are commonly called spring-run Chinook salmon since adults with this life history migrate into near shore waters and return to natal streams in spring to early summer. The ocean type life history is commonly called the fall-run PS Chinook salmon since most of the adults move to their natal streams in late summer and early fall. Fall-run PS Chinook salmon spawn in late September through October (Healey 1991). Most PS Chinook salmon are ocean type.

2.2.2.1.3 Abundance and Productivity. Using peak recorded harvest landings in Puget Sound in 1908, Bledsoe et al. (1989) estimated that the historical run size of the ESU was 670,000. During a recent five-year period, the geometric mean of natural spawners in populations of PS Chinook salmon ranged from 222 to just over 9,489 fish. Most populations had natural spawners numbering in the hundreds (median recent natural escapement is 766), and, of the six populations with greater than 1,000 natural spawners, only two have a low fraction of hatchery fish. Estimates of the historical equilibrium abundance, based on pre-European settlement habitat conditions, range from 1,700 to 51,000 potential PS Chinook salmon spawners per population (Good et al. 2005).

The artificial propagation of fall-run PS Chinook salmon is widespread throughout the ESU. Transfers between watersheds within and outside the ESU have been commonplace throughout the last century. Nearly two billion Chinook salmon have been released into Puget Sound tributaries since the 1950s. The vast majority of these were from local returning fall-run adults. Returns to hatcheries have accounted for 57 percent of the total spawning escapement, although the hatchery contribution to spawner escapement is probably much higher in some populations due to hatchery derived strays on the spawning grounds. The electrophoretic similarity between Green and Duwamish River fall-run PS Chinook salmon and several other fall-run stocks in Puget Sound suggests that there may have been a significant and lasting effect from Green River hatchery transplants (Good et al. 2005).

The NMFS Biological Review Team (BRT) identified the following risks to the PS Chinook salmon ESU: (1) the concentration of the majority of natural production in just two basins; (2) high levels of hatchery production in many areas of the ESU; and (3) widespread loss of estuary and lower floodplain habitat diversity (Good et al. 2005).

2.2.2.1.4 Affected Populations of Puget Sound Chinook Salmon. Puyallup River Chinook salmon. The Puyallup River historically supported 42,000 Chinook salmon. Recently, natural spawning escapement has ranged from 1,500 to 5,000 (Shared Strategy 2007). From 2005-2010, adult returns averaged 2,007. Late returning fall-run Puyallup Chinook salmon natural spawning occurs in South Prairie Creek up to RM 15, the Puyallup mainstem up to the Electron Dam, the lower Carbon River, Voights Creek and Kapowsin Creek. Some spawning is now believed to occur in the upper Puyallup since passage has recently been established at the Electron diversion dam (Shared Strategy 2007). Approximately 99 percent of Puyallup River fall-run Chinook salmon are ocean-type fish, with the remaining one percent being stream-type fish (Beechie et al. 2006).

Hylebos Creek Chinook salmon are considered to be a subpopulation of the Puyallup River fall run population (Kerwin 1999). No data quantifying current escapement levels are available, but adult abundance is at a fraction of historical levels (Kerwin 1999).

White River Chinook salmon. The White River early-run Chinook salmon population is the most genetically distinctive stock in central and south Puget Sound. It is the last spring-run population in southern Puget Sound (Shared Strategy 2007). The earliest return records for White River spring-run Chinook salmon are from the Buckley fish trap in 1941 (Kerwin 1999 citing Miyamoto 1986). Adult returns from 1942 to 1950 averaged 2,953. Returns were lowest in the 1970's when approximately 50 fish returned in 1977. The recent escapement trend has been increasing primarily because of hatchery intervention programs initiated in the late 1970's. The mean number of natural Chinook salmon spawners in the White River between 1998 and 2002 was 1,039, with a range of 316 to 2,002 (Good et al. 2005). From 2005-2010, adult returns averaged 1,468.

Lake Washington Chinook salmon. The Lake Washington Basin PS Chinook salmon are fall-run stocks. The adults first appear at the lock complex in mid-June. In general, peak returns occur in mid- to late-August and the adult run is completed by early October.

Lake Washington PS Chinook salmon have declined since peak returns during the mid-1980s (Weitkamp and Ruggerone 2000). Adult returns have declined more than eight percent per year for each run, with the PS Chinook salmon Cedar River run declining at 10.1 percent per year, the Issaquah Creek run at 8 percent per year, and the North Lake Washington run at 16.6 percent per year. Of the 22 populations of PS Chinook salmon in Puget Sound, the Lake Washington populations were among the five populations showing the steepest declines (Myers et al. 1998).

Two populations of the PS Chinook salmon ESU are present in the Lake Washington Basin, the north Lake Washington Tributaries population, including Issaquah Creek, and the Cedar River population. Most natural production of juvenile Chinook salmon in Lake Washington originates in the Cedar River. For the north Lake Washington Tributaries population, most natural production is from Bear Creek. Escapement of naturally spawning PS Chinook salmon into the Lake Washington basin between 1994 and 2007 has averaged 243 for the north Lake Washington tributaries population and 581 for the Cedar River population. Small numbers of Chinook salmon also spawn in other tributaries to Lake Washington and Lake Sammamish, but no

information is available for the production from these streams (Celedonia et al. 2008a) Hatchery production in the basin occurs at the Issaquah Creek State Hatchery. Chinook salmon from this hatchery are part of the ESU. The University of Washington (UW) ended its hatchery program in 2010, how even, adults from past smolt releases will still return over the next several years. These Chinook salmon are not included in the ESU.

Most juvenile Lake Washington Chinook salmon migrate to the ocean in their first year. DeVries et al. (2005; 2007) documented juvenile outmigration through the Lake Washington Ship Canal (Ship Canal) from May to August with peak out-migration from late May to early June. Less than one percent of Chinook salmon spend a year or more in the lake prior to emigrating, however there are no data on their actual numbers or densities within Lake Washington or the Ship canal. (Devries et al. 2005). In Lake Washington, juvenile Chinook salmon use lentic habitat as a migratory corridor from late May through July and for rearing from January-June (Celedonia et al. 2008a). Chinook salmon juveniles either enter Lake Washington shortly after emergence (mid-January to March) and rear in the Lake for three to five months, or they rear in their natal tributaries and enter Lake Washington between April and late June (Celedonia et al. 2008a; Seiler et al. 2005).

Juvenile Chinook salmon from the Cedar River enter Lake Washington and rear in the south end of the Lake from January to May (Tabor and Piaskowski 2002; Tabor et al. 2006). During this time, they inhabit shallow areas (0.1 to 1.3 m deep) with a sandy substrate and gentle sloping gradient. Juvenile Chinook salmon will also rear in non-natal tributaries (Tabor et al. 2006). Overwater structures can provide cover for small juvenile Chinook salmon in February and March but, as they grow larger and predators such as smallmouth bass move inshore, Chinook salmon avoid structures. Fresh (2000) found juvenile Chinook salmon in Lake Washington are primarily restricted to the littoral zone until mid-May when they are large enough to move offshore. From May to July, juvenile Chinook salmon are located throughout the Lake (Celedonia et al. 2008a).

Juvenile Chinook salmon from the Cedar River migrate north along the western shoreline of the lake during the day in shallow water three to eight feet deep. Migrating smolts do not avoid milfoil (Tabor and Piaskowski 2002; Tabor et al. 2006; Celedonia et al. 2008), but rather the milgoil serves as a false-bottom which juvenile Chinook salmon migrate above. Celedonia et al. (2008; 2009) observed juvenile Chinook salmon in deeper water (up to 16 feet deep) in areas of dense milfoil. Migrating Chinook salmon smolts avoid overwater structures (Tabor and Piaskowski 2002; Tabor et al. 2006). They either move into deeper water to pass beneath the structure or move around the perimeter of the structure (Celedonia et al. 2008a).

2.2.2.2 Puget Sound Steelhead

2.2.2.2.1 Listing, Spatial Structure, and Diversity. The National Marine Fisheries Service designated PS steelhead as threatened under the Endangered Species Act (ESA) on June 11, 2007 (72 FR 26722). PS steelhead are found in all accessible large tributaries to Puget Sound and the eastern Strait of Juan de Fuca (WDFG 1932). Nehlsen et al. (1991) identified nine PS steelhead stocks at some degree of risk or concern. The WDF et al. (1993) identified 53 stocks within the DPS, of which 31 were considered to be of native origin and predominantly natural

production. Of the 31 stocks, they rated 11 as healthy, three as depressed, one as critical, and 16 as unknown.

Since 1992 there has been a general downward trend in steelhead populations in this DPS. Busby et al. (1996) reviewed the 21 populations in the Puget Sound DPS and found that 17 had declining trends and four had increasing trends. Marked declines in natural run size are evident in all areas of the DPS. Even sharper declines are observed in southern Puget Sound and in Hood Canal. Throughout the DPS, natural steelhead production has shown a weak response to reduced harvest since the mid 1990s. Median population growth rates were estimated for several populations in the DPS, using the 4-year running sums method (Holmes 2001; Holmes and Fagan 2002). They estimated that the growth rate was less than 1 for most populations in the DPS, meaing the populations are declining.

2.2.2.2.2 Life History. Steelhead are the anadromous form of *O. mykiss*. PS steelhead typically spend two to three years in freshwater before migrating downstream into marine waters. Once the juveniles emigrate, they move rapidly through Puget Sound into the North Pacific Ocean where they reside for several years before returning to spawn in their natal streams. Unlike other species of *Oncorhynchus*, *O. mykiss* are capable of repeat spawning. Averaged across all West Coast steelhead populations, eight percent of spawning adults have spawned previously. Coastal populations have a higher incidence of repeat spawning than inland populations (Busby et al. 1996). There are two types of steelhead, winter steelhead and summer steelhead. Winter steelhead become sexually mature during their ocean phase and spawn soon after arriving at their spawning grounds. Adult summer steelhead enter their natal streams and spend several months holding and maturing in freshwater before spawning.

2.2.2.2.3 Abundance and Productivity. The PS steelhead DPS is composed primarily of winter-run populations. No abundance estimates exist for most of the summer-run populations; all appear to be small, most averaging less than 200 spawners annually. Summer-run populations are concentrated in northern Puget Sound and Hood Canal; only the Elwha River and Canyon Creek support summer-run steelhead in the rest of the DPS. Steelhead are most abundant in northern Puget Sound, with winter-run steelhead in the Skagit and Snohomish rivers supporting the two largest populations (approximately 3,000 and 5,000 respectively). Most populations have declined in the last five years. Widespread declines in abundance and productivity in most natural populations have been caused by the following factors:

(1) Steelhead habitat has been dramatically affected by a number of large dams in the Puget Sound Basin that eliminated access to habitat or degraded habitat by changing river hydrology, temperature profiles, downstream gravel recruitment, and movement of large woody debris.

(2) In the lower reaches of rivers and their tributaries, urban development has converted natural areas (e.g. forests, wetlands, and riparian habitat) into impervious surfaces (buildings, roads, parking lots, etc.). This has changed the hydrology of urban streams causing increases in flood frequency, peak flow, and stormwater pollutants. The hydrologic changes have resulted in gravel scour, bank erosion, sediment deposition during storm events, and reduced summer flows (Moscrip and Montgomery 1997; Booth et al. 2002; May et al. 2003).

(3) Agricultural development has reduced river braiding, sinuosity, and side channels through the construction of dikes and the hardening of banks with riprap. Constriction of rivers, especially during high flow events, increases gravel scour and the dislocation of rearing juveniles. Much of the habitat that existed before European immigration has been lost due to these land use changes (Beechie et al. 2001; Collins and Montgomery 2002; Pess et al. 2002).

(4) In the mid 1990s, WDFW banned commercial harvest of wild steelhead. Previous harvest management practices contributed to the decline of PS steelhead (Busby et al. 1996). Predation by marine mammals (principally seals and sea lions) and birds may be of concern in some local areas experiencing dwindling steelhead run sizes (Kerwin 2001).

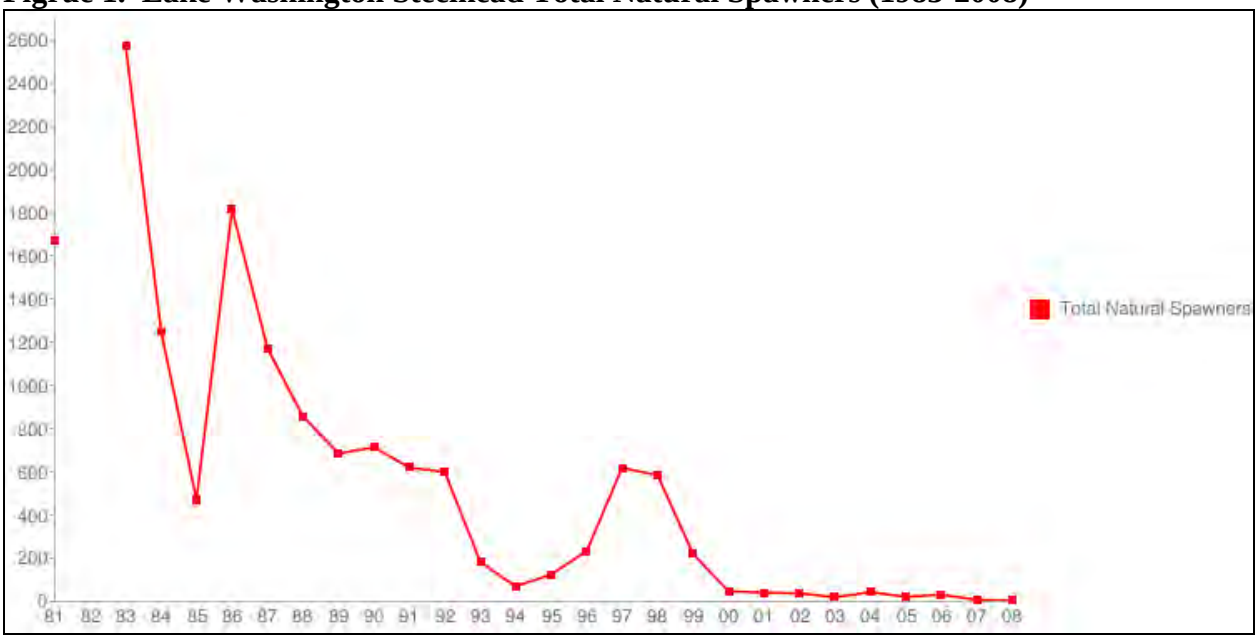
(5) Ocean and climate conditions can have profound impacts on steelhead populations. Changing weather patterns affect their natal streams. As snow pack decreases, in-stream flow is expected to decline during summer and early fall (Battin et al. 2007).

(6) The extensive propagation of the Chambers Creek winter steelhead and the Skamania Hatchery summer steelhead stocks have contributed to the observed decline in abundance of native PS steelhead populations (Hard et al. 2007). Approximately 95 percent of the hatchery production in the PS DPS originates from these two stocks. The Chambers Creek stock has undergone extensive breeding to provide an earlier and more uniform spawn timing. This has resulted in a large degree of reproductive divergence between hatchery and wild winter-run fish. The Skamania Hatchery stock is derived from summer steelhead in the Washougal and Klickitat rivers and is genetically distinct from the Puget Sound populations of steelhead. For these reasons, Hard et al. (2007) concluded that all hatchery summer- and winter-run steelhead populations in Puget Sound derived from the Chambers Creek and Skamania Hatchery stocks should be excluded from the DPS. NMFS included two hatchery populations that were derived from native steelhead, the Green River winter-run and the Hamma Hamma winter-run, as part of the DPS (72 FR 26722).

2.2.2.2.4 Affected Populations of Puget Sound Steelhead. Lake Washington Steelhead. The Lake Washington steelhead have undergone steep declines in abundance. Abundance trends over the most recent decade were strongly negative and alarmingly low. Estimates were computed from 10 years of data (1995-2004). Between 2000 and 2004, escapement averaged 38 fish (WDFW 2002). From 2005 to 2008, escapement continued to decline. The average escapement was 11 with a low of four in 2008 (Figure 1). Since 2008, returns have been less than 10 fish each year (Friends of the Ballard Locks in litt.)

WDFW operates smolt traps in Bear Creek and the Cedar River to estimate the production of juvenile Chinook salmon, coho salmon, and steelhead. Between 2007 and 2009, WDFW captured one smolt per year in the Cedar River. In Bear Creek, WDFW capture one smolt in 2007 and 2008 and none in 2009 (Kiyohara and Volkhardt 2008; Kiyohara and Zimmerman 2009; 2011). There has been a loss of connectivity between the Duwamish (Green) and Snohomish rivers due to the virtual extirpation of steelhead in the Lake Washington basin.

Figrue 1. Lake Washington Steelhead Total Natural Spawners (1983-2008)



WDFW data,
http://fortress.wa.gov/dfw/gispublic/apps/salmonscape/salmonscapeJSP/summaryStockReport.jsp?SasiStkNum=6154

In the Cedar River, wild steelhead are closely related to resident *O. mykiss*. Resident *O. mykiss* are abundant below Landsberg dam and are a native wild population. Marshall et al. (2004) found that resident Cedar River *O. mykiss* produce outmigrating smolts and speculated that steelhead could produce adult resident *O. mykiss*. They concluded that the conservation of resident *O. mykiss* is likely an important aspect of reducing extinction risk for steelhead.

2.2.3 Status of Critical Habitat

NMFS designated critical habitat for the PS Chinook salmon ESU on September 2, 2005. The following are the primary constituent elements (PCEs) NMFS identified for PS Chinook salmon critical habitat:

> PCE 1--Freshwater spawning sites with water quantity and quality conditions and substrate that support spawning, incubation, and larval development;
>
> PCE 2--Freshwater rearing sites with (1) water quantity and floodplain connectivity to form and maintain physical habitat conditions and support juvenile growth and mobility, (2) water quality and forage that support juvenile development, and (3) natural cover such as shade, submerged and overhanging large wood, logjams and beaver dams, aquatic vegetation, large rocks and boulders, side channels, and undercut banks;
>
> PCE 3--Freshwater migration corridors free of obstruction and excessive predation with water quantity and quality conditions and natural cover such as submerged and

overhanging large wood, aquatic vegetation, large rocks and boulders, side channels, and undercut banks that support juvenile and adult mobility and survival;

PCE 4--Estuarine areas free of obstruction and excessive predation with (1) water quality, water quantity, and salinity conditions that support juvenile and adult physiological transitions between fresh water and salt water, (2) natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, and side channels, and (3) juvenile and adult foraging opportunities, including aquatic invertebrates and prey fish, supporting growth and maturation;

PCE 5--Nearshore marine areas free of obstruction and excessive predation with (1) water quality and quantity conditions and foraging opportunities, including aquatic invertebrates and fishes, supporting growth and maturation, and (2) natural cover including submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, and side channels;

PCE 6--Offshore marine areas with water quality conditions and forage, including aquatic invertebrates and fishes, supporting growth and maturation.

The PS 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 values, and eight received a medium rating. Of the marine areas, all 19 are ranked with high conservation value. Watersheds within designated critical habitat, called Fifth Field Hydrologic Unit Codes (HUCs) have been ranked as to the conservation value they provide to each listed species they support14; conservation rankings are high, medium, or low. To determine the conservation value of each watershed to ESU viability, the Critical Habitat Analytical Review Team (CHART) evaluated the quantity and quality of habitat features, the relationship of the area compared to other areas within the ESU, and the significance to the ESU of the population occupying that area. Thus, even a location that has poor quality of habitat could be ranked at high conservation value if that location was essential due to factors such as limited availability, the unique contribution of the population it served, or other important role.

Critical habitat throughout the Puget Sound basin has been degraded by numerous activities, including hydropower development, loss of mature riparian forests, increased sediment inputs, removal of large woody debris, intense urbanization, agriculture, alteration of floodplain and stream morphology, riparian vegetation disturbance, wetland draining and conversion, dredging, armoring of shorelines, marina and port development, road and railroad construction and maintenance, timber harvest, and mining. Changes in habitat quantity, availability, diversity, stream flow, temperature, sediment load, and channel instability are common limiting factors of critical habitat.

2.3 Environmental Baseline

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 consultation, and the impact of state or private actions which are contemporaneous with the

consultation in process (50 CFR 402.02). Elements of the proposed action occur in several discrete locations, with effects limited to those locations. Therefore, this opinion presents environmental baseline by activity location, including the locations of the proposed habitat restoration projects.

The presence and operation of the Ship Canal, in addition to urban development in the area have dramatically altered the Lake Washington Basin. From the east end of the Ship Canal to Lake Union, there is little open shoreline (City of Seattle 1999). Portage Bay has numerous over-water structures ranging from small docks to large marinias with dozens of slips. Riparian vegetation within these areas is limited, except for the area south of SR 520 that contains the highest abundance of natural vegetation (Weitkamp and Ruggerone 2000). Portage Bay is lined by University of Washington facilities, commercial facilities, and houseboats. The southeastern portion of Portage Bay has an area of freshwater marsh habitat. Aside from the marsh, little natural vegetation remains in the riparian zone.

The Ship Canal has concrete bulkheads throughout the Montlake Cut. The Ship Canal extends eastward through Union Bay and terminates at Webster Point beyond which is the main body of Lake Washington. Union Bay has several areas of freshwater marsh and milfoil. The south side of the bay is bordered by the Arboretum and traversed by the SR 520 Bridge, creating a network of smaller embayments and canals. Numerous residences with landscaped waterfronts and docks dominate the remainder of the shoreline.

Water temperatures increase in the Ship Canal during the juvenile Chinook salmon out-migration season with temperatures reaching 66°F (19°C), a temperature that stresses salmonids. Water temperature and stratification in the Ship Canal has been documented to influence smolt distribution (water depth used) and behavior. The only portion of the Ship Canal that is stratified is just upstream of the locks where saltwater forms a cool, oxygen-rich lower layer. Fresh et al. (1999) observed adult salmon moving from the Locks immediately after near-surface temperatures dropped below 22°C, and there is a strong positive relationship between water temperatures above 19°C and increased delay at the Locks. Physiological causes of delay at the locks may include spawning readiness and readiness for freshwater.

A survey of 1991 aerial photographs estimated that 4 percent of the shallow water habitat within 100 feet of the shore was covered by residential piers (excluding coverage by commercial structures and vessels) (USFWS 2008). Later studies report that about 2,700 docks are present in Lake Washington and approximately 80 percent of the shoreline is armored (Warner and Fresh 1999; City of Seattle 2000; Toft 2001). The density of docks and shoreline modifications throughout the Ship Canal, Portage Bay, and Lake Union approaches 100 percent (City of Seattle 1999; Weitkamp and Ruggerone 2000).

2.3.1 Port of Tacoma (Blair Waterway, Commencement Bay)

The Blair Waterway is 2.6 miles long and is open to Commencement Bay. Freshwater enters the Blair Waterway through Wapato Creek and numerous stormwater outfalls. Water quality is impaired by high benzene concentrations, and the sediment has high concentrations of hexachlorobenzene. The CTC is approximately one mile from the mouth of the waterway.

There is no riparian vegetation at the CTC, and it is absent from most of the waterway. And almost all of the shoreline is developed with either armoring or over-water structures. Two small restoration sites, one of which is adjacent to CTC, are exceptions. These sites have gently-sloping shorelines, anchored LWD, and woody riparian vegetation. NMFS has designated most of Commencement Bay, including the action area, as critical habitat for PS Chinook salmon (PCE 4, estuarine areas). Critical habitat within the action area is degraded due to poor water quality, lack of natural cover, and limited foraging opportunities.

Juvenile Chinook salmon use the estuarine waters of the Blair Waterway in low numbers in March, peak in late May or early June and drop to low numbers again by July 1. They typically use areas near the mouths of the waterways more than near the heads (Kerwin 1999). Pacific International Engineering (2000; 2002) reported juvenile Chinook salmon densities from the Sitcum waterway which is adjacent to the Blair waterway. Prior to May 15, densities were averaged 0.001 fish per square foot. Between May 15 and June 15, densities were averaged 0.06 fish per square foot.

Available evidence shows that steelhead spend very little time in Commencement Bay. Adult steelhead spend little time staging in the marine areas prior to river entry, moving rapidly through nearshore habitats (Spence 1989), and steelhead smolts migrate rapidly to offshore marine habitats (Welch et al. 2004; Melnychuk et al. 2007; Pearcy 1992). Acoustic tagging studies of Puyallup River steelhead demonstrate similar behavior (Berger and Ladley 2006).

2.3.2 Portage Bay

Most of the Portage Bay shoreline, similar to the rest of the Ship Canal, is developed. There are several large marinas, houseboats, residential docks, and shoreline armoring. However, the area immediately south of the existing SR 520 bridge is mostly undeveloped with dense riparian and aquatic vegetation. Portage Bay also has a large population of salmonid predators. Tabor et al. (2004) estimated the population of small mouth bass in Portage Bay at 1,941with peak abundance in June. Other predators include largemouth bass and northern pikeminnow. The action area is in southern Portage Bay, approximately 0.25 mile south of the primary migratory corridor. Despite the less-than-ideal habitat conditions, this portion of the action area provides rearing and migration habitat for juvenile Chinook salmon (PCEs 2 and 3).

2.3.3 Montlake Cut

The Montlake Cut is a 30-foot deep channel connecting Union Bay and Portage Bay. All anadromous fish in the Lake Washington, including PS Chinook salmon and PS steelhead must migrate through the Cut (PCE 3, freshwater migration corridors). Due to poor habitat conditions (steep, armored shorelines, lack of riparian vegetation, and high water temperatures), NMFS does not expect any life history of PS Chinook salmon or PS steelhead to rear, hold, or mill within the Montlake Cut.

2.3.4 West Approach (Arboretum, Union Bay, and Lake Washington)

The west approach has two distinct habitat types. The area from the eastern shore of Montlake to the eastern shore of Foster Island has shallow, narrow waterways with dense aquatic vegetation. This area likely supports high populations of largemouth and smallmouth bass. PS Chinook salmon and PS steelhead are unlikely to use this habitat for any length of time. However, given this area's proximity to the only migratory corridor into and out of Lake Washington, NMFS cannot discount the possibility of adults and juveniles of both species moving through this area. Juvenile Chinook salmon in particular are likely to be present in small numbers in May and June during the peak of their out-migration.

The west approach area east of Foster Island is the primary migratory corridor for anadromous fish from the Cedar River (PCE 3). Juvenile Chinook salmon also rear within this area (Celdonia et al. 2008; 2009). These PCEs are degraded due to the high density of over-water structures, armored shoreline, aquatic macrophytes, and high summer temperatures. Given that Chinook salmon and steelhead do not necessarily migrate in the most direct path, fish from the north Lake Washington populations could also be present.

2.3.5 Floating Bridge (Lake Washington)

Puget Sound Chinook salmon and PS steelhead spend little time in the deeper portions of Lake Washington near the floating bridge. Fresh et al. (1999) found that adult Chinook salmon spend an average of 2.9 days in the Lake. Juvenile Chinook salmon, while predominately shoreline-oriented, have been observed near the existing floating bridge (P. Bloch pers. comm.). Very little information is available on adult and juvenile steelhead use in Lake Washington (SPU and USACE 2008). In other systems, steelhead typically migrate quickly from riverine habitats to saltwater and vice versa. NMFS expects that Lake Washington steelhead exhibit similar migratory behavior.

2.3.6 East Approach (Eastern shore of Lake Washington)

The east approach is on the eastern shore of Lake Washington near the City of Medina. This area provides habitat for rearing and migrating juvenile Chinook salmon (PCEs 2 and 3). These PCEs are degraded due to the high density of over-water structures and an armored shoreline. The shoreline has a very gradual slope. However, it is over four miles from any natal Chinook salmon or steelhead streams and over 1.5 miles from the western shore of the lake (Tabor et al. 2006). Therefore, NMFS expects juvenile Chinook salmon numbers to be lower than along the western shoreline and Union Bay. While the east approach is not within a direct line between the Ship Canal and any natal tributaries, NMFS cannot discount the possibility of adult Chinook salmon and juvenile and adult steelhead passing through the area during their migrations.

2.3.7 Habitat Project Locations

2.3.7.1 Washington Department of Natural Resources Renton/Cedar River Site

This three-acre Washington Department of Natural Resources (WDNR) site is on the Lake Washington shoreline just east of the mouth of the Cedar River in the City of Renton. This property was created in 1965 when Puget Sound Power and Light placed 150,000 cubic yards of fill into the lake. Tabor et al. (2004a; 2006) have documented high levels of juvenile Chinook salmon use on the site. The project area is most heavily used by Chinook salmon fry that migrate through the site from the Cedar River toward the Ship Canal (PCEs 2 and 3). These PCEs are degraded at this site. Approximately half of the shoreline consists of the 650-foot long flume on the northeastern half of the project area. The remaining shoreline in the project area (600 feet) has a natural grade, but is hardened with riprap. The entire shoreline and riparian zone is in a degraded condition, but with native vegetation cover. Three dolphins are located east of the shoreline. Each dolphin consists of seven creosote piles.

2.3.7.2 Cedar River

The lower Cedar River provided spawning, rearing, and migration habitat for PS Chinook salmon and PS steelhead (PCEs 1, 2, and 3). Floodplain development and levees have degraded these PCEs within the action area at RM 5.3. The river channel throughout most of this reach is confined and stabilized by levees and revetments which contribute to a loss of connectivity between the river and its floodplain leading to poor riparian conditions (King County 2005). The aquatic habitat has very little complexity, fish cover, or pool habitat for adult holding and juvenile rearing.

On the upstream half of the left (south) bank, the floodplain is unconfined. An upper terrace on the left bank floodplain is likely formed from fill (3 to 5 feet above the active floodplain). Several residences in the project area have been acquired by King County as part of a floodplain property acquisition program. These structures are vacant and slated for demolition as part of the restoration project. A levee with large riprap extends into the River; it is located about midway through the project area. The River is confined along this stretch, resulting in concentrated flow. The River has sufficient gradient and energy to produce a dynamic channel morphology if the artificial constraints confining the existing channel are removed. Just upstream of the levee and riprap, the river has eroded the bank.

A King County restoration area is located on the right bank, the most upstream and northeast corner of the project area; it is vegetated with an off-channel habitat feature. The second levee extends approximately 500 linear feet farther downstream. The levee has large boulder-size riprap below the OHWM that extends approximately five feet waterward and three to five feet below the waterline. The levee has cobble-sized riprap. Downstream of the levee, the floodplain is at a natural grade and is equal to or around two feet higher than the base flow river stage.

2.3.7.3 Taylor Creek

Taylor Creek, in southeast Seattle, enters Lake Washington 1.7 miles from the mouth of the Cedar River. Sockeye, coho, and Chinook salmon use Taylor Creek (Washington Trout 2000). Juvenile Chinook salmon use the Taylor Creek delta and convergence pool for feeding and rearing, but cannot access the upstream habitat because the gradient is too high (Tabor et al. 2004a). Tabor et al. (2010) surveyed Taylor Creek in the summer and found juvenile Chinook salmon and coho in Taylor Creek.

Juvenile Chinook salmon use this site for rearing and migration (PCEs 2 and 3). Taylor Creek's delta at Lake Washington consists of cobble in the prevailing flow paths and gravel and sand in the remainder of the delta. The delta transitions into a sandy beach with small pockets of marsh vegetation. Upstream from the delta, the Creek flows through residential properties for 560 feet before reaching Rainier Avenue South. The stream habitat in this reach is degraded because it has been confined by concrete walls, boulders, and pavers. The channel has been straightened to allow for historical industrial use and current residential use adjacent to the Creek. The riparian and floodplain areas have been modified with fill, residential homes, asphalt driveways, and a dock. The small amount of vegetation along the Creek consists of a few mature trees and ornamental plants. The culvert under Rainier Avenue South is a total barrier to salmonids.

2.3.7.4 Seward Park

Seward Park has an extensive shoreline with areas of bulkheads, native vegetation, invasive aquatic vegetation and a variety of bank heights and slopes. The Seward Park shoreline is used by juvenile Chinook salmon for feeding, rearing, and migration from the Cedar River toward the Ship Canal (PCEs 2 and 3), though Chinook salmon abundance is lower here than along the South Lake Washington shoreline (Tabor and Piaskowski 2002). These PCEs are degraded in some areas (e.g. those with bulkheads). Some segments of the park shoreline were restored in 2001 and 2006 by regrading the bank to a lower slope, importing gravel to the re-sloped beaches, installing LWD for fish cover, and re-vegetating narrow riparian zone strips immediately adjacent to the shoreline. The shoreline segments with shallow water and vegetative cover provide food resources (invertebrates) and protection from piscivorous fish and avian predators. The absence of piers, ramps, and floats along the park's natural shorelines allows unhindered migration along the area's littoral zone.

2.3.7.5 Magnuson Park

Similar to Seward Park, Magnuson Park has an extensive shoreline with areas of bulkheads, native vegetation, invasive aquatic vegetation and a variety of bank heights and slopes. Similar to Seward Park, some segments of the Magnuson Park shoreline have been restored by grading the bank to a lower slope, placing gravel, and re-vegetating riparian areas. A boat launch on the southern end of the park has a heavily armored shoreline up to 50 feet on either side of the ramps.

The Magnuson Park shoreline is used by juvenile Chinook salmon from the North Lake Washington tributaries and the Sammamish/Issaquah Creek system as they migrate toward the Ship Canal (PCEs 2 and 3). The shoreline segments with shallow water and cover are used by the juvenile Chinook salmon for rearing, foraging, and refugia. North Lake Washington Chinook salmon juveniles have bimodal migration timing, with a some 0+ juveniles migrating out of their natal stream toward the lake as newly emerged fry in early spring and others as smolts in late May to June (Seiler et al. 2003). The early fry probably use the Magnuson Park shoreline and other nearshore areas in Lake Washington for rearing, foraging, and migration. The larger Chinook salmon juveniles reside in waters between three and 18 feet deep during the day, primarily over sand-gravel substrates.

2.4 Effects of the Action

"Effects of the action" means the direct and indirect effects of an action on the species or critical habitat, together with the effects of other activities that are interrelated or interdependent with that action, that will be added to the environmental baseline (50 CFR 402.02). Indirect effects are those that are caused by the proposed action and are later in time, but still are reasonably certain to occur. During consultation, neither NMFS nor the action agency identified any interrelated or interdependent actions.

2.4.1 Effects on Species

2.4.1.1 Lighting

The proposed lighting design will reduce the amount of artificial light cast onto adjacent waters. Along the west approach and floating bridge, the number of roadway light fixtures will be reduced by more than 50 percent (WSDOT 2010). The new bridge will not have roadway lighting from east of Foster Island to the east end of the floating span. The maintenance dock below the east approach will have on-demand overhead lighting. Only low-intensity path lighting would remain on at all times (WSDOT 2010). Similar to current conditions, the project will have continuous lighting from I-5 to Foster Island and on bridges crossing the Montlake Cut.

While WSDOT will minimize light spillage during construction, NMFS expects that artificial lighting during construction will be greater than current conditions. The behavioral responses of fish to natural and artificial lighting are complicated, with significant variation dependent on species, life history stage, feeding strategy, and environmental factors. Fish may be attracted by, or may avoid artificial sources of light, dependent upon a complex set of feeding, foraging, concealment, and predator avoidance strategies.

Tabor and Piaskowski (2002) investigated patterns of habitat use by outmigrating juvenile Chinook salmon and found that fish were inactive at night, residing at the bottom of shallow waters, even near sources of artificial light. Fish became active, moved off the bottom, and began schooling as light intensity increased at dawn. Mazur and Beauchamp (2003) investigated prey detection and reaction distance in piscivorous salmonids. Reaction distances for cutthroat and rainbow trout increased as light levels increased. However, Tabor et al. (1998) found that juvenile sockeye salmon's predator avoidance ability increased with increased light intensity.

Petersen and Gadomski (1994), in a similar finding, observed that the rate of capture of juvenile chinook salmon by northern squawfish was inversely related to light intensity.

Caledonia et al. (2009) found that juvenile Chinook salmon were attracted to areas of the existing SR 520 Bridge adjacent to roadway lights. The NMFS expects that artificial lighting will influence juvenile Chinook salmon behavior in the areas of the Lake adjacent to construction and permanent lights. Lighting will have the effect of extending the duration of twilight incident light conditions around dawn and dusk. These conditions are likely to allow juvenile Chinook salmon to visually detect prey and predators at night and also allow visual predators of juvenile Chinook salmon to forage. However, the studies cited above show that increased lighting favors juvenile salmonids more than their predators. Juvenile Chinook salmon in Lake Washington typically migrate during the day and are inactive at night (Celadonia et al. 2008a; Tabor and Piaskowski 2002), therefore, the attraction of the roadway and construction lighting at night is unlikely to delay their migration. Overall, NMFS does not anticipate adverse effects to juvenile Chinook from the permanent and construction lighting.

NMFS does not expect roadway and construction lighting to have any effect on adult Chinook salmon or juvenile or adult steelhead. Adult Chinook salmon and steelhead are too large to be preyed upon by piscivorous fish. Juvenile steelhead smolts are larger and better able to avoid predation, and are less likely than juvenile Chinook salmon to change their behavior due to artificial lighting (Newcomb and Coon 1997; McComas et al. 2008)

2.4.1.2 Suspended Sediment

Salmonids typically avoid areas of higher suspended sediment which can displace them from their preferred habitats. Fish unable to avoid suspended sediment can experience adverse effects. The severity of effect of suspended sediment increases as a function of the sediment concentration and exposure time, or dose (Newcombe and Jensen 1996; Bash et al. 2001). Suspended sediments can cause sublethal effects such as elevated blood sugars and cough rates (Servizi and Martens 1991), physiological stress, and reduced growth rates. Elevated turbidity levels can reduce the ability of salmonids to detect prey, cause gill damage (Sigler et al. 1984; Lloyd et al. 1987; Bash et al. 2001), and cause juvenile steelhead to leave rearing areas (Sigler et al. 1984). Additionally, short-term pulses of suspended sediment influence territorial, gill-flaring, and feeding behavior of salmon under laboratory conditions (Berg and Northcote 1985). Adult and larger juvenile salmonids appear to be little affected by the high concentrations of suspended sediments that occur during storm and snowmelt runoff episodes (Bjornn and Reiser 1991). However, research indicates that chronic exposure can cause physiological stress responses that can increase maintenance energy and reduce feeding and growth (Lloyd et al. 1987; Servizi and Martens 1991).

Monitoring turbidity, a measurement of water clarity, is a surrogate for monitoring the concentration of suspended sediment in a water sample. A nephelometric turbidity unit (NTU) is a measurement of turbidity. For in-water project activities in Lake Washington and the Ship Canal, NMFS expects turbidity levels will not exceed five nephelometric turbidity units (NTUs) over background at 150 feet from the in-water activity. For the Cedar River habitat project, NMFS expects turbidity levels will not exceed five NTUs over background at 300 feet.

Below, NMFS describes physical and temporal extent of elevated suspended sediment and the life history stages of PS Chinook salmon and PS steelhead that will be exposed. However, NMFS cannot estimate the number of individuals that will experience adverse effects from suspended sediment. Pulses of elevated suspended sediment will occur episodically throughout the in-water work seasons. NMFS cannot predict the number or duration of each pulse nor the number of individual fish that will be exposed to each pulse. Furthermore, not all exposed individuals will experience adverse effects. Therefore, NMFS will use the physical and temporal extent of elevated suspended sediment to evaluate the effects to PS Chinook salmon and PS steelhead.

2.4.1.2.1 Portage Bay. The project activities that will cause turbidity in the Portage Bay portion of the action area are the vibratory installation of sheet piles to construct cofferdams, the vibratory installation of drilled shaft casings, and the removal of temporary steel piles. All of these activities will occur between August 16 and April 30, starting August 16, 2013 and ending April 30, 2018. The in-water work window will avoid emigrating juvenile Chinook salmon and steelhead, but overlaps with the adult Chinook salmon and steelhead migration. As described above, adults from both species migrate quickly through the portion of the Ship Canal in northern Portage Bay. NMFS does not expect adults from either species to be exposed to turbidity in the action area in southern Portage Bay which is approximately 0.25 mile south of the migratory corridor through northern Portage Bay. While most juvenile Chinook salmon outmigrate as 0+ juveniles, a very small percentage rear in Lake Washington for a year or more (De Vries et al. 2007). Any residual Chinook salmon present in the action area of Portage Bay during the in-water work will be exposed to elevated levels of suspended sediment. NMFS expects these residual Chinook will experience sublethal effects from elevated suspended sediment including displacement from preferred habitats and physiological stress.

NMFS cannot estimate the number of residual Chinook salmon that will be exposed. Less than one percent of Chinook salmon residualize in Lake Washington, however there are no data on their actual numbers or densities within Lake Washington or the Ship Canal. Table 3 shows the total area that will be exposed to elevated turbidity during each construction year.

Table 3. Suspended Sediment Exposure

Total Area (Acres) Exposed to Elevated Suspended Sediment per Construction Year								
Project Area	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**Total**
Portage Bay	N/A	23.3	11.9	17.1	20.9	15.3	17.4	105.9
West Approach (Arboretum/ Foster Island)	N/A	19.5	17.3	25.6	N/A	19.5	22.4	104.4
West Approach (east of Foster	N/A	25.8	31.6	39.7	N/A	25.8	23.2	146.1

Island)								
East Approach	6.5	4.5	N/A	7.1	N/A	N/A	N/A	18.1
Total	**6.5**	**73.1**	**60.8**	**89.5**	**20.9**	**60.6**	**63.0**	**374.5**

2.4.1.2.2 West Approach (Arboretum and Foster Island). The project activities that will cause turbidity in this area are the vibratory installation of drilled shaft casings, and the removal of temporary steel piles. Because of the limited listed species presence in this area, WSDOT is not proposing to limit the timing of these activities. While NMFS agrees that this area is not extensively used by PS Chinook salmon or PS steelhead, NMFS cannot discount the possibility of small numbers of fish being exposed to elevated levels of suspended sediment. NMFS expects any PS Chinook salmon or PS steelhead exposed will experience sublethal physiological stress.

2.4.1.2.3 West Approach (East of Foster Island). The project activities that will cause turbidity in the west approach east of Foster Island are the vibratory installation of drilled shaft casings, and the removal of temporary steel piles. All of these activities will occur between August 1 and March 31, starting August 1, 2013, and ending March 31, 2018. Construction activities outside the in-water work window will be either above water or fully contained with BMPs. This window overlaps with the tail end of juvenile Chinook salmon outmigration, the adult Chinook salmon migration, residual Chinook salmon rearing, and adult steelhead migration. NMFS expects these fish, with the exception of adult steelhead, will experience sublethal effects from elevated suspended sediment including displacement from preferred habitats and physiological stress. NMFS does not expect large fish such as adult steelhead to be harmed by brief exposure to elevated turbidity levels because larger fish can tolerate short term increases in suspended sediment (Bjornn and Reiser 1991).

Adult Chinook salmon are likely to be exposed to elevated turbidity levels. As described above, adult Chinook salmon, after holding in the cold saltwater just upstream of the Locks, migrate rapidly through the LWSC. Adult Chinook salmon may seek refuge from high water temperatures in water greater than 30 feet in depth (below the thermocline). However, they do not always avoid warm water once in Lake Washington. Adult Chinook salmon will hold at the mouths of natal tributaries in warm shallow water prior to migrating upstream (R. Tabor and F. Goetz pers comm). While adult Chinook salmon would not typically be harmed by brief exposure to elevated turbidity levels, adult Chinook salmon in the action area will be heat-stressed after migrating over six miles through the Ship Canal. Heat stress increases salmonids' sensitivity to other stressors, including turbidity (Materna 2001). NMFS expects that adult Chinook salmon exposed to elevated turbidity will alter their migration routes and experience sublethal physiological stress. These effects may lead to reduced spawning success.

2.4.1.2.4 East Approach. The project activities that will cause turbidity in the east approach portion of the action area are the vibratory installation of sheet piles to construct cofferdams, the vibratory installation of drilled shaft casings, and the removal of temporary steel piles. The vibratory installation of the drilled shaft casings and sheet piles will take place between September 1 and May 15. Removal of the temporary steel piles and sheet piles will take place between July 1 and March 15. NMFS does not expect adult Chinook salmon or adult or juvenile

steelhead to be present near the east approach during these windows. Residual Chinook salmon will be present year round and juvenile Chinook salmon will be present from February to July in small numbers. NMFS expects any exposed PS Chinook salmon will experience sublethal physiological stress.

2.4.1.2.5 Habitat Restoration Activities. With the exception of the Cedar River site (and the previously consulted upon Bear Creek project), all of the habitat projects are on, or adjacent to, the Lake Washington shoreline. For sites north of the existing SR 520 Bridge, the in-water work will take place between July 16 and March 15. For sites south of the bridge, the in-water work will take place between July 16 and April 30. These work windows will avoid emigrating juvenile Chinook salmon. NMFS does not expect adult or juvenile steelhead or adult Chinook salmon to be harmed by turbidity from these habitat projects. These fish are larger in size and are unlikely to be affected by short-term exposure to elevated turbidity. Furthermore, they are not shoreline-oriented and will not be displaced from their preferred habitat if they avoid areas of higher turbidity. Residual Chinook salmon exposed to elevated levels of turbidity from these habitat projects will experience displacement from preferred habitats and physiological stress. Table 4 show the total area of habitat that will experience elevated suspended sediment.

Table 4. Habitat Project Suspended Sediment Exposure

Habitat Project	Area of Elevated Suspended Sediment (acres)
DNR Parcel (Lake Washington)	2.2
Cedar River (RM 5.3)	2.1
Taylor Creek	0.8
Seward Park (Lake Washington)	3.1
Magnuson Park (Lake Washington)	4.3

At the Cedar River site (RM 5.3), all in-water work will take place between August 1 and August 31. This window overlaps with adult Chinook salmon migration, juvenile steelhead rearing, and steelhead egg incubation in the Cedar River. Because adult Chinook salmon are not heat stressed once they reach the Cedar River, NMFS does not expect adult Chinook salmon to be affected by the pulses of suspended sediment generated during the in-water work because adult salmonids can tolerate short-term increases in suspended sediment (Bjornn and Reiser 1991). Juvenile steelhead may be present during the in-water work in very low numbers. Any 0+ and 1+ juvenile steelhead exposed to elevated levels of turbidity from these habitat projects will experience displacement from preferred habitats and physiological stress. Larger juvenile steelhead (2+) are unlikely to respond adversely to their exposure.

Given the extremely low number of returning adult steelhead (e.g. four fish in 2008) and the miles of available spawning habitat in the Lake Washington Basin, NMFS considers the probability of steelhead redds being present within the action area to be discountable.

2.4.1.3 Impact Pile Driving

High levels of underwater sound can injure or kill fish and cause alterations in behavior (Turnpenny et al. 1994; Turnpenny and Nedwell 1994; Popper 2003; Hastings and Popper 2005).

Death from barotrauma can be instantaneous or delayed up to several days after exposure. Even in the absence of mortality, elevated noise levels can cause sublethal injuries. Fish suffering damage to hearing organs may suffer equilibrium problems, and may have a reduced ability to detect predators and prey (Turnpenny et al. 1994; Hastings et al. 1996). Hastings (2007) determined that a Sound Exposure Level (SEL) as low as 183 dB (re: 1 μPa^2-sec) [2] was sufficient to injure the non-auditory tissues of juvenile spot (*Leiostomus xanthurus*) and pinfish (*Lagodon rhomboides*) with an estimated mass of 0.5 grams.

Adverse effects on survival and fitness can occur even in the absence of overt injury. Exposure to elevated noise levels can cause a temporary shift in hearing sensitivity (referred to as a temporary threshold shift), decreasing sensory capability for periods lasting from hours to days (Turnpenny et al. 1994; Hastings et al. 1996). Popper et al. (2005) found temporary threshold shifts in hearing sensitivity after exposure to cumulative SELs as low as 184 dB. Temporary threshold shifts reduce the survival, growth, and reproduction of the affected fish by increasing the risk of predation and reducing foraging or spawning success.

Cumulative SEL is a measure of the risk of injury from exposure to multiple pile strikes. The Equal Energy Hypothesis, described by NMFS (2007), is used as a basis for calculating cumulative SEL. The number of pile strikes is estimated per continuous work period. This approach assumes that there will be a break of at least 12 hours between work periods. NMFS uses the practical spreading model to calculate transmission loss. The NMFS, USFWS, FHWA, and WSDOT agreed to interim criteria to minimize potential impacts to fishes (FHWG 2008). The interim criteria include peak sound pressure level (SPL) and SEL injury threshold limits of:

- Peak SPL: levels at or above 206 dB from a single hammer strike likely results in the onset of physical injury.
- SEL: cumulative levels at or above 187 dB for fish sizes of 2 grams or greater, or 183 dB for fish smaller than 2 grams. (All Chinook salmon and steelhead within the action area during impact pile driving will exceed 2 grams. Therefore, the injury threshold for cumulative SEL for this project is 187 dB.)
- The current criteria also include the disturbance threshold of 150 dB_{rms} for potentially altering fish behavior.

NMFS uses an SPL of 150 dB_{rms} as a guideline for when underwater sound may alter fish behavior. Whether these behavior alterations occur or result in actual injury is dependent on project specific factors. For the proposed action, NMFS does not expect underwater sound to alter the behavior of PS Chinook salmon or PS steelhead to the extent to cause actual injury because the timing of impact pile driving will avoid adult Chinook salmon and juveniles of both species. PS steelhead may avoid areas near pile driving; however, NMFS does not expect this to delay migration or significantly alter migration routes.

In analyzing the sound levels for impact pile driving, NMFS typically uses underwater sound data from previous projects with the same or similarly sized piles. Given the very soft substrates in Portage and Union bays, WSDOT and NMFS predicted that the actual underwater sound

[2] Throughout this document, the reference values for dB SEL is 1 μPa^2-sec.

levels from impact pile driving in these areas would be substantially lower than previous projects. In October 2009, WSDOT and FHWA conducted a test pile project to collect site specific data in Union and Portage Bays. The study measured underwater sound levels for impact pile driving and evaluated the effectiveness of three attenuation BMPs. Two of the BMPs, a confined bubble curtain and an unconfined bubble curtain, substantially attenuated underwater sound. The third BMP was not effective. For the analyses of impact pile driving for Portage Bay and the west approach, NMFS used the site-specific data from this study, including the bubble curtain performance (between 19dB and 30dB reduction).

The substrate at the east approach is more similar to previous pile driving projects than Portage and Union bays. Therefore, NMFS used data from past projects to analyze effects from impact pile driving at the east approach (Illingworth and Rodkin 2007; WSDOT unpublished data). Based on past data, NMFS predicts that the confined or unconfined bubble curtain will achieve a 10dB reduction at this location.

Below, NMFS describes the physical and temporal extent of injurious levels of underwater sound and the life history stages of PS Chinook salmon and PS steelhead that will be exposed. However, NMFS cannot estimate the number of individuals that will experience adverse effects from underwater sound. Impact pile driving will occur episodically throughout the in-water work seasons. NMFS cannot predict the number of individual fish that will be exposed. Furthermore, not all exposed individuals will experience adverse effects. Therefore, NMFS will use the physical and temporal extent of injurious levels of underwater sound to analyze the effects to PS Chinook salmon and PS steelhead.

For all of the work bridges and falsework in the work areas described below, WSDOT will use a vibratory hammer to drive the piles. However, in order to ensure that the pile will be able to support the weight of construction equipment, WSDOT will finish driving each pile with an impact hammer. WSDOT will use a confined or unconfined bubble curtain for all impact pile driving.

2.4.1.3.1 Portage Bay. To construct the temporary work bridges, WSDOT will drive 900, 24- to 30-inch steel piles between September 1, 2013 and April 30, 2014. In order to construct the falsework, WSDOT will drive 200, 24- to 30-inch steel piles between September 1, 2014 and April 30, 2015 and an additional 200 piles between September, 2016 and April 30, 2017. WSDOT estimates that the maximum piles and pile strikes per day for the work bridges will be 32 and 16,000 (500 strikes per pile), respectively. For the falsework piles, the maximum piles per day will be 16 with up to 8,000 impact pile strikes.

The NMFS estimates that the maximum sound levels for a single strike in Portage Bay will be 169 dB_{peak}, 155 dB_{rms}, and 139 dB SEL after attenuation based on data from the test pile project, (I&R, 2010). Using the above methodology and project information provided in the BA, NMFS calculated the distance from and the area that will be subjected to cumulative SELs greater than or equal to 187dB. The area within two meters of the pile driving (270 square feet per pile) will be affected. Table 5 gives the total area that will be subjected to cumulative SELs 187dB or higher per construction year. Table 6 gives the maximum area that will be affected in any single day.

Table 5.

Total Area (Acres) Exposed to Cumulative Sound Exposure Levels Greater than 187dB per Construction Year								
Project Area	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**Total**
Portage Bay	N/A	1.9	0.8	N/A	0.8	N/A	N/A	**3.5**
West Approach (Arboretum/ Foster Island)	N/A	1.3	N/A	1.6	N/A	N/A	N/A	**2.9**
West Approach (east of Foster Island)	N/A	4.0	N/A	3.8	N/A	N/A	N/A	**7.8**
East Approach	150.2	134.1	N/A	N/A	N/A	N/A	N/A	**284.3**
Total	**150.2**	**141.3**	**0.8**	**5.4**	**0.8**	N/A	N/A	**298.5**

Table 6.

Maximum Daily Area (Acres) Exposed to Sound Exposure Levels Greater than 187dB								
Project Area	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**Total**
Portage Bay	N/A	0.2	0.1	N/A	0.1	N/A	N/A	**0.4**
West Approach (Arboretum Foster Island)	N/A	0.1	N/A	0.1	N/A	N/A	N/A	**0.2**
West Approach (east of Foster Island)	N/A	0.8	N/A	0.8	N/A	N/A	N/A	**1.6**
East Approach	125.4	125.4	N/A	N/A	N/A	N/A	N/A	**250.8**
Total	**125.4**	**126.5**	**0.1**	**0.9**	**0.1**	N/A	N/A	**253.0**

The in-water work window of September 1 to April 30 will avoid emigrating juvenile Chinook salmon and steelhead, but overlaps with the adult Chinook salmon and steelhead migration. As described above, adults from both species migrate quickly through the ship canal. NMFS does not expect adults from either species to be exposed to injurious levels of underwater sound in the

action area in southern Portage Bay. Residual Chinook salmon present in the action area of Portage Bay during the in-water work will be exposed to injurious levels of underwater sound. NMFS expects that these individuals will be injured or killed.

2.4.1.3.2 West Approach (Arboretum and Foster Island). To construct the temporary work bridges for the west approach (Arboretum and Foster Island), WSDOT will drive 500, 24- to 30-inch steel piles between September 1, 2013 and April 30, 2014 and an additional 600 piles between September 1, 2015 and April 30, 2016. WSDOT estimates that the maximum piles and pile strikes per day for the work bridges will be 16 and 8,000 (500 strikes per pile), respectively.

The in-water work window (September 1 to April 30) for impact pile driving for this area will avoid out-migrating juvenile Chinook salmon and steelhead. While this window overlaps with the adult Chinook salmon and steelhead migrations, injurious levels of underwater sound from impact pile driving in this area will not extend into areas used by these fish for migration. Migrating adult fish may occasionally move through this area, but, due to the habitat conditions (shallow, narrow waterways with dense aquatic vegetation), they are unlikely reside for any length of time. NMFS estimates that the maximum sound levels for a single strike in this area will be 169 dB_{peak}, 155 dB_{rms}, and 139 dB_{SEL} after attenuation. These sound levels are not enough to cause injury for a single strike. In order in to sustain injury (cumulative SEL of 187dB), adult Chinook salmon and steelhead would have to remain within two meters of the pile for over 700 strikes. NMFS considers this scenario unlikely. Residual Chinook salmon could spend longer periods of time in this area, particularly in the winter months when water temperatures are lower and predators (largemouth and smallmouth bass) are less active. NMFS expects any residual Chinook salmon to be injured or killed.

2.4.1.3.3 West Approach (East of Foster Island). To construct the temporary work bridges for the west approach east of Foster Island, WSDOT will drive 450, 24- to 30-inch steel piles between October 1, 2013 and April 30, 2014 and an additional 500 piles between October 1, 2015 and April 30, 2016. WSDOT estimates that the maximum piles and pile strikes per day for the work bridges will be eight and 4,000 (500 strikes per pile), respectively.

Results from the test pile project demonstrated that attenuated underwater sound levels for the west approach near Foster Island were similar to Portage Bay and that the bubble curtains were less effective near western end of the west approach. NMFS estimates that the maximum sound levels for a single strike in the west approach near Foster Island will be 169 dB peak, 155 dB_{rms}, and 139 dB SEL after attenuation and 178 dB_{peak}, 167 dB_{rms}, and 155 dB SEL after attenuation for the western end of Foster Island (Illingworth and Rodkin 2010). For the west approach near Foster Island, the area within two meters of the pile driving (270 square feet per pile) will be affected. For the western end of the west approach, the area within 19 meters of the pile driving (0.1 acres per pile) will be affected. Table 5 gives the total area that will be subjected to cumulative SELs 187dB or higher per construction year. Table 6 gives the maximum area that will be affected in any single day.

The in-water work window for impact pile driving will avoid out-migrating juvenile Chinook salmon and steelhead and adult Chinook salmon. Residual Chinook salmon and adult steelhead will be exposed to injurious levels of underwater sound at the west approach. NMFS expects

residual Chinook salmon to be injured or killed. However, given their larger size, NMFS expects adult steelhead will experience sublethal effects including temporary threshold shifts.

2.4.1.3.4 East Approach. To construct the temporary work bridges, WSDOT will drive 125, 24- to 30-inch steel piles between August 16, 2012 and March 15, 2013. To construct the falsework, WSDOT will drive 40, 24- to 30-inch steel piles between August 16, 2013 and March 15, 2014. WSDOT estimates that the maximum piles and pile strikes per day will be eight and 4,000 (500 strikes per pile), respectively.

The test pile project did not cover the east approach area. Therefore, WSDOT will perform up to 500 unattenuated pile strikes to gather baseline data. This will allow them to ensure that the bubble curtain is working properly. NMFS used monitoring data from past projects to predict the levels of underwater sound in this area (Illingworth and Rodkin 2007; WSDOT unpublished data). Because the substrate at the east approach is harder than Portage Bay or the west approach, these values are substantially higher. NMFS estimates that the maximum sound levels for a single strike at the east approach will be 202 dB $_{peak}$, 185 dB $_{rms}$, and 176 dB SEL after attenuation. Using the above methodology and project information provided in the BA, NMFS calculated the distance from and the area that will be subjected to cumulative SELs greater than or equal to 187dB. The area within 541 meters of the pile driving (125.4 acres per pile) will be affected. Table 5 gives the total area that will be subjected to cumulative SELs 187dB or higher per construction year. Table 6 gives the maximum area that will be affected in any single day.

The in-water work window will avoid out-migrating juvenile Chinook salmon and steelhead, but overlaps with the adult Chinook salmon and steelhead migration. However, the east approach is not near any natal streams for Chinook salmon or steelhead, nor is the east approach between the Ship Canal and natal Chinook salmon and steelhead streams. While adult Chinook salmon will hold at tributary mouths prior to migrating up their natal tributaries, there is no evidence that adults of either species use other areas of Lake Washington for anything other than migration. However, given the much higher sound levels in this location, even actively migrating adult fish could be exposed to enough pile strikes to cause injury. NMFS expects adult Chinook salmon and adult steelhead will experience sublethal effects including temporary threshold shifts.

Residual Chinook salmon will be in the action area of the east approach during impact pile driving and will be exposed to injurious levels of underwater sound. NMFS expects that these individuals will be injured or killed.

2.4.1.4 Overwater Structure

Prior to 2001, most evidence for over-water structure effects on juvenile salmon migration was observational (Simenstad et al. 1999). The two primary concerns with overwater structures for juvenile Chinook salmon are migration delays and increased vulnerability to predators. In 2001, the USFWS began a series of studies to characterize the movement and habitat use of juvenile Chinook salmon and two of their predators in Lake Washington and the Ship Canal (Celadonia et al. 2008a). These studies included acoustic tracking of tagged juvenile Chinook salmon. Between 2003 and 2008, the USFWS studied the movement and habitat use of juvenile Chinook salmon, smallmouth bass, and northern pikeminnow in the Ship Canal and at the SR 520 bridge

west approach (east of Foster Island) using acoustic tracking (Celadonia et al. 2008a; 2008b; 2009). Below are summaries of the findings of these studies.

Celedonia et al. (2008a) reported findings from tracking studies performed in Lake Washington and the Ship Canal during May, June, and July of 2004 and 2005:

1. Juvenile Chinook salmon movement patterns varied within each site, from site to site, and from year to year. Each site was used differently by juvenile Chinook salmon, and the behavior of individual fish varied considerably.

2. Juvenile Chinook salmon showed two predominant migratory behaviors: active migration, where they swam rapidly toward Puget Sound; and holding, where they appeared paused in their migration.

3. At the one site studied in both years (Portage Bay), juvenile Chinook salmon movement patterns were different in the two sample years. In 2004, most fish spent several hours to several days at the site, whereas in 2005 most fish actively migrated spending less than one hour at the site. Differences in timing of moon apogee relative to tagged fish release appeared to be the primary contributing factor to these differences.

4. Distinct diel patterns were observed. In Lake Washington, juvenile Chinook salmon were close to shore in shallow water (1 to 5 m) during the day, and far offshore in limnetic areas at night.

5. Overwater structures and macrophyte beds appeared to influence movement patterns and depth selection. Actively migrating juvenile Chinook salmon appeared to change course as they approached and moved around structures. Fish appeared less hesitant to pass beneath narrow structures. Fish also sometimes moved into deeper water to travel beneath or around structures.

6. When macrophytes were present, juvenile Chinook salmon appeared to use deeper water, moving above the macrophyte canopy rather than avoiding macrophytes altogether. Macrophytes appear to function as a false bottom.

7. Smallmouth bass were generally close to shore in water that was less than four meters deep. Smallmouth bass were usually closely associated with overwater structure, steep sloping shoreline, and the offshore edge of aquatic macrophytes. Overlap in habitat between smallmouth bass and juvenile Chinook salmon appears to occur within each of these habitat types.

8. Prickly sculpin were primarily active at night, especially in shallow water. Nighttime patterns of prickly sculpin behavior may help explain the distribution of juvenile Chinook salmon (nighttime selection of offshore limnetic areas).

Celedonia et al. (2008b) reported findings from tracking studies performed in Lake Washington during May to August of 2007:

1. Behaviors of juvenile Chinook salmon were similar within release groups, but varied considerably between release groups. June 1 smolts exhibited an active migration pattern, rapidly migrating through the study site. June 14 and 28 smolts exhibited holding behaviors at or near the study site. Differences in migration cues (moon apogee), physiological status, water temperature and clarity, and prey availability may have contributed to the observed differences in behavior between release groups.

2. There was no evidence that the bridge at any time presented a complete barrier to juvenile Chinook salmon migration. Common behaviors included: 1) fish passing beneath the bridge with no apparent delay; 2) fish passing beneath the bridge after delays of a few seconds up to 46 minutes; and 3) fish passing beneath the bridge on multiple occasions.

3. Among actively migrating juvenile Chinook salmon, slightly more than one-third were delayed 3 to 46 minutes (median 15 minutes). Slightly less than one-third were delayed for less than one minute, and one-third appeared completely unhindered by the presence of the bridge.

4. Behavior may have been influenced by water depth, height of the bridge above the water surface, location of the bridge shadow at time of encounter, degree of contrast at the light-shadow edge, light intensity at time of crossing, and presence and variation in macrophyte density. Many of these factors varied together, and thus could not be isolated for their individual influence on behavior.

5. Holding juvenile Chinook salmon often crossed beneath the bridge to the north and were later observed returning to and holding in areas around the bridge. Holding smolts selected for areas near the bridge (5 to 20 meters from bridge edge), as well as areas of dense macrophytes away from the bridge. When near the bridge, smolts selected deeper water.

6. Holding behaviors may be triggered by an inhibition to enter the Montlake Cut arising from one or more ecological barriers, such as high water clarity, lack of directional flow, and/or elevated water temperatures. Inhibitions may also arise from a decrease in migration urge associated with desmoltification caused by prolonged exposure to elevated water temperatures.

7. Smallmouth bass previously captured in the Ship Canal were observed at the study site. Small bass overwhelmingly selected for nearshore overwater structures, and made no notable use of the bridge. Larger bass selected for both nearshore overwater structures and the bridge. Some bass were closely associated with bridge columns.

Celedonia et al. (2009) reported findings from tracking studies performed in Lake Washington during May to August of 2008:

1. Patterns in juvenile Chinook salmon behavior were similar to those observed in 2007, generally similar within release groups, but varied considerably between release groups. Three release groups primarily exhibited holding behaviors.

2. As in 2007, response to the bridge was at least partially dependent upon whether fish were actively migrating or holding. Behaviors of actively migrating fish were similar in both years, although few independent observations were obtained in 2008. Combining both years, 35 percent of actively migrating smolts showed minimal or no response to the bridge, 42 percent paralleled the bridge before passing underneath, and 23 percent paralleled the bridge and milled near the bridge before passing underneath. Median delay was 63 seconds (range 6 seconds to 19 minutes) for paralleling fish, and 22 minutes (range 3 to 46 minutes) for milling fish.

3. Holding juvenile Chinook salmon commonly selected for areas near the bridge (within 20 m) or condominium on the south side of the site. During the day, fish selected for deeper water when near the bridge or condominium than when they were not near either structure. Similar observations were made in 2007.

4. At night, juvenile Chinook salmon were attracted to areas where street lamps cast light into the water. A reevaluation of 2007 data found a similar pattern. Bridge lighting may be partially responsible for nighttime selection of the bridge area by juvenile Chinook salmon. However, neither smallmouth bass nor northern pikeminnow were attracted to the lights.

5. Results for northern pikeminnow and smallmouth bass were similar to 2007, and therefore data from both years were combined to provide more robust analyses. Northern pikeminnow concentrated in moderately dense vegetation, with no strong affinity for the bridge. Smallmouth bass did show a strong affinity for overwater structures, including the bridge. Smallmouth bass were also often closely associated with bridge columns.

6. Juvenile salmonids made up 35 percent of the northern pikeminnow diet. Approximately half of the smallmouth bass diet was composed of juvenile salmonids.

7. The authors suggest, with regard to holding behaviors and daytime attraction to the bridge, that the proposed bridge should lessen attraction. Consequences could include shorter area residence times. The proposed new bridge would reduce the quality of habitat for smallmouth bass.

Together these reports and findings suggest 1) some emigrating juvenile Chinook salmon experience a measurable delay in travel time in response to the existing bridge; 2) some juvenile Chinook salmon use the bridge as cover during day and/or night, typically occupying deeper portions of the lake than they might otherwise; 3) nighttime selection of the bridge may be a response to artificial light cast on to the adjacent waters, but may also reflect behavioral avoidance of littoral foraging sculpin (or other predators); and, 4) where holding or milling behaviors are exhibited, they may be in response to any number of factors and cannot be causally linked to the bridge's influence alone.

Based on the results of these studies, NMFS quantified the stressors from over-water as the total area shaded (behavior changes) and the area within five feet of piles or columns (predation zone). The predation zone area is based on data describing predator behavior and is defined as the plan view distance of the portion of the water body extending from the outside edge of a column or pier to a distance of five feet. The five-foot distance is based on field observations and scientific studies of the visual detection and reaction distances in picivorous fish. For example, Sweka and Hartman (2003) measured a maximum reactive distance for smallmouth bass of 2.1 feet in clear water. The reactive distance decreased exponentially with increasing turbidity. Similar reactive distances (between 0.8 and 6.6 feet) have been measured for largemouth bass (Howick and O'Brien 1983; Savino and Stein 1989), with the vast majority of strikes occurring within a distance of five feet. Based on these data, a predation zone of five feet was applied to each pile and column.

2.4.1.4.1 Portage Bay. Table 7 shows the area of over water cover for Portage Bay for the existing and new bridges, as well as for each year of construction. Celodonia et al. (2008a) described two primary behaviors for juvenile Chinook salmon tracked in northern Portage Bay, active migration and holding. Forty-seven percent of fish tracked were actively migrating. These fish were tracked only once moving quickly through the tracking area towards Puget Sound. Actively migrating Chinook salmon smolts are unlikely to enter the action area in southern Portage Bay. Shade from the existing, temporary, and new bridges in Portage Bay will not cross the migratory path of Chinook salmon smolts and will not cause migration delays.

Table 7.

Total Area of Overwater Coverage from Existing, New, and Temporary Structures (Acres)									
Project Area	**Existing**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**Permanent**
Portage Bay	**3.1**	3.1	8.9	8.9	11.1	9.3	5.2	9.6	**7.6**
Montlake Cut	**0.2**	0.2	0.2	0.2	0.2	0.2	0.4	0.4	**0.4**
West Approach (Arboretum/ Foster Island)	**6.6**	6.6	9.2	12.3	16.6	16.0	12.7	12.7	**8.4**
West Approach (east of Foster Island)	**5.6**	5.6	8.3	15.8	19.1	17.4	13.9	13.9	**10.6**
East Approach	**0.7**	2.4	2.4	2.4	2.4	1.3	1.3	1.3	**1.3**
Total	**16.2**	17.9	29.0	38.3	47.2	44.2	33.5	37.9	**28.3**

Forty-three percent of the juvenile Chinook salmon tracked in northern Portage Bay exhibited holding behavior. These fish moved in and out of the tracking area repeatedly and resided in the

area for up to 74 hours. Celadoina et al. (2008a) concluded that the tracking area was part of a larger area the holding fish were using. An unknown portion of juvenile Chinook salmon exhibiting holding behavior within Portage Bay are likely enter the action area in southern Portage Bay. Celedonia et al. (2008b) found smallmouth bass closely associated with existing columns. While the project will reduce the total number of columns and piles in the long term, from 99 to 50, during construction there will be a dramatic increase in the number of piles and columns, with a peak of 1,173 in 2015 (Table 8). This will increase the amount of smallmouth bass habitat in southern Portage Bay during construction and lead to increased predation rates on holding juvenile Chinook salmon in this area (Table 9). NMFS cannot predict the number or proportion of holding juvenile Chinook salmon that will choose to venture into the action area in southern Portage Bay and be exposed to increased predation from smallmouth bass. NMFS also cannot predict what proportion of the exposed fish will actually be eaten. Therefore, NMFS will use the area within five feet of piles and columns to quantify the effects on holding juvenile Chinook salmon in this area.

Table 8

Total Number of Columns and Piles from Existing, New, and Temporary Structures									
Project Area	**Existing**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**Permanent**
Portage Bay	**99**	99	1,031	1,017	1,173	500	700	700	**50**
Montlake Cut	**0**	0	0	0	0	0	0	0	**0**
West Approach (Arboretum/ Foster Island)	**186**	186	746	649	1,293	704	704	704	**104**
West Approach (east of Foster Island)	**228**	228	702	774	1,316	1,227	629	629	**129**
East Approach	**14**	148	188	188	188	9	9	9	**9**
Total	**527**	661	2,667	2,628	3,970	2,440	2,042	1,342	**292**

Table 9

Total Area Within Five Feet of Columns and Piles from Existing, New, and Temporary Structures (Acres)									
Project Area	**Existing**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**Permanent**
Portage Bay	**0.37**	0.37	3.15	3.05	3.63	1.50	2.14	2.14	**0.25**
Montlake Cut	**0**	0	0	0	0	0	0	0	**0**
West Approach	**0.71**	0.71	2.16	1.97	3.81	2.01	2.01	2.01	**0.27**

(Arboretum/ Foster Island)									
West Approach (east of Foster Island)	**0.90**	0.90	2.21	2.56	4.28	3.97	2.07	2.07	**0.62**
East Approach	**0.06**	0.44	0.57	0.57	0.51	0.03	0.03	0.03	**0.03**
Total	**2.04**	2.42	8.09	8.15	12.23	7.51	6.25	6.25	**1.17**

2.4.1.4.2 Montlake Cut. Because of conflicts with boat traffic, the tracking studies have not examined juvenile Chinook salmon use within Montlake Cut itself. However, given the habitat conditions in the Cut, NMFS expects juvenile Chinook salmon to migrate rapidly through the Cut. NMFS does not expect the 0.4 acre of shade from the existing and new Montlake bridges to delay juvenile Chinook salmon migration. Furthermore, both the existing and new bridges will have a grated deck which will allow some light through and generate a less intense shadow. The existing and new bridges do not have any in-water piles or columns. Therefore, the action will not increase predation from smallmouth bass in the Montlake Cut.

2.4.1.4.3 West Approach (Arboretum and Foster Island). As described above, juvenile Chinook salmon rarely use this area. The existing, temporary, and new bridges in this area do not cross the migratory corridor, and NMFS does not expect actively migrating juvenile Chinook salmon to use this area. Therefore, shading from these bridges is not likely to cause migration delays. However, NMFS expects that small numbers of holding juvenile Chinook salmon explore this area for short periods of time. Similar to the Portage Bay area, the project will dramatically increase the number of in-water piles and columns during construction (a peak of 1,293 in 2015) and reduce the total number of columns and piles in the long term (from 186 to 104). The small number of holding juvenile Chinook salmon will be exposed to greater predation from smallmouth bass for short periods of time during the five years of construction (Table 9). Residual Chinook salmon will also be exposed to greater predation risk during construction.

2.4.1.4.4 West Approach (East of Foster Island). State Route 520 in this area crosses the primary migratory corridor for juvenile Chinook salmon from the Cedar River. The proposed action will expose migrating juvenile Chinook salmon to increased shading (from the existing, new, and temporary work bridges, and barges). As described above, Celadonia et al. (2009) found that 65 percent of actively migrating fish were delayed by the bridge with a maximum delay time of 46 minutes. Forty-five percent of these delayed fish (29 percent of the actively migrating fish) were delayed for less than three minutes. During construction, NMFS expects that both the percentage of actively migrating fish delayed and the length of the delay to increase due to the increased area of shading (from 5.6 acres from the existing bridge to greater than 20 acres in 2015), the greater light/dark contrast of the shadow produced by the work bridges and barges, and the increase in the number of light/dark transitions. Given the overall magnitude of the shading during construction, NMFS expects that, between 2014 and 2018, virtually all

actively migrating fish will experience some delay and the maximum delay time could increase to three hours.

The new bridge will permanently increase shading in this area from 5.6 acres to 10.6 acres and, because of a 50-foot gap between the eastbound and west bound bridges, double the number of light/dark transitions. These changes are likely to increase both the percentage of actively migrating fish that are delayed and the length of delay compared to the existing bridge. However, the new bridge will be higher than the existing, and will therefore produce a shadow with a less intense light/dark contrast. This may reduce the magnitude of the delay.

De Vries et al. (2008) released tagged juvenile Chinook salmon in Bear Creek and the Cedar River. Mean travel time ranged from 13 to 16 days. It is unlikely that delays of a few minutes to a few hours will cause reduced survivorship or fitness of juvenile Chinook salmon migrating through the action area.

Similar to the Portage Bay area, the project will dramatically increase the number of in-water piles and columns during construction (a peak of 1,316 in 2015) and reduce the total number of columns and piles in the long term (from 228 to 129). The majority of the in-water structures (950) are temporary piles to support the temporary work bridges. WSDOT will construct the work bridges in water 10-feet deep or shallower. Celadonia et al. (2009) found that both smallmouth bass and juvenile Chinook salmon selected water depths between 13 and 26 feet deep when near the existing west-approach bridge. The temporary piles are much less likely to be used as habitat by smallmouth bass and juvenile Chinook salmon are less likely to encounter any smallmouth bass in this area. The greatest increase in smallmouth bass habitat will occur between 2013 and 2016 when the existing and new columns will be present in the depths between 13 and 26 feet. This will increase the predation risk to juvenile Chinook from smallmouth bass during these years. Overall, the project will reduce the number of in-water columns and the risk of predation from smallmouth bass.

2.4.1.4.5 East Approach. While juvenile Chinook salmon do migrate along the eastern shore of Lake Washington, their numbers are much lower than the western shore due to the distance of the east approach from any natal streams and the Ship Canal (Tabor et al. 2006). Juvenile Chinook salmon exposed to the over-water structures and in-water piles and columns will experience similar effects as described for other the other portions of the project. The increase in piles and columns during the four years of construction (a peak of 188 from 2013 to 2015) will increase the availability of smallmouth bass habitat at the east approach and increase the risk of predation for juvenile Chinook salmon. The new bridge will have fewer piles than the existing bridge (from 14 to nine) (Table 8).

Shading from the 1,500 square-foot maintenance dock and the work bridges will be more pronounced than the shade of the new east approach bridge. The maintenance dock and work bridges will be less than three feet above the lake. Overwater structure this close to the water surface creates a shadow with a greater light/dark contrast. Juvenile Chinook salmon that encounter these types of structures typically migrate around the perimeter and return to shallower water (Tabor et al. 2006). Juvenile Chinook salmon in Lake Washington in May and June typically inhabit waters between 3 to 18 feet deep during the day to reduce predation risk. The

end of the dock is in water approximately 20 feet deep. Juvenile Chinook salmon moving around the dock will be forced into water deeper than they prefer and will briefly be exposed to greater predation risk.

Shade from the east approach bridge will function similarly to the west approach and have similar effects to juvenile Chinook salmon. Because fewer juvenile Chinook salmon migrate along the eastern shore, there will be substantially fewer individuals exposed to shading at the east approach. The new east approach bridges will be 66 to 78 feet above the water creating a shadow with less light/dark contrast.

2.4.1.4.6 Summary of Effects of Overwater Structure. The NMFS does not expect the over-water structures to affect the migration of adult Chinook salmon or adult and juvenile steelhead. These actively migrating fish do not show behavioral responses to over-water shade. NMFS also does not expect in-water piles and columns to increase predation on these life history stages. Adult Chinook salmon and steelhead are too large to be preyed upon by smallmouth bass. Juvenile steelhead smolts are too large (greater than 175mm) for most size classes of smallmouth bass, better able to avoid predation, and less likely than juvenile Chinook salmon to migrate through preferred smallmouth bass habitat.

2.4.1.5 Fish Handling

Handling stresses fish, increasing plasma levels of cortisol and glucose (Hemre and Krogdahl 1996; Frisch and Anderson 2000). Electrofishing can kill fish or cause physical injuries including internal hemorrhaging, spinal misalignment, or fractured vertebrae. Although potentially harmful to fish, electrofishing is intended to locate fish in the isolated work area for removal to avoid more certain injury. Ninety-five percent of fish captured and handled survive with no long-term effects, and up to five percent are expected to be injured or killed, including delayed mortality because of injury (NMFS 2003).

2.4.1.5.1 Fish Handling at Concrete Technology Corporation. WSDOT will construct 23 supplement stability pontoons (SSPs) at the CTC site in the Blair waterway of Commencement Bay. The WSDOT estimates 10 gate openings to launch the 23 SSPs between August 2012 and June 2014. The casting basin is approximately 77,500 square feet. When the gate is open and the basin flooded, fish can enter the casting basin. WSDOT will remove fish once the gate is closed and the basin has begun to drain. NMFS considers the potential for adult Chinook salmon and steelhead and emigrating steelhead smolts to enter the casting basin to be discountable. These fish migrate rapidly through Commencement Bay and do not use the Blair waterway. Juvenile Chinook salmon use the nearshore of Commencement Bay from March 1 to July 1, and their numbers peak between May 15 and June 15 (Kerwin 1999). Of the 10 scheduled openings, three will occur from March 1 and May 15, and four from May 15 and June 15. As described above, between March 1and May 15, juvenile Chinook salmon densities in Commencement Bay averaged 0.001 fish per square foot, and between May 15 and June 15, densities averaged 0.060 fish per square foot (Pacific International Engineering 2000; 2002). Using this data, NMFS expects that up to 78 juvenile Chinook salmon could be within the casting basin for each of the three launchings (a total of 234) between March 1 and May 15, and up to 4,650 fish for each of the four launchings (a total of 18,600) between May 15 and June 15. Five percent of these fish

could be injured or killed, a total of 942 fish. Using average smolt-to-adult survival rates from Quinn (2005) of 0.031 for Chinook salmon, this equates to 29 adult equivalents.

2.4.1.5.2 Portage Bay. To construct mudline footings, WSDOT will install cofferdams in Portage Bay between August 16, 2014 and April 30, 2015 and August 16, 2015 and April 30, 2016. The cofferdams will occupy approximately 14,000 square feet of substrate. After completion of the cofferdam, they will remove any trapped fish using NMFS-approved WSDOT fish handling protocols to the greatest extent practical (WSDOT 2009a). As described above, NMFS does not expect adult or juvenile Chinook salmon or adult or juvenile steelhead to be present in southern Portage Bay between August 16 and April 30. Residual Chinook salmon will be present and small numbers could be trapped within the cofferdams. The cofferdams will enclose 8,200 square feet in 2014 and 5,500 in 2016. NMFS does not have density data for residual Chinook salmon in Portage Bay or other parts of the Ship Canal or Lake Washington. However, Tabor et al. (2006) reported densities of juvenile Chinook salmon at 11 sites in Lake Washington from February to July. By July, densities of juvenile Chinook salmon had dropped to less than 0.02 fish per square foot. Using this density data, NMFS expects that up to 164 residual Chinook salmon could be within the cofferdams in 2014 and 110 in 2016. Five percent, or up to 14 fish, could be injured or killed.

2.4.1.5.3 East Approach. To construct mudline footings, WSDOT will install cofferdams at the east approach between September 1, 2012 and May 15, 2013. The cofferdams will occupy approximately 9,550 square feet of substrate. After completion of the cofferdam, they will remove any trapped fish using approved WSDOT fish handling protocols (WSDOT 2009a). As described above, NMFS does not expect adult Chinook salmon or steelhead to be present near the east approach during this window. Residual Chinook salmon will be present year round and juvenile Chinook salmon will be present from February to July in small numbers. These fish could be trapped within the cofferdams. Tabor et al. (2006) found juvenile Chinook salmon densities as high as 0.15 per square foot at site along the eastern shore of Lake Washington between February and May 15 (the end of the in-water work window). Using this density data, NMFS expects that up to 1,433 juvenile and residual Chinook salmon could be within the cofferdams in 2012. Five percent, or up to 72 fish, could be injured or killed. Using average smolt-to-adult survival rates from Quinn (2005) of 0.031 for Chinook salmon, this equates to two adult equivalents.

2.4.1.6 Stormwater

Widening SR 520 will increase PGIS and stormwater runoff in the action area. Exposure to stormwater pollutants causes reduced growth, impaired migratory ability, and impaired reproduction. The extent and severity of these effects varies depending on the extent, timing, and duration of the exposure, ambient water quality conditions, the species and life history stage exposed, pollutant toxicity, and synergistic effects with other contaminants (EPA 1980). The primary pollutants of concern in stormwater from road surfaces are total suspended solids (TSS), total zinc, dissolved zinc, total copper, and dissolved copper. Dissolved metals are particularly difficult to remove from stormwater. WSDOT is providing enhanced treatment where practicable to maximize the removal of dissolved metals.

The WSDOT used the Highway Runoff Dilution and Loading model (HI-RUN) model to predict the post-treatment annual pollutant loading, effluent concentration, and dilution zone dimensions (WSDOT 2009). The HI-RUN model uses a statistical procedure called Monte Carlo simulation. Monte Carlo simulation is a method that estimates possible outcomes from a set of random variables by simulating a process a large number of times and observing the outcomes. Using Monte Carlo simulation, the HI-RUN model calculates multiple model output scenarios by repeatedly sampling values for each input variable from computer-generated probability distributions. In this way, a probability distribution can be derived for the model output that indicates which predicted values have a higher probability of occurrence. The probability of exceeding a specific threshold for detrimental effects also can be determined using this procedure. WSDOT used the CORMIX dilution model for the Lake Washington discharges. WSDOT used a modified version of HI-RUN to calculate pollutant loadings and concentrations for the outfalls and fed that information into the CORMIX model.

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 (Sandahl et al. 2007; Sprague 1968). Increased copper and zinc loading presents two pathways for possible adverse effects: direct exposure to water column pollutant concentrations in excess of biological effects thresholds and indirect adverse effects resulting from the accumulation of pollutants in the environment over time, altered food web productivity, and possible dietary exposure.

Baldwin et al. (2003) found that 30 to 60 minute exposures to a dissolved copper concentration of 2.3 μg/L over background level caused olfactory inhibition in coho salmon juveniles. Sandahl et al. (2007) found that a three hour exposure to a dissolved copper concentration of 2.0 μg/L caused olfactory inhibition in coho salmon juveniles.

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). Juveniles 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.

The results of CORMIX modeling are shown in Table 10. This table shows the distances from each outfall where the concentrations of dissolved zinc and dissolved copper will remain above the biological effects thresholds during stormwater discharge.

Table 10.

Outfall	Receiving Water body	Dilution Zone Dissolved Zinc (ft)	Dilution Zone Dissolved Copper (ft)
East Allison Street	Lake Union	7.9	4.4

Portage Bay 1	Portage Bay	10.3	2.2
Portage Bay 2	Portage Bay	13.2	4.9
MOHAI	Union Bay	11.1	6.7
Floating Bridge (44 outfalls)	Lake Washington	70.0	20.0

2.4.1.6.1 Interstate 5 Interchange. As described above, WSDOT will add 0.05 acres of PGIS and will construct a bioswale to treat stormwater from four acres of PGIS in this area. The bioswale will direct stormwater to Lake Union via the City of Seattle's East Allison Street outfall. This outfall also carries untreated stormwater from the City of Seattle PGIS outside of the action area. This section analyzes the effects of proposed action's contribution to the total stormwater discharged at this outfall. Table 10 shows the distances from the outfall where dissolved zinc and dissolved copper will dilute to below the biological effects thresholds. Because they are shoreline-oriented, individual juvenile and residual Chinook salmon will have the highest probability of exposure to stormwater pollutants from this outfall. However, because the project will discharge stormwater in perpetuity and the outfall is close to the migratory corridor, NMFS cannot discount the probability of adult and juvenile steelhead and adult Chinook salmon exposure.

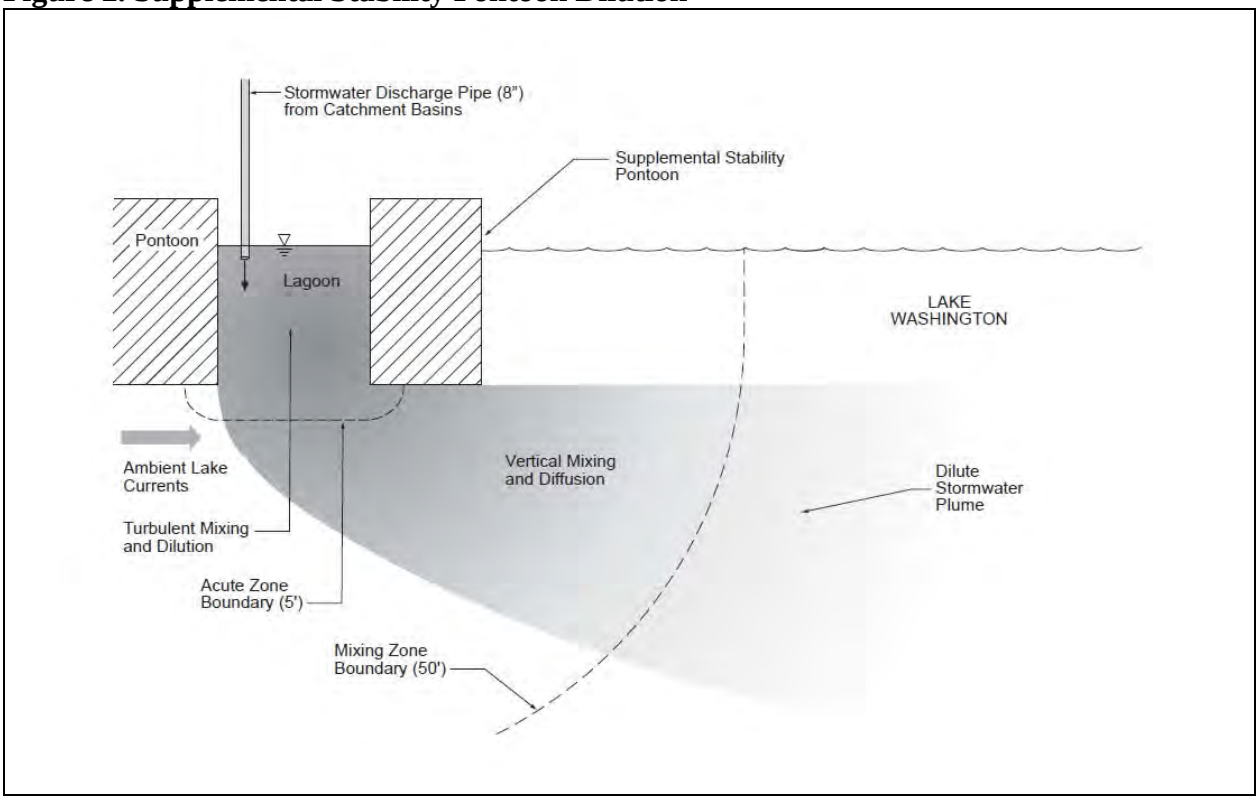
2.4.1.6.2 Portage Bay. This portion of the action area has 9.81 acres of existing PGIS. The project will add 2.19 acres of PGIS for a total of 12.00 acres. WSDOT will construct two stormwater treatment facilities, a bioswale and a constructed wetland, to treat stormwater from 11.64 acres of PGIS from this area. The bioswale will treat stormwater from 2.94 acres of PGIS and discharge at the southwest corner of Portage Bay via outfall PB 1. The constructed wetland will treat stormwater from 8.70 acres of PGIS and discharge at the southeast corner of Portage Bay via outfall PB 2. The various life history stages of Chinook salmon and steelhead exposed to stormwater pollutants will be similar to those seen at the East Allison outfall.

2.4.1.6.3 West Approach. Existing PGIS for SR 520 in this area measures 12.60 acres. The project will add 8.71 acres of PGIS for a total of 21.31 acres. WSDOT will direct stormwater from this area to a constructed wetland on the site currently occupied by the Museum of History and Industry (MOHAI). Stormwater from this facility will discharge into Union Bay south of the Montlake cut via the MOHAI outfall. The various life history stages of Chinook salmon and steelhead exposed to stormwater pollutants will be similar to those seen at the East Allison outfall.

2.4.1.6.4 Floating Bridge. The PGIS for the existing floating bridge measures 17.28 acres. The new bridge will have 20.56 acres of PGIS, an increase of 3.28 acres. The existing bridge does not have any stormwater treatment. WSDOT will treat stormwater on the new bridge using monthly high-efficiency sweeping, modified catch basins (cleaned twice a year), and spill control lagoons. High-efficiency sweeping will consist of a broom sweeper followed by a regenerative

air sweeper. The modified catch basins will be larger than standard catch basin structures. The catch basins will direct stormwater to spill control lagoons built into the SSPs (Figure 2). Forty-four of the 54 supplemental stability pontoons will have 19- by 29-foot spill control lagoons in the center of the pontoons. Stormwater will mix with water in the spill control lagoons prior to flowing into Lake Washington. Based on the dilution distances in Table 11, dissolved copper will dilute to below the biological effect threshold inside the spill control lagoons, while dissolved zinc will remain above the biological effect threshold for 40 to 50 feet beyond the lagoons.

Figure 2. Supplemental Stability Pontoon Dilution



The SSPs will be 28.5 feet deep. This will limit exposure of Chinook salmon and steelhead to stormwater in the lagoons. It is unlikely that any life history stage of either species will dive to a depth greater than 28.5 feet deep, and then resurface in the lagoons. Juveniles and adults of both species spend little time in the deeper portions of Lake Washington near the floating bridge. Fresh et al. (1999) found that adult Chinook salmon spend an average of 2.9 days in the lake. Juvenile Chinook salmon, while predominately shoreline-oriented, have been observed near the existing floating bridge (P. Bloch pers comm). Very little information is available on adult and juvenile steelhead use in Lake Washington (SPU and USACE 2008). In other systems, steelhead typically migrate quickly from riverine habitats to saltwater and vice versa. NMFS expects that Lake Washington steelhead exhibit similar behavior. Therefore, small numbers of juveniles and adults of both species are likely to experience short-term exposures to concentrations of dissolved zinc above the biological effects threshold.

2.4.1.6.5 Local Arterials (Combined Sewer System). Areas of PGIS from local streets (I-5 Interchange, Portage Bay, and the Montlake Interchange) the proposed action will modify drain

to the City of Seattle's combined sewer system (CSS). The CSS joins sewage from homes and businesses and stormwater together in a single conveyance system to the West Point Treatment Plant. Under typical operating conditions, the combined stormwater and sanitary sewage are treated and discharged to the marine waters of Puget Sound. During extreme wet weather, the CSS can exceed capacity resulting in untreated discharges at CSS outfalls. The CSS outfalls are relief points for the excess flow to prevent sewer backups, surface flooding, or operational issues at the West Point Treatment Plant. The proposed action will reduce CSS contributions from the action area and will not increase the frequency or size of CSS discharges.

2.4.1.6.4 Stormwater Summary. Because of they are shoreline-oriented and spend a greater amount of time within the action area, juvenile PS Chinook salmon will have the greatest exposure to stormwater discharges. While none of the dilution zones reach the primary migratory corridor, they will impact sub-optimal holding and rearing habitat. Juveniles using the dilution zones for rearing during stormwater discharges will likely experience increased physiological stress, reduced feeding, impaired ability to detect predators, and behavior alterations.

Because they migrate quickly through the action area, adult and juvenile steelhead and adult Chinook salmon will experience less exposure to dissolved copper and dissolved zinc than juvenile Chinook salmon. Juvenile steelhead will likely experience increased physiological stress, reduced feeding, impaired ability to detect predators, and behavior alterations. Adult Chinook salmon and adult steelhead exposed to stormwater discharges will experience increased physiological stress and behavior alterations (e.g. altered migration routes). As described above, heat stress can increase salmonids sensitivity to other stressors. Heat stressed adult Chinook salmon exposed to stormwater discharges will likely experience more severe effects which could lead to reduced spawning success.

NMFS cannot predict the number of Chinook salmon and steelhead that will exposed to the stormwater discharges into Lake Washington. Stormwater discharges will occur in perpetuity. The numbers of each species within Lake Washington varies year to year as does the number of rain events that produce stormwater effluent. NMFS also cannot estimate the proportion of fish each year that will enter the dilution zones. Therefore, NMFS will use the distance from the outfalls where dissolved copper and dissolved zinc are above the biological effects thresholds described above as a surrogate for the number of Chinook salmon and steelhead affected.

2.4.1.7 Beneficial Effects of Habitat Restoration Activities

2.3.1.7.1 Washington Department of Natural Resources Renton/ Cedar River Sites. Restoration of sites close to the mouth of the Cedar River will have a significant benefit for fisheries because juvenile Chinook salmon are very abundant near the mouth of the Cedar River (Tabor 2006). The mouth of the Cedar River does not have a functioning delta with estuarine marsh or freshwater emergent wetlands that Chinook salmon typically depend on during early rearing (King County 2005). Therefore, Cedar River Chinook salmon fry are dependent on suitable Lake Washington shoreline immediately adjacent to the mouth of the Cedar River during early rearing for feeding opportunities and refugia from predators. This restoration will remove 540 feet of flume and three dolphins (composed of 21 creosote piles), restore another

630 feet of rip rapped shoreline, increase native vegetation by removing invasive species and planting native riparian species,and place LWD and appropriately-sized substrate. These activities will increase the quantity and quality of rearing habitat for Chinook salmon fry. The removal of the flume and dolphins will reduce predator habitat. The shoreline restoration will increase the shallow near-shore habiat that Chinook salmon fry depend upon for predator avoidance and increase food resources through the placement of gravel and the riparian plantings.

2.3.1.7.2 Cedar River. The Cedar River will be reconnected to its historical floodplain on the left and right bank through 900 feet of levee setbacks. Reconnection of the floodplain will attenuate flood intensity downstream and reduce channel incision and erosion. Increased connectivity to the floodplain will also increase wetlands, import LWD, and provide refuge during high flows. Riparian restoration in the floodplain will provide fish cover, increase prey resources for fish, filter pollutants from nearby roads and development, provide bank stability, and contribute LWD to the river. LWD recruitment is currently rated as poor along almost all of the lower Cedar River, and land use practices generally preclude active recruitment.

This reach has very few pools and areas of fish cover. Scour pools will be used by adults of multiple salmonid species during upstream migration and for pre-spawn holding. Chinook salmon, in particular, will benefit from increased pools in the reach because they hold in pools prior to spawning, then spawn in riffle habitat adjacent to pools. Juvenile coho often rear in pools associated with LWD and fish cover. The creation of off-channel rearing habitat will benefit all salmonid species. In the Cedar River, this habitat was historically used by juvenile Chinook salmon for rearing, which in turn likely resulted in a larger and later timing of outmigration from the Cedar River.

2.3.1.7.3 Taylor Creek. Because of Taylor Creek's location in southern Lake Washington, the Chinook salmon juveniles using the creek are smaller and more dependent upon shallow nearshore areas and natural cover. These fish will benefit from improved rearing and migration habitat and feeding in the delta and the 560 feet of creek. Because of Taylor Creek's proximity to the Cedar River, NMFS expects densities of juvenile Chinook between 0.2 and 0.6 per square meter from February to May.

2.3.1.7.4 Seward Park. The WSDOT will remove two bulkheads in Seward Park, a 250-foot long concrete bulkhead and a 250-foot long riprap bulkhead. Cedar River Chinook salmon juveniles will benefit from the conversion of these bulkheads to a gradual, sloping shore with riparian vegetation. These improved habitat features will provide an unobstructed migratory pathway, protection from predators, and enhanced food sources from the natural sediments and overhanging vegetation.

2.3.1.7.5 Magnuson Park. The WSDOT will remove a 250-foot long concrete bulkhead at Magnuson Park. The Magnuson Park shoreline is along the migratory corridor for the North Lake Washington tributaries juvenile Chinook salmon. These juveniles use the entire littoral zone during migration. Chinook salmon juveniles will benefit from the conversion of the bulkhead to a gradually-sloping natural condition with functional riparian vegetation. These improved habitat features will provide an unobstructed migratory pathway, protection from

piscivorous and avian predators, and enhanced food sources from the natural sediments and overhanging vegetation.

2.4.2 Effects on Critical Habitat

2.4.2.1 Freshwater Spawning Sites (PCE 1)

The only spawning habitat in the action area is at the Cedar River habitat restoratrion site (RM 5.3). The project will have short term impacts to water quality from elevated sediment. The project will substantially improve spawning habitat at this location in the long term by creating side channels and improving floodplain function.

2.4.2.2 Freshwater Rearing Sites and Freshwater Migration Corridors (PCE 2 and PCE 3)

The project will have significant temporary effects to rearing habitat over the seven years of construction. WSDOT will schedule all impact pile driving to avoid juvenile and adult Chinook salmon rearing and migration. Impact pile driving will not affect the ability of these PCEs to provide for the conservation of PS Chinook salmon.

The WSDOT will schedule activities causing elevated suspended sediment to avoid areas heavily used by juvenile Chinook salmon for rearing and migration. Some in-water activities will take place in areas with low levels of juvenile Chinook salmon use (e.g. the Arboretum and Foster Island areas) during rearing and migration. In-water work will also occur during the adult Chinook salmon migration. Elevated suspended sediment will temporary degraded water quality and impair PCEs 2 and 3. There will be no permanent impacts to these PCEs from the elevated turbidity.

Over-water structures and their supporting piles and columns will also impact PCEs 2 and 3. Lack of excessive predation is a component of PCE 3. The increase in in-water pile and columns during construction will increase the availability of smallmouth bass habitat in the action area and degrade PCE 3 (juvenile migration). The new bridge will result in a reduction in the number of piles. As described above, shading from the over-water structures will not affect migrating adults or rearing/holding juveniles. Shading will cause short term delays for a portion of actively migrating juveniles and degrade PCE 3 both during construction and for the life of the new bridge. Stormwater discharges will also affect these PCEs by intermittently degrading the water quality component in areas near the outfalls for the life of the new bridge (Table 10).

The Cedar River habitat restoration site will improve PCEs 2 and 3 for a 900-foot long reach of the lower Cedar River by restoring floodplain connectivity, improving physical habitat conditions, increasing available forage, and providing natural cover (including side channels and LWD). The DNR restoration site will improve PCEs 2 and 3 for a 1,170 feet of Lake Washington shoreline adjacent to the mouth of the Cedar River by improving physical habitat conditions, increasing available forage, reducing predation risk (by remove in-water structure that provides predator habitat), and providing natural cover. The Taylor Creek site will improve these PCEs by restoring 560 feet of a non-natal stream improving physical habitat conditions (restoring the delta and creating a meandering channel), increasing available forage (improved

substrate and riparian planting), and reducing predation risk. The Seward and Magnuson Park restoration sites will restore a combined 750 feet of shoreline by removing bulkheads and creating gently-sloping shore. This will improve the function of the essential elements of PCEs 2 and 3, improving physical habitat conditions, increasing available forage (improved substrate and riparian planting), and reducing predation risk.

2.5 Cumulative Effects

"Cumulative effects" are those effects of future state or private activities, not involving Federal activities, that are reasonably certain to occur within the action area of the Federal action subject to consultation (50 CFR 402.02). 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 Act. NMFS conducted an online search of State and local agencies' websites with jurisdiction in the action area. These agencies included the City of Seattle (Department of Planning and Development, Department of Transportation, and Seattle Public Utilities), the City of Medina (Departments of Public Works and Development Services), the University of Washington, and the State of Washington (Departments of Transportation, Natural Resources, and Fish and Wildlife). NMFS did not find any future activities that were both within the action area and did not involve Federal activities. Furthermore, the action area is already fully developed with the exception of areas protected from development such as the Arboretum and Seattle Parks.

2.6 Integration and Synthesis

The Integration and Synthesis section is the final step of NMFS' 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 2.4) to the environmental baseline (Section 2.3) and the cumulative effects (Section 2.5) to formulate the agency's biological opinion as to whether the proposed action is likely to: (1) result in appreciable reductions in the likelihood of both survival and recovery of the species in the wild by reducing its numbers, reproduction, or distribution; or (2) reduce the value of designated or proposed critical habitat for the conservation of the species. These assessments are made in full consideration of the status of the species and critical habitat (Section 2.2).

2.6.1 Puget Sound Chinook Salmon ESU

2.6.1.1 Puyallup River Chinook Salmon Populations

Fish handling at the CTC site in Commencement Bay will affect juvenile Chinook salmon from two populations, the Puyallup River and the White River. Natural origin spawners average over 1,000 fish per year for both of these populations. The loss of the equivalent of 29 adults from these populations over two years will result in a short-term reduction in abundance. From 2005-2010, adult returns for the Puyallup River population averaged 2,007, and returns for the White River population averaged 1,468 spawners for a total of 3,475 per year. Twenty-nine adults would be 0.4 percent of the total number of spawners over two years and is less than the year-to-year fluctuations in returns.

Therefore, the loss of the equivalent of 29 adults from these populations over two years will not affect the productivity, spatial structure, diversity, long-term abundance, or the potential for recovery of these populations or the ESU as a whole.

2.6.1.2 Lake Washington Chinook Salmon Populations

A small portion of the Lake Washington populations Chinook salmon residualize. Residual Chinook salmon are present in Lake Washington year-round and are not protected by the in-water work windows. They will be exposed to the each of the stressors of the action occurring in Lake Washington. De Vries et al. (2007) found that juvenile Chinook salmon residualize in Lake Washington, with rates ranging between zero and 0.45 percent. Residual fish were tagged and released in 2003 and 2004 and detected leaving the Ship Canal in 2004 and 2005. None of the fish tagged in 2002 or 2007 migrated through the Ship Canal as 1+ or older fish. Anecdotal reports suggest that residual Chinook in Lake Washington are in poor condition (Tabor pers. comm.). These residual fish are unlikely to survive and return to spawn. Because these fish do not breed, the effects to them will not affect the VSP parameters of the Lake Washington populations or the ESU as a whole.

For most Chinook salmon in Lake Washington, prescribed timing for construction will help avoid exposure of juvenile Chinook salmon to project effects (e.g. impact pile driving). Other projects will occur in habitats Lake Washington Chinook salmon are unlikely to use (e.g. the Arboretum and Foster Island). Effects during construction will include sublethal effects from elevated suspended sediment at the east approach and the west approach (during August). While NMFS cannot predict the number of fish or the precise percentage of the population that will be affected by elevated suspended sediment, NMFS can conclude that it will be a very small proportion of the populations because: (1) the habitat at the west approach in the Arboretum and Foster Island is unsuitable for Chinook salmon and is unlikely to be used for any length of time; (2) in-water work at the west approach east of Foster Island will not start until August 1, when the vast majority of juvenile Chinook have already migrated out of lake Washington; (3) the area of elevated suspended sediment in-water work at the west approach east of Foster Island will take up a small percentage of the migratory corridor available to adult Chinook salmon; and (4) juvenile Chinook are present at the east approach only in low densities. These sublethal effects to a small proportion of the Lake Washington populations will not have an observable effect on the spatial structure, productivity, long-term abundance, or diversity of the PS ESU.

Fish handling at the east approach will injure or kill up to 72 juveniles (2 adult equivalents). The loss of the equivalent of two adults from these populations will result in a short-term reduction in abundance. From 2005-2010, adult returns for the Cedar River population averaged 850, and returns for the North Lake Washington population averaged 140 spawners for a total of 990 per year. Two adults would be 0.2 percent of the total number of spawners and is less than the year-to-year fluctuations in returns. Therefore, the loss of the equivalent of two adults from these populations will not affect the productivity, spatial structure, diversity, long-term abundance, or the potential for recovery of these populations or the ESU as a whole.

All juvenile Chinook salmon from the Cedar River and a small percentage of the North Lake Washington population will be exposed to increased shading during construction and for the life

of the bridge. Holding juvenile Chinook salmon will not be affect by the additional shading. For actively migrating fish, the response to the shading will range from no response to a delay in migration of up to a few hours. The vast majority of actively migrating juvenile Chinook salmon will experience delays of less than an hour (Celadonia et al. 2009). Migration times from the Sammamish and Cedar Rivers to the locks in the Ship Canal averages between 13 and 16 days. Delays up to a few hours are unlikely to have any lasting adverse effects on individual Chinook salmon. Therefore, shading will not affect the VSP parameters of the Lake Washington populations or the ESU as a whole.

All juvenile Chinook salmon from the Cedar River and a some percentage of the North Lake Washington population will be exposed to increased predation risk from smallmouth bass from the increase in in-water piles and columns during construction. However, given that there are over 2,700 docks in lake Washington and the Ship Canal, the increase in in-water piles and columns during construction does not represent a significant increase in in-water structures that migrating juvenile Chinook salmon encounter, and, therefore, will not significantly increase the rate of predation by smallmouth bass. The new project will reduce the number of in-water columns and reduce predation risk from smallmouth bass in the long-term. The increase in predation risk from smallmouth bass will not have an observable affect on the VSP parameters of the Lake Washington populations or the ESU as a whole.

PS Chinook salmon will be exposed to elevated pollutant levels from stormwater discharges. While none of the dilution zones reach the primary migratory corridor, they will impact sub-optimal holding and rearing habitat. Juveniles using the dilution zones for rearing during stormwater discharges will likely experience increased physiological stress, reduced feeding, impaired ability to detect predators, and behavior alterations. However, only a subset of the populations in any given year will migrate or rear within the dilution zone of the outfalls. Furthermore, migration of Chinook salmon through the action area occurs from late-spring to early-fall (peak migration for juveniles in June and July and July through September for adults) when rain events large enough to cause stormwater discharges are less frequent. Only individuals within the dilution zones during stormwater discharges will be affected. Given the low level of Chinook salmon use of the dilution zones, the infrequency of rain events during the Chinook salmon migration times, and the small area of the dilutions zones compared to the amount of habitat in the action area, the elevated pollutant levels from stormwater discharges will not have an observable affect on the VSP parameters of the Lake Washington populations or the ESU as a whole.

The proposed action will improve spawning, rearing, and migration habitat for Chinook salmon by restoring a 900-foot long reach of the lower Cedar River at RM 5.3 through levee removal and floodplain restoration. The proposed action will improve rearing and migration habitat for Chinook salmon by restoring 1,170 feet of Lake Washington shoreline adjacent to the mouth of the Cedar River through shoreline restoration, 560 feet of Taylor Creek through channel and delta restoration; and 750 feet of Lake Washington shoreline at Seward and Magnuson Parks through shoreline restoration. These activities are likely to improve the productivity of the Lake Washington populations, but will not have an observable affect on the VSP parameters of the ESU as a whole.

Because the viability of the Lake Washington Chinook salmon populations will not impaired by the proposed action, and there are no adverse cumulative effects, the project will not reduce the likelihood of survival or recovery of the PS Chinook salmon ESU.

2.6.2 Puget Sound Steelhead DPS

Lake Washington Basin steelhead are virtually extirpated (less than 10 adult fish per year). Populations of steelhead this small are not viable. However, steelhead (anadromous *O. mykiss*) interbreed with rainbow trout (resident *O. mykiss*) in the Cedar River (Marshall et al. 2004). NMFS's June 2007 status review found that, where resident and anadromous *O. mykiss* co-occur, rainbow trout had a close biological relationship to steelhead (Hard et al. 2007). Hard et al. (2007) also concluded that resident *O. mykiss* are likely to reduce imminent risk of extinction and that the resident *O. mykiss* can retain the genetic basis for anadromy for several decades. Negative effects from the loss of anadromy include lower productivity and increased extinction risk over the long-term (Hard et al. 2007).

For the most part, construction activities will be timed to avoid PS steelhead, will occur in habitats steelhead are unlikely to use, or generate stressors that do not typically harm larger salmonids such as adult and out-migrating juvenile steelhead. Impact pile driving will cause sublethal injury to small numbers of adult steelhead at the west approach (in 2013 and 2015) and at the east approach (2012 to 2013). At most, 30 fish could be exposed to impact pile driving during these three years of construction. It is unlikely that all adult steelhead will migrate through the action area during impact pile driving, and only a subset of those that do will remain near the pile driving activities long enough to sustain sublethal injury (i.e. be exposed to enough pile strikes so that the cumulative SEL reaches the injury threshold of 187dB or higher).

The restoration activities at the Cedar River will cause sublethal injury small numbers of 0+ and 1+ juvenile steelhead. Since 2007, WDFW has not been able to estimate the production of steelhead in the Cedar River because the number of steelhead smolts trapped is so low (zero to one per year) (Kiyohara and Zimmerman 2011). For 2006, the last year that WDFW trapped enough fish to estimate the production of steelhead, they estimated the total number of steelhead smolts in the Cedar River to be 267 fish. Only a very small percentage of juvenile steelhead within the Cedar River will be exposed to elevated suspended sediment at the restoration site, and these fish are unlikely to suffer permanent injury. Overall, the habitat restoration activities at this site will improve habitat for PS steelhead.

The resident *O. mykiss* in the Cedar River are native and abundant and they interbreed with steelhead (Marshall et al. 2004). It is likely that the resident population retains much of the genetic diversity and the genetic basis for anadromy of the population (Hard et al. 2007). The sublethal impacts to small numbers of individuals described above will not significantly change the percentage of the Cedar River *O. mykiss* population that expresses anadromy, and will therefore not affect the abundance, productivity, spatial structure, and diversity of the PS DPS as a whole.

Restoration of the anadromous form of Lake Washington *O. mykiss* is still possible. Restoration efforts have previously brought extirpated and nearly extirpated populations of anadromous

salmonids back to sustainable numbers (e.g. Redfish Lake sockeye salmon and Tahuya River summer-run chum salmon). If efforts are undertaken to restore steelhead in the Lake Washington Basin, the proposed action will not reduce the likelihood of success of those efforts.

2. 2.6.1 Puget Sound Chinook Salmon Critical Habitat

The CHART rated the conservation value of critical habitat in Lake Washington as "medium" and in the Cedar River as "high." The temporary effects of the proposed action on critical habitat include elevated suspended sediment, increased shading from over-water structures, and increased smallmouth bass habitat. These effects are likely to cause a reduction in the conservation value of PCEs 2 and 3 during construction within the action area, but will not result in lasting effects. Furthermore, most of the effects to PCEs 2 and 3 will be timed to avoid Chinook salmon or will occur in areas of low Chinook salmon use. Permanent impacts to critical habitat include increased shading from over-water structures and stormwater discharges. The proposed action will improve PCEs 1, 2, and 3 for a 900-foot reach of the lower Cedar River and at the Lake Washington restoration sites. Overall, critical habitat will remain functional and retain the current ability for PCEs to serve the intended conservation role for the species. Therefore, the proposed action will not significantly reduce the conservation value of critical habitat at the ESU scale.

7 Conclusion

After reviewing the current status of the listed species, the environmental baseline within the action area, the effects of 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 or PS steelhead or destroy or adversely modify PS Chinook salmon designated critical habitat.

2.8. Incidental Take Statement

Section 9 of the ESA and Federal regulation pursuant to section 4(d) of the ESA prohibit the take of endangered and threatened species, respectively, without a permit or 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 results in death or injury to listed species by significantly impairing essential behavioral patterns, including breeding, feeding, or sheltering. Incidental take is defined as take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity. 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 incidental take statement.

2.8.1 Amount or Extent of Take

Effects of the action will coincide with the presence of PS Chinook salmon and PS steelhead such that the incidental take is reasonably certain to occur. Take from fish handling is reported as the number of fish. Take caused by elevated suspended sediment, impact pile driving, over-

water structures, increased smallmouth bass habitat, and stormwater discharges cannot be accurately quantified as a number of fish because NMFS cannot predict, using the best available science, the number of PS Chinook salmon and PS steelhead that will be exposed to these stressors. Furthermore, even if NMFS could estimate that number, the manner in which each exposed individual responds to that exposure cannot be predicted. In contrast, the number of fish affected by capture and handling can be estimated as provide below.

In circumstances where NMFS cannot estimate the amount of individual fish that would be injured or killed by the effects of the proposed action, NMFS assesses the extent of take as an amount of modified habitat and exempts take based only on that extent. This extent is readily observable and therefore suffices to trigger reinitiation of consultation, if exceeded and necessary (see H.R. Rep. No 97-567, 97th Cong., 2d Sess. 27 (1982).

Take from elevated suspended sediment is exempted for:

1. 105.9 acres in Portage Bay, with a maximum of 23.3 acres in any one construction year;
2. 104.4 acres at the West Approach (Arboretum and Foster Island), with a maximum of 26.5 acres in any one construction year;
3. 146.1 acres at the West Approach (east of Foster Island), with a maximum of 39.7 acres in any one construction year;
4. 18.1 acres at the east approach, with a maximum of 7.1 acres in any one construction year;
5. 2.2 acres at the DNR Parcel (south Lake Washington);
6. 2.1 acres at the Cedar River (RM 5.3);
7. 0.8 acre at Taylor Creek;
8. 3.1acres at Seward Park; and
9. 4.3 acres at Magnuson Park.

Take from impact pile driving (cumulative SEL greater than 187dB) is exempted for:

1. 3.5 acres in Portage Bay, with a maximum of 1.9 acres in any one construction year and a maximum of 0.2 acre in any one day;
2. 2.9 acres at the West Approach (Arboretum and Foster Island), with a maximum of 1.6 acres in any one construction year and a maximum of 0.1 acre in any one day
3. 7.8 acres at the West Approach (east of Foster Island), with a maximum of 4.0 acres in any one construction year and a maximum of 0.8 acre in any one day; and
4. 284.3 acres at the east approach, with a maximum of 150.2 acres in any one construction year and a maximum of 125.4 acres in any one day.

Take from increased shading from over-water structures is exempted for the areas shown in Table 7.

Take from increased smallmouth bass habitat from over-water structures is exempted for the areas shown in Table 9.

Take from fish handling is exempted for:

1. 18,834 juvenile Chinook salmon at the CTC site with 3,836 that will be injured or killed;
2. 274 residual Chinook salmon in Portage Bay with 14 that will be injured or killed; and
3. 1,433 juvenile and residual Chinook salmon at the east approach with 72 that will be injured or killed.

Take from stormwater discharges (dissolved zinc 5.6 mg/l over background concentrations and dissolved copper at 2.0 mg/l over background concentrations) is exempted for:

1. The area within 7.9 feet of the East Allison street outfall for dissolved zinc and within 4.4 feet for dissolved copper;
2. The area within 10.3 feet of the Portage Bay 1 outfall for dissolved zinc and within 2.2 feet for dissolved copper;
3. The area within 13.2 feet of the Portage Bay 2 outfall for dissolved zinc and within 4.9 feet for dissolved copper;
4. The area within 11.1 feet of the MOHAI outfall for dissolved zinc and within 6.7 feet for dissolved copper; and
5. The area within 70 feet of the 44 floating bridge outfalls for dissolved zinc and within 20 feet for dissolved copper.

2.8.2 Effect of the Take

The effect of take on PS Chinook salmon and PS steelhead is describe above in Section 2.4.

2.8.3 Reasonable and Prudent Measures

"Reasonable and prudent measures" (RPMs) are nondiscretionary measures to minimize the amount or extent of incidental take (50 CFR 402.02). "Terms and conditions" implement the reasonable and prudent measures (50 CFR 402.14). These must be carried out for the exemption in section 7(o)(2) to apply.

The FHWA shall minimize take of PS Chinook salmon and PS steelhead. These reasonable and prudent measures are necessary and appropriate to minimize the take of PS Chinook salmon and PS steelhead. The FHWA shall:

1. minimize incidental take from elevated suspended sediment;

2. minimize incidental take from underwater sound;

3. minimize incidental take from over-water structures;

4. minimize take from fish handling; and

5. minimize incidental take from stormwater discharges.

2.8.4 Terms and Conditions

1. To implement RPM 1, FHWA shall:

   a) monitor turbidity levels during in-water work to ensure that the turbidity does not exceed 5 NTUs above background at 150 feet from the source. The FHWA shall report the results of the turbidity monitoring to NMFS within 60 days of the completion of each in-water work season; and

   b) Preclude any turbidity generating in-water work at the west approach east of Foster Island between April 15 and September 1 in all construction years.

2. To implement RPM 2, FHWA shall:

   a) Use a vibratory hammer to drive piles to the maximum extent practicable;

   b) Use a confined or unconfined bubble curtain with the same specifications as the bubble curtains from the test pile project (Illingsworth and Rodkin 2009) for all impact pile driving except up to 500 strikes per day at the east approach (to establish baseline sound levels);

   c) Monitor at least 10 piles in Portage Bay, the west approach (Arboretum and Foster Island), and the east approach for each construction year. If the number of impact strikes required to reach bearing capacity increases by more than 50 percent from the average for four consecutive pilings, then additional five pilings will be monitored to confirm underwater noise levels.

   d) Monitor at least 20 piles in the west approach east of Foster Island for each construction year. At least 10 of these pile will be between the midpoint of the work bridge and its eastern terminus; and

   e) Preclude any impact pile driving at the west approach east of Foster Island between April 15 and October 8 in any construction year.

3. To implement RPM 3, FHWA shall:

   a) Between April 15 and September 1 of any construction year, within the area of the west approach (east of Foster Island) between 15 and 27 feet deep, maintain at least a 100-foot unobstructed corridor between barges and between barges and work bridges to allow juvenile salmonid outmigration. The 100-foot corridor can be relocated throughout the work window to accommodate construction sequencing;

   b) Move any barges delivering or removing construction materials, equipment, or debris out of the primary migratory corridor (the area of the west approach (east of

Foster Island) between 15 and 27 feet deep) as soon as possible after loading or off-loading;

c) For the east approach, moor any barges at least 15 feet away from the temporary work bridge and falsework. Moorage closer to the structure is allowed during inclement weather or when moving heavy loads onto or off of the barge;

d) Construct the maintenance dock with open grating for at least one third of its width (approximately 4.5 feet); and

e) Preclude mooring barges in the Montlake Cut between April 15 and September 1.

4. To implement RPM 4, FHWA shall:

a) Submit a fish removal plan for the CTC and the cofferdams at least 60 days prior to any gate openings. The fish removal plan will follow the NMFS-approved WSDOT Fish Exclusion Protocols and Standards as closely as possible;

b) Document all PS Chinook salmon encountered during work area isolation by submitting an In-water Construction Monitoring Report (Appendix I) or equivalent to NMFS within 30 days of work area isolation;

c) To the maximum extent practical, preclude gate openings at the CTC site between May 15 and June 15; and

d) Provide NMFS a schedule of CTC gate openings and a description of the necessity of any openings between May 15 and June 15. The description will include the date of the next suitable tide cycle to launch the pontoons.

5. To implement RPM 5, FHWA shall:

a) Upon project completion, monitor stormwater discharges from the floating bridge and the MOHAI outfall for two years in order to accurately characterize stormwater BMP effectiveness and "end-of-pipe" effluent concentrations for treated and untreated stormwater runoff (total and dissolve copper, total and dissolved zinc; total suspended solids);

b) Submit stormwater monitoring plans to NMFS for the floating bridge and the MOHAI outfall by October 31, 2011;

c) Submit annual monitoring reports to NMFS.

2.9. Conservation Recommendations

Section 7(a)(1) of the ESA directs Federal agencies to use their authorities to further the purposes of the ESA by carrying out conservation programs for the benefit of the threatened and endangered species. Specifically, conservation recommendations are suggestions regarding

discretionary measures to minimize or avoid adverse effects of a proposed action on listed species or critical habitat or regarding the development of information (50 CFR 402.02).

In order to develop information regarding improving migratory habitat for Lake Washington PS Chinook salmon, NMFS recommends that FHWA, in cooperation with the USACE and other stakeholders, investigate methods to reduce summer water temperatures in the Ship Canal.

2.10 Reinitiation of Consultation

As provided in 50 CFR 402.16, reinitiation of formal consultation is required 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 take is exceeded, (2) new information reveals effects of the agency action on listed species or designated critical habitat in a manner or to an extent not considered in this opinion, (3) the agency action is subsequently modified in a manner that causes an effect on the listed species or critical habitat not considered in this opinion, or 4) a new species is listed or critical habitat designated that may be affected by the action.

2.11 "Not Likely to Adversely Affect" Determinations

2.11.1 Southern Resident Killer Whale and Southern Resident Killer Whale Critical Habitat

The proposed action will not have any direct effects on Southern Resident killer whales; the towing speeds for the pontoons from Grays Harbor to Lake Washington are too slow to strike whales. However, the project may indirectly affect the quantity of prey available to Southern Residents. Any salmonid take up to the aforementioned maximum extent and amount would result in an insignificant reduction in adult equivalent prey resources for Southern Resident killer whales that may intercept these species within their range. Therefore, NMFS concurs with FHWA's determination that the proposed action may affect, but is not likely to adversely affect Southern Resident killer whales.

2.11.2 Yelloweye Rockfish, Canary Rockfish, Bocaccio

Rockfish fertilize their eggs internally and the young are extruded as larvae. Rockfish larvae are pelagic, often found near the surface of open waters, under floating algae, detached seagrass, and kelp. Juvenile bocaccio and canary rockfish settle onto shallow nearshore water in rocky or cobble substrate that support kelp and other macroalgae at 3 to 6 months of age, and move to progressively deeper waters as they grow (Love et al. 2002). Juvenile yelloweye rockfish do not typically occupy shallow waters (Love et al. 1991) and are very unlikely to be within the project area. Adult yelloweye rockfish, canary rockfish, and bocaccio typically occupy waters deeper than 120 feet (Love et al. 2002).

The project will occur adjacent to waters that consist of sand and mud substrates of Commencement Bay and that are devoid of kelp. The action area are less than 120 feet deep. As such, adults of ESA-listed rockfish are not expected to occur within this area and will not be affected by project activities. Juvenile canary rockfish, yelloweye rockfish, and bocaccio are

unlikely to occupy the action area because of the characteristics of their substrates and lack of kelp.

Larval yelloweye rockfish, canary rockfish or bocaccio could occur within the project and action area, though they are readily dispersed by currents after they are born, making the concentration or probability of presence of larvae in any one location extremely small (NMFS 2003). The size of the project and action area where effects could occur to larval ESA-listed rockfish, combined with the short duration of project activities, make it extremely unlikely and therefore discountable that a larvae will be present and thus exposed to project activities.

Because all potential adverse effects are discountable, NMFS concurs with the FHWA determination of may affect, not likely to adversely affect for yelloweye rockfish, canary rockfish, and bocaccio.

3. MAGNUSON-STEVENS FISHERY CONSERVATION AND MANAGEMENT ACT ESSENTIAL FISH HABITAT CONSULTATION

The consultation requirement of 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 effects include the direct or indirect physical, chemical, or biological alterations 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 EFH, 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 salmon (PFMC 1999) contained in the fishery management plans developed by the Pacific Fishery Management Council (PFMC) and approved by the Secretary of Commerce.

3.1 Essential Fish Habitat Affected by the Project

The proposed action and action area for this consultation are described in the Introduction to this document. The action area includes areas designated as EFH for various life-history stages of Chinook salmon (*O. tshawytscha*) and coho salmon (*O. kisutch*), but does not occur within a Habitat Area of Particular Concern.

3.2 Adverse Effects on Essential Fish Habitat

The NMFS determined that the proposed action will have adverse effects to EFH designated for Chinook salmon and coho salmon, based on information provided in the BA and the analysis of effects presented in the ESA portion of this document. The NMFS determined that the proposed action will adversely affect EFH by temporarily elevating suspended sediment levels, increasing over-water shading (both temporary and permanent), and discharging stormwater. EFH will also be improved by the habitat restoration activities.

The following is the amount of EFH that will be adversely affected by elevated suspended sediment for each portion of the action area:

1. 105.9 acres in Portage Bay;
2. 104.4 acres at the West Approach (Arboretum and Foster Island);
3. 146.1 acres at the West Approach (east of Foster Island);
4. 18.1 acres at the east approach, with a maximum of 7.1 acres in any one construction year;
5. 2.2 acres at the DNR Parcel (south Lake Washington);
6. 2.1 acres at the Cedar River (RM 5.3);
7. 0.8 acre at Taylor Creek;
8. 3.1acres at Seward Park; and
9. 4.3 acres at Magnuson Park.

The amount of EFH that will be adversely by shading from over-water structures in each portion of the action area is shown in Table 7.

The following is the amount of EFH that will be adversely affected by stormwater discharges:

1. The area within 7.9 feet of the East Allison street outfall;
2. The area within 10.3 feet of the Portage Bay 1 outfall;
3. The area within 13.2 feet of the Portage Bay 2 outfall;
4. The area within 11.1 feet of the MOHAI outfall; and
5. The area within 70 feet of the 44 floating bridge outfalls.

The following is the amount of EFH that will be improved by the restoration activities:

1. A 900-foot long reach of the lower Cedar River at RM 5.3 through levee removal and floodplain restoration;
2. 1,170 feet of Lake Washington shoreline adjacent to the mouth of the Cedar River through shoreline restoration;
3. 560 feet of Taylor Creek through channel and delta restoration; and
4. 750 feet of Lake Washington shoreline at Seward and Magnuson Parks through shoreline restoration.

3.3 Essential Fish Habitat Conservation Recommendations

NMFS expects that full implementation of these EFH conservation recommendations would protect, by avoiding or minimizing the adverse effects described in section 3.2 above, approximately 395 acres of designated EFH for Pacific coast salmon. These conservation recommendations are a subset of the ESA terms and conditions. NMFS recommends that FHWA:

1. Monitor turbidity levels during in-water work to ensure that the turbidity does not exceed 5 NTUs above background at 150 feet from the source.

2. Report the results of the turbidity monitoring to NMFS within 60 days of the completion of each in-water work season;

3. Preclude any turbidity generating in-water work at the west approach east of Foster Island between April 15 and September 1 in all construction years;

4. Between April 15 and September 1 of any construction year, within the area of the west approach (east of Foster Island) between 15 and 27 feet deep, maintain at least a 100-foot unobstructed corridor between barges and between barges and work bridges to allow juvenile salmonid outmigration. The 100-foot corridor can be relocated throughout the work window to accommodate construction sequencing;

5. Move any barges delivering or removing construction materials, equipment, or debris out of the primary migratory corridor (the area of the west approach (east of Foster Island) between 15 and 27 feet deep) as soon as possible after loading or off-loading;

6. For the east approach, moor any barges at least 15 feet away from the temporary work bridge and falsework;

7. Construct the maintenance dock with open grating for at least one third of its width (approximately 4.5 feet);

8. Preclude mooring barges in the Montlake Cut between April 15 and September 1;

9. Upon project completion, monitor stormwater discharges from the floating bridge and the MOHAI outfall for two years in order to accurately characterize stormwater BMP effectiveness and “end-of-pipe” effluent concentrations for treated and untreated stormwater runoff (total and dissolve copper, total and dissolved zinc; total suspended solids);

10. Submit stormwater monitoring plans to NMFS for the floating bridge and the MOHAI outfall by October 31, 2011; and

11. Submit annual monitoring reports to NMFS.

3.4 Statutory Response Requirement

As required by section 305(b)(4)(B) of the MSA, the Federal agency must provide a detailed response in writing to NMFS within 30 days after receiving an EFH Conservation Recommendation from NMFS. 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, mitigating, or offsetting the impact of the activity on EFH. In the case of a response that is inconsistent with NMFS Conservation Recommendations, the Federal agency must explain its reasons for not following the recommendations, including the scientific justification for any disagreements with NMFS over the anticipated effects of the action and the measures needed to avoid, minimize, mitigate, or offset such effects [50 CFR 600.920(k)(1)].

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

3.5 Supplemental Consultation

The 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

Section 515 of the Treasury and General Government Appropriations Act of 2001 (Public Law 106-554) (Data Quality Act) specifies three components contributing to the quality of a document. They are utility, integrity, and objectivity. This section of the Biological Opinion addresses these Data Quality Act (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. These users include four agencies of the Federal government (NMFS, FHWA, USACE, and the US Coast Guard), the WSDOT, the residents of the Cities of Seattle and Medina, King County, the State of Washington, and the general public.

Individual copies were provided to the above-listed entities. This consultation will be posted on the NMFS Northwest Region website (http://www.nwr.noaa.gov). 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

4.3.1 Information Product Category

Natural Resource Plan.

4.3.2 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 600.920(j).

4.3.3 Best Available Information

This consultation and supporting documents use the best available information, as referenced in the Literature Cited section. The analyses in this Opinion/EFH consultation contain more background on information sources and quality.

4.3.4 Referencing

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

4.3.5 Review Process

This consultation was drafted by NMFS staff with training in ESA and MSA implementation, and reviewed in accordance with Northwest Region ESA quality control and assurance processes.

5. REFERENCES

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.

Bash, J., C. Berman, and S. Bolton. 2001. Effects of turbidity and suspended solids on salmonids. Center for Streamside Studies, University of Washington, Seattle, Washington.

Battin, J., M. W. Wiley, M. H. Ruckelshaus, R. N. Palmer, E. Korb, K. K. Bartz, and H. Imaki. 2007. Projected impacts of climate change on salmon habitat restoration. Proceedings of the National Academy of Sciences, USA 104(16):6720-6725.

Beechie, T.J., B.D. Collins, and G.R. Pess. 2001. Holocene and recent geomorphic processes, land use and salmonid habitat in two north Puget Sound river basins. In Dorava, J.B., D.R. Montgomery, F. Fitzpatrick, and B. Palcsak (editors), Geomorphic processes and riverine habitat, p. 37-54. Water Science and Application, American Geophysical Union, Washington D.C.

Beechie, T., E. Buhlel, M.H. Ruckelshaus, A. Fullerton, and L. Holsinger. 2006. Hydrologic regime and the conservation of salmon life history diversity. Biological Conservation 130: 560-572.

Berg, L. and T.G. Northcote. 1985. Changes in territorial, gill-flaring, and feeding behavior in juvenile coho salmon (*Oncorhynchus kisutch*) following short-term pulses of suspended sediment. Canadian Journal of Fisheries and Aquatic Sciences 42: 1410-1417.

Berger, A. and R. Ladley. 2006. Acoustic tagging of winter steelhead in the Puyallup River: 2006. Puyallup Tribe of Indians, Fisheries Department.

Bjornn, T.C. and D.W. Reiser. 1991. Habitat requirements of salmonids in streams. American Fisheries Society Special Publication 19: 83-138.

Bledsoe, L.J., D.A. Somerton, and C.M. Lynde. 1989. The Puget Sound runs of salmon: An examination of the changes in run size since 1896. Canadian special publication of fisheries and aquatic sciences 105: 50-61.

Booth, D.B., D. Hartley, and C.R. Jackson. 2002. Forest cover, impervious-surface area, and the mitigation of stormwater impacts. J. Amer. Water Res. Assoc. 38:835-845.

Busby, P.J., T.C. Wainwright, G.J. Bryant, L. Leirheimer, R.S. Waples, F.W. Waknitz, and I.V. Lagomarsino. 1996. Status review of west coast steelhead from Washington, Idaho, Oregon, and California. U.S. Dep. Commerce, NOAA Tech. Memo. NMFS-NWFSC-27, 281p

Celedonia, M.T., R.A. Tabor, S. Sanders, D.W. Lantz, and J. Grettenberger. 2008a. Movement and Habitat Use of Chinook Salmon Smolts and Two Predatory Fishes in Lake Washington and the Lake Washington Ship Canal. 2004–2005 Acoustic Tracking Studies. U.S. Fish and Wildlife Service, Lacey, Washington. 129 pp.

Celedonia, M.T., R.A. Tabor, S. Sanders, S. Damm, T.M. Lee, D.W. Lantz, Z. Li, J. Pratt, B. Price, and L. Seyda. 2008b. Movement and Habitat Use of Chinook Salmon Smolts, Northern Pikeminnow, and Smallmouth Bass Near the SR 520 Bridge. U.S. Fish and Wildlife Service, Lacey, Washington. 139 pp.

Celedonia, M.T., R.A. Tabor, S. Sanders, S. Damm, D.W. Lantz, T.M. Lee, Z. Li, B.E. Price, W. Gale, and K. Ostrand. 2009. Movement and Habitat Use of Chinook Salmon Smolts, Northern Pikeminnow and Smallmouth Bass Near the SR 520 Bridge, 2008 Acoustic Tracking Study. U.S. Fish and Wildlife Service, Washington Fish and Wildlife Office, Fisheries Division, Lacey, Washington.

City of Seattle. 1999. City of Seattle Built Environment Shoreline Surveys. Prepared by Parametrix and Natural Resources Consultants, for the Seattle Public Utilities. Seattle, Washington.

City of Seattle. 2000. Final Cedar River Watershed Habitat Conservation Plan for the Issuance of a Permit to Allow Incidental Take of Threatened and Endangered Species. Seattle, Washington.

Collins, B.D., and D.R. Montgomery. 2002. Forest development, log jams, and the restoration of floodplain rivers in the Puget Lowland. Restor. Ecol. 10:237-247.

De Schamphelaere K. A., and C. R. Janssen. 2004. Bioavailability and chronic toxicity of zinc to juvenile rainbow trout (*Oncorynchus mykiss*): comparison with other fish species and development of a biotic ligand model. Environmental Science and Technology. 2004. 38, 6201-6209.

DeVries, P., and 18 others. 2005. PIT Tagging of Juvenile Salmon Smolts in the Lake Washington Basin: Fourth Year (2003) Pilot Study Results and Synopsis of 2000–2003 Findings. Technical Report to U.S. Army Corps of Engineers, Seattle District and Seattle Public Utilities.

DeVries, P., and 14 others. 2007. PIT Tagging of Juvenile Salmon Smolts in the Lake Washington Basin: Fifth and Sixth Year (2004–2005) Pilot Study Results. Final report prepared for U.S. Army Corps of Engineers, Seattle District. R2 Resource Consultants, Inc. Redmond, Washington.

DeVries, P., and nine others. 2008. PIT Tagging of Juvenile Salmon Smolts in the Lake Washington Basin: Seventh and Eighth Year (2006–2007) Study Results. Final report prepared for U.S. Army Corps of Engineers, Seattle District. R2 Resource Consultants, Inc. Redmond, Washington.

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. 106 pp.

EPA (U.S. Environmental Protection Agency). 1980. Ambient Water Quality Criteria for Copper - 1980. EPA, Publication 440/5-80-036, Washington, DC (October 1980). 162p.

EPA (U.S. Environmental Protection Agency). 1987. Ambient Water Quality Criteria for Zinc - 1987. EPA, Publication 440/5-87-003, Washington, DC (February 1987). 207 p.

FHWG (Fisheries Habitat Working Group). 2008. Agreement in Principal for Interim Criteria for Injury to Fish from Pile Driving Activities. Memorandum of Agreement between NOAA Fisheries' Northwest and Southwest Regions; USFWS Regions 1 and 8; California, Washington, and Oregon Departments of Transportation; California Department of Fish and Game; and Federal Highways Administration. June 12, 2008.

Fresh, K.L., E. Warner, R. Tabor, and D. Houck. 1999. Migratory Behavior of Adult Chinook Salmon Spawning in the Lake Washington Watershed in 1998 and 1999 as Determined with Ultrasonic Telemetry. King County Wastewater Treatment Division, Seattle, Washington.

Frisch, A.J. and T.A. Anderson. 2000. The response of coral trout (*Plectropomus leopardus*) to capture, handling and transport and shallow water stress. Fish Physiology and Biochemistry 23(1): 23-24.

Good, T.P., R.S. Waples, and P. Adams, editors. 2005. Updated Status of Federally Listed ESUs of West Coast Salmon and Steelhead. U.S. Department of Commerce, National Marine Fisheries Service, Northwest Fisheries Science Center, NOAA Technical Memo. NMFS-NWFSC-66, Seattle, Washington. 598 p.

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. Dept. Commer., NOAA Tech. Memo. NMFS-NWFSC-81, 117 p.

Hastings, M.C. 2007. Calculation of SEL for Govoni et al. (2003, 2007) and Popper et al. (2007)studies. Report for Amendment to Project 15218, J&S Working Group, Applied Research Lab, Penn State University. 7 pp.

Hastings, M.C. and A.N. Popper. 2005. Effects of Sound on Fish. Prepared by Jones and Stokes for the California Department of Transportation, Sacramento, California (August

23, 2005). 82 p.

Hastings, M.C., A.N. Popper, J.J. Finneran, and P. Lanford. 1996. Effects of low-frequency underwater sound on hair cells of the inner ear and lateral line of the teleost fish Astronotus ocellatus. Journal of the Acoustical Society of America 99(3): 1759-1766

Healey, M.C. 1991. Life history of Chinook salmon (*Oncorhynchus tshawytscha*). Pages 311 393 *in* C. Groot and L. Margolis, editors. Life History of Pacific Salmon. University of British Columbia Press, Vancouver, BC.

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.

Holmes, E.E. 2001. Estimating risks in declining populations with poor data. Proc. Natl. Acad. Sci. USA 98:5072-5077.

Holmes, E.E., and W. Fagan. 2002. Validating population viability analysis for corrupted data sets. Ecology 83:2379-2386.

Howick, G. L. and W. J. O'Brien. 1983. Piscivorous feeding behavior of largemouth bass: an experimental analysis. Transactions of the American Fisheries Society. 12:508-516.

Illingworth and Rodkin, Inc. 2007. Compendium of pile driving sound data. Draft technical memorandum prepared for the California Department of Transportation by Illingworth and Rodkin.

Illingworth and Rodkin, Inc. 2010. Underwater Sound Levels Associated with Driving Steel Piles for the State Route 520 Bridge Replacement and HOV Project Pile Installation Test Program. Report to Washington State Department of Transportation, Seattle, Washington. 143 pp.

ISAB (Independent Scientific Advisory Board). 2007. Climate change impacts on Columbia River basin fish and wildlife. Northwest Power and Conservation Council, Portland, Oregon.

Kerwin, J. 1999. Salmon Habitat Limiting Factors Report for the Puyallup River Basin (Water Resource Inventory Area 10). Washington State Conservation Commission, Olympia, Washington (July 1999). 123 p.

Kerwin, J. 2001. Salmon and Steelhead Habitat Limiting Factors Report for the Cedar-Sammamish Basin (Water Resource Inventory Area 8). Washington Conservation Commission, Olympia, Washington.

King County. 2005. Final Lake Washington/Cedar/Sammamish Watershed (WRIA 8) Chinook Salmon Conservation Plan – WRIA 8. July 2005.

Kiyohara, K. and Volkhardt, G. 2008. Evaluation of downstream migrant salmon production in 2007 from the Cedar River and Bear Creek. Washington Department of Fish and Wildlife, Annual Report.

Kiyohara, K. and M. S. Zimmerman. 2009. Evaluation of juvenile salmon production in 2008 from the Cedar River and Bear Creek. Washington Department of Fish and Wildlife, Olympia, Washington.

Kiyohara, K. and M. S. Zimmerman. 2011. Evaluation of juvenile salmon production in 2009 from the Cedar River and Bear Creek. Washington Department of Fish and Wildlife, Olympia, Washington.

Lloyd, D.S., J.P. Koenings, and J.D. LaPerriere. 1987. Effects of turbidity in fresh waters of Alaska. North American Journal of Fisheries Management 7: 18-33.

Love, M.S., M. Carr, and L. Haldorson. 1991. The ecology of substrate associated juveniles of the genus *Sebastes*. Env. Bio. Fish. 30:225-243.

Love, M.S., M. M. Yoklavich, and L. Thorsteinson. 2002. The rockfishes of the Northeast Pacific. University of California Press, Berkeley, California.

Mantua, N., I. Tohver, and A. F. Hamlet. 2009. Impacts of climate change on key aspects of freshwater salmon habitat in Washington State. In: Washington Climate Change Impacts Assessment: Evaluating Washington's future in a changing climate. Climate Impacts Group, University of Washington, Seattle, Washington.

Marshall, A.R., M. Small, and S. Foley. 2004. Genetic Relationships among Anadromous and Non-anadromous *Oncorhynchus mykiss* in Cedar River and Lake Washington—Implications for Steelhead Recovery Planning. Progress report to Cedar River Anadromous Fish Committee and Seattle Public Utilities, Washington Department of Fish and Wildlife, Olympia and Mill Creek, Washington. June 2004.

Materna, E. 2001. Issue Paper 4. Temperature Interaction. Prepared as part of U.S. EPA Region 10, Temperature Water Quality Criteria Guidance Development Project. EPA-910-D-01-004.

Mazur, M.M., and D.A. Beauchamp. 2003. A comparison of visual prey detection among species of piscivorous salmonids: Effects of light and low turbidities. Environmental Biology of Fishes 4:397–405.

McComas, L.R., B.P. Sandford, J.W. Ferguson, and D.M. Katz. 2008. Biological Design Criteria for Fish Passage Facilities: High-Velocity FlumeDevelopment and Improved Wet-Separator Efficiency, 2001. Walla Walla District, U.S. Army Corps of Engineers. Walla Walla, Washington.

May, C.W., R.R. Horner, J.R. Karr, B.W. Mar, and E.B. Welch. 2003. Effects of urbanization on small streams in the Puget Sound Ecoregion. Watersh. Prot. Tech. 2: 483-494.

McElhany, P., M. H. Ruckelshaus, M. J. Ford, T. C. Wainwright, and E.P. Bjorkstedt. 2000. Viable salmonid populations and the recovery of evolutionarily significant units. U.S. Dept. of Commerce, NOAA Tech. Memo., NMFS-NWFSC-42, 156p.

Melnychuk, M.C., D.W. Welch, C. J. Walters, and V. Christensen. 2007. Riverine and early ocean migration and mortality patterns of juvenile steelhead trout (*Oncorhynchus mykiss*) from the Cheakamus River, British Columbia. Hydrobiologia (2007) 582:55–65.

Moscrip, A.L., and D.R. Montgomery. 1997. Urbanization, flood frequency, and salmon abundance in Puget lowland streams. J. Am. Water Res. Assoc. 33(6):1289-1297.

Mote, P. W. and E. P. Salathé. 2009. Future climate in the Pacific Northwest. In: Washington Climate Change Impacts Assessment: Evaluating Washington's future in a changing climate. Climate Impacts Group, University of Washington, Seattle, Washington.

Myers, J.M., R.G. Kope, G.J. Bryant, D. Teel, L.J. Lierheimer, T.C. Wainwright, W.S. Grand, 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, National Marine Fisheries Service, Northwest Fisheries Science Center, NOAA Technical Memo. NMFS-NWFSC-35, Seattle, Washington (February 1998). 443 p.

NMFS 2003. Alaska Fishery Science Center, processed report 2003-10. Marine protected areas and early life-history of fishes.

NMFS. 2007. Rationale for the Use of 187 dB Sound Exposure Level for Pile Driving Impacts Threshold. Unpublished memorandum. Seattle, Washington: National Oceanic and Atmospheric Administration, National Marine Fisheries Service.

Nehlsen, W., J. E. Williams, and J. A. Lichatowich. 1991. Pacific salmon at the crossroads: Stocks at risk from California, Oregon, Idaho, and Washington. Fisheries 16(2):4-21.

Newcombe, C.P. and J. Jensen. 1996. Channel suspended sediment and fisheries: a synthesis for quantitative assessment of risk and impact. North American Journal of Fisheries Management 16: 693-727.

Newcomb, T. J., and T. G. Coon. 1997. Evaluation of alternate methods for estimating numbers of outmigrating steelhead smolts. Michigan Department of Natural Resources, Fisheries Research Report 2045, Ann Arbor.

PFMC (Pacific Fishery Management Council). 1999. Amendment 14 to the Pacific Coast Salmon Plan. Appendix A: Description and Identification of Essential Fish Habitat,

Adverse Impacts and Recommended Conservation Measures for Salmon. Pacific Fishery Management Council, Portland, Oregon. 153 pp.

Pacific International Engineering. 2000. Milwaukee habitat area juvenile salmon utilization study, 1999. Draft report prepared for Port of Tacoma. Sitcum Waterway Remedication Project. Pacific International Engineering, Tacoma, WA.

Pacific International Engineering. 2002. Milwaukee habitat area juvenile salmon utilization study, 2000. Draft report prepared for Port of Tacoma. Sitcum Waterway Remedication Project. Pacific International Engineering, Tacoma, WA.

Pearcy, W. G. 1992. Ocean ecology of North Pacific salmonids. Books in Recruitment Fishery Oceanography. Washington Sea Grant, University of Washington Press, Seattle, 179 p.

Petersen, J. M. and D. M. Gadomski. 1994. Light-mediated predation by northern squawfish on juvenile chinook salmon. J. Fish Biol. 45(Suppl. A): 227-242.

Popper, A.N. 2003. Effects of anthropogenic sounds on fishes. Fisheries 28(10): 24-31.

Pess, G.R., D.R. Montgomery, T.J. Beechie, and L. Holsinger. 2002. Anthropogenic alterations to the biogeography of salmon in Puget Sound. In Montgomery, D.R., S. Bolton, and D.B. Booth (editors), Restoration of Puget Sound Rivers, p. 129-154. University of Washington Press, Seattle, WA.

Popper, A.N., M.E. Smith, P.A. Cott, B.W. Hanna, A.O. MacGillivray, M.E. Austin, and D.A. Mann. 2005. Effects of exposure to seismic airgun use on hearing of three fish species. Journal of the Acoustical Society of America 117:3958-3971.

Quinn, T.P. 2005. The Behavior and Ecology of Pacific Salmon and Trout. American Fisheries Society, Bethesda, Maryland. University of Washingotn Press, Seattle, Washington and Lond, England. 378 p

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.

Savino, J. F. and R. A. Stein. 1989. Behavior of fish predators and their prey: habitat choice between open water and dense vegetation. *Environmental Biology of Fishes*, Vol. 24, No. 4 , pp. 287-293.

Seattle Public Utilities and the U.S. Army Corps of Engineers. 2008. Synthesis of Salmon Research and Monitoring, Investigations conducted in the western Lake Washington basin.

Seiler, D., G. Volkhardt, and L. Kishimoto. 2003. Evaluation of Downstream Migrant Salmon

Production in 1999 and 2000 from Three Lake Washington Tributaries: Cedar River, Bear Creek, and Issaquah Creek. Wild Salmon Production Evaluation Unit Science Division, Fish Program. Washington Department of Fish and Wildlife, Olympia, Washington.

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: 493-497.

Shared Strategy Development Committee (Shared Strategy). 2007. Puget Sound Salmon Recovery Plan. Formally dopted January 19, 2007. Shared Strategy for Puget Sound, Seattle, Washington. 494 p.

Simenstad, C. A., B. J. Nightengale, R. M. Thom and D. K. Shreff.er. 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, Wash. State Dept. Transportation, Washington Sate Trans. Center (TRAC), Seattle, WA. 116 pp + appendices.

Sigler, J.W., T.C. Bjornn, and F.H. Everest. 1984. Effects of chronic turbidity on density and growth of steelheads and coho salmon. Transactions of the American Fisheries Society 113: 142-150.

Spence, C.R. 1989. Rates of Movement and Timing of Migrations of Steelhead Trout to and within the Skeena River, 1988. Skeena Fisheries Report# SK 62, Ministry of Environment, Lands, and Parks. British Columbia, Canada.

Sprague, J.B. 1968. Avoidance reactions of rainbow trout to zinc sulphate solutions. Water Research 2(1968):367–372.

Sweka, J.A. and K.J. Hartman. 2003. Reduction of reactive distance and foraging success in smallmouth bass, *Micropterus dolomieu*, exposed to elevated turbidity levels. Environmental Biology of Fishes. Vol.67:341-347.

Tabor, R. A., G. Brown, and V. T. Luting. 1998. The effects of light intensity on predation of sockeye fry by prickly sculpin and torrent sculpin. May 1998. Region 1, U.S. Fish and Wildlife Service, Western Washington Office, Aquatic Resources Division, Lacey, Washington. 16 p.

Tabor, R.A., M.T. Celedonia, F. Mejia, R.M. Piaskowski, D.L. Low, B. Footen, and L. Park. 2004. Predation of Juvenile Chinook Salmon by Predatory Fishes in Three Areas of the Lake Washington Basin. U.S. Fish and Wildlife Service, Lacey, Washington. 86 pp.

Tabor, R.A., H.A. Gearns, C.M. McCoy III, and S. Camacho. 2006. Nearshore Habitat Use by Juvenile Chinook Salmon in Lentic Systems of the Lake Washington Basin: Annual Report, 2003 and 2004. U.S. Fish and Wildlife Service, Lacey, Washington.

Tabor, R.A., D. Lantz, and S. Sanders. 2010. Distribution and Habitat Use of Fish in Seattle's Streams Final Report, 2005 and 2006. U.S. Fish and Wildlife Service, Western Washington Fish and Wildlife Office, Lacey, Washington.

Tabor, R. A. and R.M. Piaskowski. 2002. Nearshore Habitat Use by Juvenile Chinook Salmon in Lentic Systems of the Lake Washington Basin. U.S. Fish and Wildlife Service, Western Washington Fish and Wildlife Office, Lacey, Washington.

Turnpenny, A. and J. Nedwell. 1994. The Effects on Marine Fish, Diving Mammals and Birds of Underwater Sound Generated by Seismic Surveys. Fawley Aquatic Research Laboratories Limited, Marine and Freshwater Biology Unit, Southampton, Hampshire, UK. 48 p.

Turnpenny, A.W.H., K.P. Thatcher, and J.R. Nedwell. 1994. The effects on fish and other marine animals of high-level underwater sound. Fawley Aquatic Research Laboratory, Ltd., Report FRR 127/94, United Kingdom (October 1994). 79 p.

USFWS. 2008. Endangered Species Act - Section 7 Consultation Biological Opinion—Operation and Maintenance of the Lake Washington Ship Canal, Lower Sammamish River 171100120301, Cedar River 171100120302, and Shell Creek 171100190401 King County, Washington. U.S. Fish and Wildlife Service, Western Washington Fish and Wildlife Office. Report # 1-3-02-F-0393.

Warner, E., and K. Fresh. 1999. Draft Lake Washington Chinook Salmon (*Oncorhynchus tshawytscha*) Recovery Plan. Muckleshoot Indian Tribe Fisheries Department, Washington Department of Fish and Wildlife, and Suquamish Indian Tribe Fisheries Department. March 25, 1999. 141 pp.WDFW. 2010. Stock Inventory. WRIA 08 – Lake Washington. Washington Department of Fish and Wildlife, Olympia, Washington.

WDFW (Washington Department of Fish and Wildlife). 2002. Salmonid Stock Inventory. Olympia, WA.

WDF (Washington Department of Fisheries), WDW (Washington Department of Wildlife), and Western Washington Treaty Indian Tribes. 1993. 1992 Washington State Salmon and Steelhead Stock Inventory. Washington Department of Fisheries and Washington Department of Wildlife, Olympia, Washington. 580p.

WDFG (Washington Department of Fisheries and Game). 1932. Fortieth and forty-first annual reports of State Department of Fisheries and Game. Division of Fisheries, Olympia, WA.

WSDOT 2009a. WSDOT Fish Exclusion Protocols and Standards. http://www.wsdot.wa.gov/NR/rdonlyres/6832EEA1-9B77-42C3-9F68-BE28C561B298/0/BA_FishHandling.pdf.

WSDOT 2009b. Highway Runoff Dilution and Loading Model Documentation. Analysis of

Highway Stormwater Water Quality Effects for Endangered Species Act Consultations. http://www.wsdot.wa.gov/Environment/Biology/BA/BAguidance.htm#Stormwater. Olympia, Washington.

WSDOT. 2010. Biological Assessment – SR 520, I-5 to Medina Bridge Replacement and High Occupancy Vehicle Project.

Washington Trout. 2000. Water typing and fish distribution within the City of Seattle. Draft report. May 18, 2000.

Weitkamp, D., and G.T. Ruggerone. 2000. Factors Influencing Chinook Salmon Populations in Proximity to the City of Seattle. Prepared for the City of Seattle by Parametrix, Natural Resources Consultants, and Cedar River Associates. 224 pp. (International Water Association Award Finalist).

Welch, D.W., B.R. Ward, and S.D. Batten. 2004. Early Ocean Survival and Marine Movements of Hatchery and Wild Steelhead Trout (*Oncorhynchus mykiss*) Determined by an Acoustic Array: Queen Charlotte Strait, British Columbia. Deep Sea Research Part II: Topical Studies in Oceanography 51(6-9):897-909.